

Improving population estimates for public health programmes

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Purpose and scope of this manual

This manual provides rationale, process steps and practical annexes to guide public health programmes toward better population denominators for planning, resource allocation and coverage monitoring. Population denominators are crucial to public health disease burden estimation, commodity quantification and intervention targeting. However, these same methodologies for strengthening population denominators for health could also be used in coordination with other sectors, including education, environment, humanitarian preparedness and agriculture and food security to support broader planning, resource allocation and coverage monitoring.

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Contents

Purpose and scope of this manual.....	1
Acknowledgements	1
Introduction	3
Robust population estimations	5
Current challenges	6
Purpose and target audience	6
Steps to improving population estimation.....	6
Step 1. Establish or strengthen a Population Estimation Working Group	7
Governance and leadership of the PopWG	7
Recommended membership of the PopWG	7
Step 2. Assess and compare existing population estimates	8
Step 2a. Identify relevant estimates and population assets for review	9
Step 2b. Document each population estimate.....	10
Step 2c. Compare the estimates.....	11
Step 2d. Interpret and discuss the compared estimates.....	14
Step 3. Review findings and co-develop methods to improve population estimation across programmes.....	15
Population estimation maturity model and scoring.....	16
Step 4. Develop a detailed, costed improvement plan.....	16
Annex 1. Population estimation workshop participants	18
Annex 2. Improving population estimations: Case study.....	20
Annex 3. Sample population estimates sources table	21
Annex 4. Population estimate comparison table	23
Annex 5. Managing political and operational pressures.....	24
Annex 6. Population estimate quality assessment scoring	25
Step 1. Creating scoring criteria	25
Step 2. Score population estimates based on established criteria.....	25
Step 3. Calculate a weighted score (optional)	26
Annex 7. Population estimation maturity model and scoring methodology	28
Annex 8. Example costed population estimation improvement plan	35
Annex 9. Improving public health population estimates: Mini case studies	40

Introduction

Reliable population estimates are foundational to effective public health programmes and disease prevention, control and elimination. Accurate denominators allow health programmes to target populations, assess coverage and evaluate the impact of interventions, such as insecticide-treated net (ITN) campaigns, vaccination programmes or service delivery coverage, and to identify where populations remain underserved. Inaccuracies in population estimates can misdirect investments, bias coverage indicators and misrepresent programme impact, causing progress to appear overstated or understated and ultimately diverting resources from where they are most needed. For example, the World Health Organization (WHO) [manual on improving immunization population estimates](#) underscores that even a 10% error in the denominator can lead to major misinterpretations in programme performance.

For public health programmes such as malaria, maternal and child health (MCH), nutrition and communicable disease control, good population data are increasingly needed at granular sub-national levels to enable stratified planning and precise targeting—and to maximize the impact of limited resources. For example, population estimates are a primary driver of commodity quantification and procurement, as well as quantification for human resources for delivery of commodities. Overestimation can result in excess procurement, storage and wastage, while underestimation can lead to stock-outs and unmet need. Improving the accuracy of population estimates therefore has direct implications for programme efficiency: the better populations are estimated, the more effectively resources can be allocated and, in some cases, conserved for other critical programme priorities.

However, population estimates are derived from diverse and sometimes inconsistent sources—census and census-based projections, civil registration and vital statistics (CRVS), household enumerations during household surveys and routine intervention campaigns, locally-derived health facility catchment estimates or small area estimation using statistical and machine learning models—each with varying quality and spatial resolution (see Table 1). In some contexts, population figures may also be administratively or politically mandated rather than empirically derived, introducing additional bias into planning and performance assessment. Discrepancies between these sources can be large and few countries have a single “gold standard.” Furthermore, most existing estimates lack the disaggregation necessary for identifying vulnerable groups such as migrants, displaced persons or isolated rural populations.

Strengthening collaboration between malaria, immunization and other health programmes, as well as with national statistical systems, offers an opportunity to harmonize methods, improve accuracy and ensure consistent use of reliable population data across the health sector.

Table 1. Strengths and weaknesses of various population estimation sources

Population estimate source	Strengths	Weaknesses
Census and census projections Periodic, systematic enumeration of the entire population through nationwide data collection exercises (censuses), with results used to generate intercensal population estimates and projections based on demographic modelling.	• Official population source • Standardized extrapolation methods to produce consistent estimates	• Often outdated between census rounds, especially with rapid population migration due to urbanization or natural disasters • May not be done every 10 years • May not contain level of detail or disaggregated values required for health programmes (i.e. specific age groups, health facility catchments) • Machine-readable highly disaggregated data often not available to health programmes
CRVS Continuous, systematic recording of vital events (such as births, deaths, marriages and divorces) through official reporting to civil authorities, including health facilities and government registration offices.	• Continuous data collection (births, deaths) • Potentially more up-to-date than census • Useful for tracking trends	• Incomplete or inconsistent coverage in many settings • May miss vulnerable groups who do not routinely seek care
Household enumeration Count of the entire population in sampled areas during household surveys (e.g. Demographic and Health Surveys [DHS] and Multiple Indicator Cluster Surveys [MICS]), microcensus surveys or within intervention areas prior to intervention, often disaggregated by target groups.	• Collects detailed data that are timely and relevant for specific health programmes	• Costly, resource intensive • Often conducted for one programme or purpose • Traditionally not integrated with data warehouses (e.g. National malaria data repositories [NMDR]) leading to limited access or use across Ministry of Health (MoH) departments
Locally-derived health facility catchment estimates Local governments provide counts of the total number of people living within their catchment area by receiving counts from village chiefs, community health workers (CHWs), counts from recent household enumerations, another intervention or recent census projections.	• Disaggregation by health facility catchment useful for programme planning	• Often inconsistent estimation methods (census extrapolations, village chief counts, past household enumeration) with limited comparability • May be influenced by administrative or political factors or subject to periodic alterations

Population estimate source	Strengths	Weaknesses
Small area estimation using statistical and machine learning models and geospatial models Combines satellite imagery with other geospatial data (built-up areas, roads, etc.), census and other surveyed population counts and statistical methods to provide population estimates for gridded cells on a map.	• Can provide high spatial resolution and estimates even with shifting administrative boundaries • Useful in hard-to-reach or data-scarce areas • Can combine with micro-surveys to improve accuracy	• Model-based (not directly observed) with varying accuracy • Limited disaggregation for vulnerable groups • Less understood and trusted than other sources due to complexity of calculations • When making decisions, need to account for uncertainties • Ground validation may be needed to build end user confidence in the modelled estimates

Robust population estimations

In an ideal situation, a country would maintain a comprehensive, continuously updated population data system that integrates multiple verified sources to produce accurate, granular and trusted estimates. The foundation would be regular, high-quality censuses, enhanced by geospatial technologies such as satellite imagery and global positioning system (GPS)-based enumeration, with intercensal updates derived from demographic surveys, CRVS and small-area modelling to maintain accuracy over time. A fully functional CRVS system would complement the census by recording all births and deaths in real time, geocoded to administrative boundaries and linked to national identification systems. In addition, a system for tracking migration could be incorporated.

Population data from the census, CRVS and statistical models would feed into an integrated national statistical and health information system, ensuring that all health programmes, including malaria, MCH and immunization use harmonized denominators and consistent sub-national population projections.

These estimates would be disaggregated by age, sex, migration and vulnerability status and available at fine geographic scales to support precise targeting of interventions in high-risk and underserved areas. Strong institutional collaboration between the national statistical office, MoH and other key agencies would ensure standardized methodologies, transparent documentation and regular data validation. Advanced geospatial and modelling tools would further refine population distribution in dynamic or hard-to-reach settings, making the system responsive to population movement and urbanization.

In this ideal state, population estimates would be:

1. Available—routinely collected with the right granularity and inclusive of vulnerable populations
2. Accurate—regularly updated, validated and transparent
3. Accessible—widely available for use, ethically secure and interoperable
4. Actionable—routinely used to inform decision-making

These principles are adapted from the UN Fundamental Principles of Official Statistics (UN General Assembly Resolution 68/261, 2014) and the ensuing [manual](#). When adhering to the principles outlined in these frameworks, population estimates can be widely trusted and form the backbone of effective planning, resource allocation and evaluation for malaria and other health programmes.

Current challenges

In practice, most countries do not yet achieve this ideal: census data are often outdated or infrequent, CRVS systems may have incomplete coverage or delays in reporting, and population projections can vary across institutions due to differing methods and assumptions. These gaps lead to inconsistencies in population denominators, limited geographic granularity and reduced confidence in data used for planning and evaluation.

The consequences for health programmes can be substantial. For example, overestimation of target populations in ITN campaigns can lead to the procurement and distribution of millions of excess nets, tying up scarce funding in unused commodities, while underestimation can leave high-risk populations unprotected, increasing disease burden and undermining programme impact. For example, in one country, a lack of confidence in outdated census data and the absence of a trusted alternative source led a national programme to inflate population estimates by 27% above WHO-recommended levels, resulting in an overbudget of approximately USD 2.55 million for ITNs. Similar issues can affect vaccine forecasting, workforce planning and service delivery coverage estimates, where inaccurate denominators can misdirect resources and distort performance metrics, and lead to substantial errors in commodity calculation. **Annex 2** provides a case study illustrating the importance of robust population denominators.

Purpose and target audience

The purpose of this document is to provide structured guidance to Public Health Directorates, Ministries of Health and their health programmes and departments. This guidance will detail how to systematically assess, compare and strengthen population estimation approaches used for planning and implementation. Specifically, it aims to support programmes in identifying inconsistencies, biases and methodological gaps in current population estimates, while promoting a shared understanding of available data sources and underlying assumptions.

The guidance further outlines a practical framework for reviewing existing estimates across programmes and sectors, facilitating cross-programme dialogue, and developing harmonized, evidence-based approaches to population estimation. By improving the accuracy, transparency and alignment of population estimates, this guidance seeks to enhance data-driven decision-making, optimize resource allocation and ensure equitable targeting of malaria and other health interventions across populations.

Steps to improving population estimation

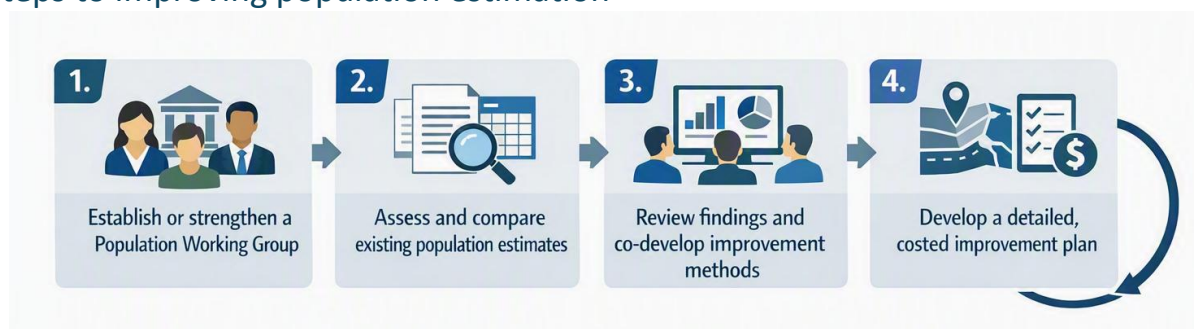


Figure 1. Four-step process for improving population estimation

Step 1. Establish or strengthen a Population Estimation Working Group

To support improvements in population estimation, a Population Estimation Working Group (PopWG) should be established or strengthened, bringing together representatives from the National Statistics Office (NSO) alongside various health programmes such as malaria, immunization, MCH, surveillance departments and health management system (HIS) groups, as well as relevant groups outside health – such as education or agriculture. This group should be responsible for overseeing the review, coordinating implementation, aligning methodologies, maintaining population datasets and institutionalizing improvements over time.

Governance and leadership of the PopWG

The PopWG should operate under endorsed terms of reference that clearly define its mandate, scope, membership, leadership, decision-making authority, reporting lines and expected outputs. The group should be anchored within an appropriate national institution and linked to existing health and statistical governance structures, rather than operating as a parallel mechanism. The NSO or responsible government institution should provide methodological leadership on official population statistics, while the MoH should ensure that programme requirements and operational realities are reflected. Where appropriate, these institutions may co-chair the group to strengthen ownership and coordination.

The terms of reference should specify:

- **Leadership and secretariat.** Identify the chair or co-chairs, a secretariat responsible for agendas, minutes and follow-up, and named focal points from each participating institution.
- **Membership and participation.** Include institutions that produce, manage or use population estimates, with clear expectations for representation, technical contributions and continuity of participation. Sub-national representatives, civil society or technical partners may be included where relevant.
- **Decision-making and escalation.** Define how technical decisions will be reached and documented, how disagreements will be resolved, and which issues require endorsement or escalation to senior leadership.
- **Accountability and reporting.** Establish reporting lines, deliverables, timelines and responsibilities, supported by a time-bound work plan that assigns actions to named institutions or members.
- **Operating arrangements.** Agree on details such as the frequency of meetings, rules for quorum, processes for reviewing membership and terms of reference, arrangements for sharing data, documenting methods and communicating decisions.

Recommended membership of the PopWG

The PopWG should include representatives from:

- NSO
- MoH planning and policy units
- National malaria programme (NMP)
- Expanded Programme on Immunization (EPI)
- Maternal, newborn and child health programmes
- Health Information System (HIS) teams
- National Digital Health Agencies
- CRVS authorities
- Geographic information systems (GIS) and geospatial mapping units
- Education, agriculture and other sectors that generate population-related data

- Refugee, migration and humanitarian agencies where relevant
- Academic and research institutions with expertise in demography, statistics or geospatial modelling
- Development partners and technical agencies
- Non-governmental organizations (NGOs) working with vulnerable, mobile, displaced or underserved populations

Where specialized technical input is required, the PopWG may establish temporary technical advisory subgroups on subjects such as demographic modelling, census analysis, geospatial estimation, CRVS strengthening or uncertainty assessment.

Meeting structure and accountability

The PopWG should meet at least quarterly and more frequently before major planning, procurement or campaign activities that rely on population estimates. Annual outputs should include:

- A consolidated inventory of population estimates and data assets, mapped to specific use cases
- A summary of major discrepancies identified
- Agreed denominator recommendations
- Progress against the population estimation maturity assessment
- A prioritized improvement plan with assigned responsibilities and timelines

These outputs should be shared with participating programmes, the NSO, the MoH and relevant partners to support coordinated action and continuous improvement.

The next steps that a PopWG should undertake are outlined below.

Step 2. Assess and compare existing population estimates

Following the establishment or strengthening of the PopWG, the next step to improving population estimation is to fully document, understand and compare existing population estimates and methodologies. **Annex 3** provides a sample population estimates source table. The PopWG should identify who can conduct this compilation and comparison and officially elicit data sets from the relevant programmes. With this assessment, the PopWG can develop a comprehensive view of how population figures are currently generated, identify inconsistencies and gaps across data sources, and understand the underlying assumptions and methodologies driving these estimates. This process enables stakeholders to highlight areas of alignment and divergence across programmes and sectors, establish a process for resolving divergence, assess the reliability and suitability of different estimates for specific use cases, and establish a common evidence base from which improvements can be designed and implemented.

The primary objective of the PopWG is not to identify a single population estimate for all purposes, but rather to establish a transparent and evidence-based process for assessing, comparing and selecting the most appropriate denominator for a given use case.

As part of this process the PopWG, should identify relevant population estimates and related assets (Step 2a), document each population estimate (Step 2b), and compare the estimates (Step 2c). When estimates differ substantially, the PopWG should assess the quality, methodology and confidence of each estimate by:

1. Reviewing the quality and documentation.

2. Assessing recency, completeness, geographic alignment and coverage.
3. Examining underlying assumptions, adjustment factors and modelling approaches.
4. Considering sources of uncertainty and potential bias.
5. Assigning an overall confidence rating to each estimate.

Based on these estimate-specific assessments the PopWG should then interpret and discuss the compared estimates (Step 2d) including:

6. Document the rationale for selecting a preferred estimate or range for a given use case.
7. Record any unresolved disagreements and proposed actions for further investigation.

All decisions should be documented in meeting minutes and technical reports to maintain transparency and institutional memory.

The four steps involved in assessing and comparing existing population estimates are outlined in Steps 2a-2d below.

Step 2a. Identify relevant estimates and population assets for review

A task for staff of all health programmes that estimate population is to identify which population estimates will be included in the review. The following should be considered for inclusion:

- **Official census.** This should include the official census reports and include the population counts from the census, projected growth rates and population estimates, and methods for calculating the projections.
- **Malaria programmes.** Within NMPs there are often several vector control sub-programmes, such as ITNs, Indoor Residual Spraying (IRS) and Seasonal Malaria Chemoprevention (SMC), each of which may have their own population estimates and sources. There may also be multiple sources within one programme, for example, an ITN programme may use one population estimate for commodity procurement and macroplanning and another for microplanning for interventions.
- **Other health programmes.** Other important programmes include facility-based EPI activities and campaigns, neglected tropical disease (NTD) programmes with community census data, community health units, and other MCH/antenatal care (ANC) programmes.
- **Other sectors:** Important sectors include the education sector, which may have useful information on school-aged children, the agriculture or food security sector that may have household surveys, or groups that work with special or hard-to-reach populations, such as organizations involved in providing services to refugee or internally displaced persons (IDP) groups.
- **Other population estimation projects.** Beyond the census, national governments and partners may be engaged in a range of population estimation efforts using diverse data sources and methods. These may include geospatial modelling initiatives (e.g. GRID3, WorldPop, LandScan, Global Human Settlement Layer) that generate gridded population estimates using input census, microcensus, household survey or health campaign data, satellite imagery and statistical techniques, as well as demographic modelling efforts (e.g. UN Population Division or World Bank estimates), administrative and programme-based registries (e.g. civil registration systems, social protection databases), and humanitarian or development partner data systems (e.g. United Nations High Commissioner for Refugees [UNHCR] or International Organization for Migration [IOM] population tracking). Together, these sources can provide complementary insights into

population size, distribution and dynamics that extend beyond traditional census-based approaches.

In many settings, there are also important national population assets that extend beyond specific programmes that support population estimation efforts. These include foundational geographic data, such as administrative unit lists and corresponding geospatial boundary files that define locations at national and sub-national levels. In addition, health service delivery points, including facility lists and geolocated service points, represent a critical asset for linking population estimates to service coverage and programme planning. These assets provide an essential framework for organizing, validating and applying population data across programmes and sectors.

As noted in the ideal state for robust population estimates described above, there should preferably be a single, standardized and regularly maintained dataset for geographic boundaries and health service delivery points. However, in practice, multiple versions of these datasets are often in use across programmes. As part of the assessment process, the PopWG should collect and document these assets as they relate to each population estimate to enable systematic comparison and identification of discrepancies in collaboration with the relevant government institutions.

Step 2b. Document each population estimate

For each population estimate, a standardized set of information should be systematically documented to support comparison and assessment.

The assessment should create a table that documents the following for each population estimate:

- **Purpose of the estimate.** This should clearly describe how the estimate is intended to be used, such as for planning, resource allocation, target setting or monitoring programme performance. Understanding the intended use helps assess whether the estimate is fit for purpose.
- **Data source.** The original data source should be identified, including whether the estimate is derived from census data, surveys, administrative systems, programme records or other sources. Where applicable, any intermediary sources or transformations should also be noted.
- **Collection methods.** Underlying data should be documented in terms of how they were collected and by whom. This includes whether data were obtained through surveys, routine reporting systems, enumeration exercises or modelling approaches, as well as any known information about the quality and reliability of the data collection process.
- **Calculation method.** Where estimates have been adjusted or projected, the methods used should be clearly described. This includes any calculations used to estimate populations across different time periods, geographic areas or subgroups, as well as the assumptions underlying these calculations (e.g. growth rates, migration patterns).
- **Level of detail.** Each population estimate should include sufficient detail to support comparison and use:
 - **Time period.** The month and year of data collection and/or estimation should be documented. Where possible, multiple years of estimates (e.g. the last five years) should be included to allow for trend analysis.
 - **Geographic coverage.** The geographic levels included in the estimate should be specified, from national to the lowest available administrative levels.
 - **Population subgroups.** Relevant population breakdowns should be included, such as sex and age groups and other demographic characteristics (e.g. pregnancy status, refugee or

IDP status), as well as detailing population groups known for movement and migration, for work or due to environmental or political instability.

- **Verification processes and known quality factors.** Each programme and population estimate may have different processes for verifying or validating their estimates after they are collected. For example, there may be processes within programmes for triangulating population estimates or checking for outliers prior to their use. Any known limitations, data gaps or potential sources of bias should be documented. This may include concerns related to data completeness, representativeness, timeliness or methodological constraints.

A sample table to conduct this review can be found in **Annex 3**.

Step 2c. Compare the estimates

Following documentation of individual population estimates, a structured comparison and analysis to identify areas of alignment, inconsistency and potential bias should be undertaken.

First, before conducting the comparison, the PopWG should confirm that the staff responsible for the programme have cleaned and validated their population dataset. If this has not occurred, the PopWG should request that this validation be conducted. Programme staff should **review their estimates for internal consistency**, including assessing the following:

- Do sub-national estimates aggregate correctly to higher administrative levels (e.g. do subdistrict populations sum to district totals)?
- Do population subgroups (e.g. age categories) sum to the total population?
- Are there any mathematical inconsistencies or gaps within the dataset?

Next, after receiving population estimates from multiple health programmes, the PopWG should:

- **Align estimates for comparison.** Compare population estimates that are similar based on geographic location, population subgroup and period of collection.
- **Consolidate estimates.** Compile all estimates into a single dataset (e.g. spreadsheet or database) to facilitate systematic comparison. Visualization tools (e.g. charts, maps, dashboards) may further support identification of patterns, discrepancies and trends.



Analytical tip

Create a table in Excel with standardized categories to align all the available datasets, including by administrative unit, time period, age group, etc. In this file each row is the lowest administrative unit (e.g. health area or district). Depending on the file structure and needs, columns could be a mix of metadata categories (time periods, age groups) and population values. See Annex 4 for an example population estimate comparison table. Where there are blanks (such as specific age groups not being available) calculate these data using a standard methodology, such as national age group proportions from the census.



Analytical tip

Create pivot tables in Excel to quickly sum disaggregated population values and compare to summary values, such as higher administrative levels or total population summaries.

**Analytical tip**

To compare geospatial boundary files, engage a geospatial expert who can use software such as ArcGIS, QGIS, R or other spatial software to compare and visualize differences in boundary datasets.

Once the data have been assembled, the PopWG can use the following checklist to compare the various population estimates (Table 2). There may be political pressure associated with some of the population estimates. Refer to **Annex 5, Managing political and operational pressures** while developing the process for collation, review and triangulation. Refer to **Annex 6, Population estimate quality assessment scoring** for a suggested template for scoring the quality of each population estimation.

Table 2. Checklist for analysis of population estimates

Topic area	Checklist questions	 Analytical tips
Cross-programme consistency and outlier detection	☐ Are there estimates that are substantially higher or lower than others for the same population, location and time period? ☐ Are outliers consistent across multiple locations or isolated to specific areas or programmes? ☐ Are discrepancies systematic (e.g. one programme consistently higher/lower than others)? ☐ Can differences be explained by methodology, timing or population coverage?	Create a heatmap or colour rules to analyse those sources which differ by >50%, 30-50%, and <30% (these thresholds can be adjusted to suit the context). This will help quickly visualize the most problematic districts. A scatter plot can also be used to compare multiple estimates.
Temporal consistency and trends over time	☐ Are estimates stable and plausible over time? ☐ Do changes align with expected population growth rates based on census projections? ☐ Are observed fluctuations consistent with known events such as migration, displacement or urban expansion? ☐ Are there abrupt changes that may indicate data quality issues or methodological shifts?	Using a trend line can help determine if there is a consistent population growth trend that is captured in any of the data sets.
Alignment of underlying population assets	☐ Are estimates based on the same geographic boundaries and administrative structures? ☐ Are differences driven by inconsistencies in boundary definitions, naming conventions, or updates (e.g. newly created districts)? ☐ Are health service delivery point lists consistent across estimates, and do they affect population attribution?	Compile a reference table of geographic units (e.g. districts, subdistricts, facilities) across all datasets and use lookup functions (such as VLOOKUP or XLOOKUP) in Excel to identify mismatches in names, codes or boundary definitions. Pay special attention to recent administrative changes to ensure all estimates align to the same version of geographic boundaries.

Topic area	Checklist questions	 Analytical tips
Coverage, representativeness and completeness	☐ Are all geographic areas and population groups adequately represented? ☐ Are there known gaps in coverage (e.g. private sector, informal settlements, mobile populations)?	Create a coverage matrix listing all expected geographic units and population groups, then map available data against it to identify missing areas or groups. Use simple counts or conditional formatting in Excel to highlight gaps and compare against external reference lists (e.g. census frames or facility registries) to assess completeness.
Methodological transparency and comparability	☐ Are methods clearly documented and comparable across estimates? ☐ Do differences in assumptions (e.g. growth rates, migration adjustments) explain observed discrepancies?	Building on the population estimate documentation table in step 2b, develop a side-by-side comparison table of key methodological elements (e.g. data sources, assumptions, adjustment factors) for each estimate. Use this to systematically identify where differences occur and assess whether variations in results are method-driven rather than data errors. Highlight major assumption differences to focus reconciliation efforts.
Harmonization and comparison across estimates	☐ Can estimates be adjusted to a common basis (e.g. geography or age group) to allow direct comparison? (for example, scale an under-5 estimate to a total population using a standard proportion) ☐ Are appropriate conversion factors (such as age group proportions or coverage ratios) applied to align datasets? ☐ After adjustment, do the estimates show reasonable agreement, or are there large discrepancies? ☐ Can any differences be explained by variation in geographic scope, population definitions, source of scaling factors or demographic structure?	Standardize all relevant population datasets to a common unit of comparison (e.g. same geography, time period and population group) in a working sheet and document any scaling factors applied. Then calculate percentage differences between estimates to quickly identify outliers and use simple charts or conditional formatting in Excel to visualize where discrepancies remain after harmonization.

Other tools and resources

Another tool that could be used for estimate comparison is the [Public Health Data Triangulation for Immunization and Vaccine-preventable Disease Surveillance Programs \(WHO, UNICEF, CDC; 2019\)](#), which provides additional guidance on triangulation of immunization data and could be used as a guide for population estimation triangulation. It also details the use of the [Health Equity Assessment Toolkit \(HEAT\)](#) and [Heat Plus](#) software package. While the HEAT Toolkit is focused on assessing equity in health programmes, the [Heat Plus](#) database allows users to upload their own data and provides simple tools for creating visualizations that would support comparison of population datasets.

Interpreting population differences

Not all differences require corrective action. The PopWG should assess whether observed differences are likely to affect programme decisions.

As a general guide for interpreting differences:

- **<10%, acceptable:** Differences of less than 10% may be considered acceptable in many contexts and simply documented.
- **10%-25%, investigate:** Differences between 10% and 25% should be investigated further.
- **25%-50%, detailed review:** Differences greater than 25% should generally trigger detailed review and reconciliation.
- **>50%, major methodology issues:** Differences greater than 50% often indicate major methodological, data quality or coverage issues requiring further investigation.

These thresholds should be interpreted according to programme context. For example, procurement of commodities may require stricter tolerances than strategic planning or long-term forecasting.

Investigate reasons for divergence

Where estimates differ substantially, the PopWG should determine whether differences are driven by:

- Different reference years
- Different geographic boundaries
- Migration, displacement or population movement
- Inclusion or exclusion of specific population groups
- Different projection assumptions or growth rates
- Survey sampling errors
- Model assumptions
- Data-entry or aggregation errors
- Political or administrative influences on reported population figures

All identified causes of discrepancy should be documented.

Assign confidence levels

Following review, each estimate should be assigned a confidence level, such as:

- **High confidence:** recent, well-documented, validated and representative
- **Moderate confidence:** generally reliable but with known limitations
- **Low confidence:** significant concerns regarding age, completeness, methodology or transparency

Confidence ratings help programmes understand the strengths and weaknesses of available estimates and support consistent decision-making.

Step 2d. Interpret and discuss the compared estimates

Following the comparison and analysis of population estimates, the PopWG should engage in a structured, cross-programme discussion to interpret observed differences and identify their underlying causes. During this discussion, the PopWG should review the key findings from the checklist (above) alongside areas of divergence, possible reasons for divergence and confidence levels for the estimates, while also considering more contextual, often undocumented factors listed in the key areas of discussion below. This step is critical for moving beyond identifying discrepancies to understanding why they exist. By bringing together perspectives from different programmes and sectors, this discussion can help

uncover methodological differences, data limitations and contextual factors influencing estimates. Particular attention should be focused on identifying potential sources of bias and variation that may affect the accuracy, comparability and appropriateness of population estimates for decision-making.

Key areas of discussion

- **Timing of population estimation**
 - When was the estimate generated, and does this timing correspond to periods of known population fluctuation (e.g. seasonal migration, agricultural cycles, school terms or internal displacement)?
 - Could the timing of data collection result in systematically higher or lower estimates relative to other sources?
 - Are different programmes using estimates from different time periods, and how does this affect comparability?
- **Intentional and unintentional bias**
 - Are there incentives that may lead to over- or under-reporting of population figures (e.g. access to resources, commodities or political representation)?
 - Could programmatic or operational pressures influence reporting (e.g. increasing estimates to secure more ITNs or vaccines)?
 - Are there biases introduced through data collection methods, such as question framing, respondent interpretation or inclusion criteria (e.g. who is considered eligible or counted)?
 - Are certain populations systematically under-represented (e.g. mobile, informal or hard-to-reach populations)?
- **Data source reliability and transparency**
 - What is the original source of the estimate, and how reliable is it considered to be?
 - For administrative or routine data sources (e.g. national health information systems), are population figures based on official projections, locally updated estimates or undocumented assumptions?
 - Are methods and assumptions clearly documented and transparent?
 - Are there differences in data quality, completeness or timeliness across sources that may explain variation?

Step 3. Review findings and co-develop methods to improve population estimation across programmes

Following completion of the assessment the PopWG, in collaboration with the programmes involved in the assessment, should synthesize and present the key findings, highlighting both areas of strength and critical gaps in current population estimation practices. This includes identifying where estimates are well-aligned, methodologically sound and consistently used across programmes, as well as where discrepancies, outdated assumptions or data limitations persist.

Based on these findings, the PopWG should apply the population estimation maturity model in **Annex 7** to assess the current state of population estimation systems across the four core principles: data availability, accuracy, accessibility and ability to use data for action. This structured assessment helps to objectively identify priority areas for improvement and provides a shared framework for benchmarking progress.

Using the results of the maturity assessment, the PopWG should work collaboratively, ideally through facilitated group discussions, to identify and prioritize practical actions to strengthen population estimation processes. These actions may include improving coordination across programmes, investing in data systems, strengthening methodological approaches or enhancing data use capacity.

Population estimation maturity model and scoring

The population estimation maturity model provides a structured framework for assessing the strength and functionality of population estimation systems across four core principles: **Availability, Accuracy, Accessibility and Ability to use data for action**. Within each principle, systems are assessed across a progression of maturity levels, ranging from **ad-hoc or fragmented approaches** to **optimized, gold-standard systems**.

At lower levels of maturity, population estimates are often outdated, inconsistent across programmes, and lack methodological rigour, with limited coordination between institutions. As systems mature, responsible ministries collect more recent census data, develop standardized projection methods, improve geographic and facility datasets and increase alignment across programmes. At higher levels, population estimation systems are characterized by regularly updated, highly disaggregated population data; strong integration of multiple data sources (e.g. census, CRVS, geospatial models and programme data); formal coordination mechanisms led by the NSO; and robust quality assurance processes.

The model also emphasizes the importance of **data accessibility and use**, assessing whether population data are available in usable formats, shared consistently across programmes and integrated into decision-making processes such as planning, targeting and resource allocation. At the most advanced level, population estimates are dynamically updated, fully interoperable across systems (e.g. DHIS2, GIS, CRVS), and supported by strong technical capacity at national and sub-national levels. By situating a country within this maturity framework, stakeholders can identify realistic, stepwise improvements and track progress toward a more harmonized, accurate and action-oriented population estimation system.

The maturity model, along with instructions on how to use and score it is provided in **Annex 7**. This scoring system will allow the PopWG to determine the key areas in which population estimations need improvement and can be used as the basis for a costed improvement plan.

Step 4. Develop a detailed, costed improvement plan

Building on the assessment and methods identified for population estimation improvement, the PopWG should be tasked with translating identified priorities into a **detailed, costed implementation plan** focused on improving population estimates and streamlining population data collection across programmes. **Annex 8** provides an example of a costed population estimation improvement plan. This plan should outline specific activities to strengthen methodologies, harmonize data sources, and improve coordination across sectors, while also identifying opportunities to reduce duplication and improve efficiency. Particular attention should be given to aligning population estimation approaches across programmes, improving data quality and leveraging shared systems or data assets to reduce costs. For each activity, the plan should clearly define objectives, responsible institutions, timelines and estimated resource requirements, ensuring that actions are both practical and achievable within the country context.

In developing this plan, the PopWG may benefit from consulting with external experts and technical partners, including those with expertise in geospatial modelling, demographic analysis, data systems and

population estimation methodologies. These partners could be included in the PopWG or consulted during key milestones in the process (e.g. data source collection, validation, triangulation...). These engagements can help ensure that proposed approaches are technically sound, appropriately scoped and reflective of current best practices, while also supporting accurate estimation of required capacities, costs and implementation timelines. Once drafted, the plan should be presented to a broader group of stakeholders, including national programme leadership and partners with key technical expertise (such as modelling population estimation or management and maintenance of population assets) for review and validation. This process ensures alignment, feasibility and shared ownership. A finalized and endorsed plan provides a clear and coordinated roadmap for improving population estimation across programmes, while maximizing efficiencies and supporting more accurate, data-driven decision-making.

Annexes 2 and 9 provide case studies of how national programmes and partners are working together to improve population estimates across health programmes.

Annex 1. Population estimation workshop participants

First Name(s)	Last Name	Organization
Ihsan	Abubakari	NMEP Ghana
Victor	Achieng	WHO Kenya
Cyril	Ademu	NMEP Nigeria
Rock	Aikpon	PNLP Benin
Carol	Akoth	Geospatial Research International
Joseph O.	Alade	NMCP Liberia
Victor	Alegana	WHO Regional Office for Africa
Fatima	Ali	NMEP Nigeria
Zainab	Ali	AMP
David Attio Gbe	Appeti	PNLP Côte d'Ivoire
Steve Kubenga	Banza	WHO Regional Office for Africa
Junaidu Adamu	Barde	Clinton Health Access Initiative
Olena	Borkovska	GRID3
Sarah	Burnett	PATH
Alioune	Camara	PNLP Guinea
Anitah	Cherono	KEMRI-Wellcome Trust Research Programme
Michael	Chipeta	Afidep
Joshua	Comenetz	US Census Bureau
Jonathan	Cox	The Gates Foundation
Marsha	Deda	RBM Partnership to End Malaria
Abdourahaman	Diallo	PNLP Guinea
Patricia	Diggs	Catholic Relief Services
Marcy	Erskine	IFRC/AMP
Tim	Freeman	Rotarians Against Malaria
David	Galick	MCD Global Health
David Attio	Gbe	PNLP Ivory Coast
Christelle	Gogue	PATH
Gracious	Hamuza	NMCP Malawi
Dr. Levi	Hinne	NMCP Liberia
Hannah	Koenker	Tropical Health LLP
Christian Sinzabda	Kompaore	PNLP Burkina Faso
Steve	Kubenga Banza	World Health Organization
Marc	Levy	GRID3
Joseph	Lewinski	CRS
Joris Losimba	Likwela	Sanru Assembly
Peter	Macharia	University of Antwerp
Munashe Emmanuel	Madinga	Clinton Health Access Initiative
Isabella	Maina	Health Data Collaborative

Stephen Karuru	Maina	World Health Organization
Justin	Millar	PATH
Cedric	Mingat	ResultsinHealth
Wahjib	Mohammed	NMEP Ghana
Muhammad	Mukhtar	NMCP Pakistan
Absalom Rannex	Mwamlima	MoH - EPI
Jose Ernesto	Nante	PNLP Guinea-Bissau
Roland	Ngom	WHO Regional Office for Africa
Chris	Nnanatu	World Pop
Patrick	Okello	Global Fund
Robert	Opoku	IFRC/AMP
Frank	Oronsaye	Catholic Relief Services
James	Otieno	WHO Kenya
Jason	Peat	IFRC
Derek	Pollard	Akros
Steve	Poyer	Tropical Health LLP
Natalie	Priestley	CHAI
Molly	Robertson	Global Fund
Jessica	Rockwood	International Public Health Advisors
Emmanuel	Rukengwa	GRID3
Estifanos	Shargie	Global Fund
Eleanore	Sternberg	Tropical Health LLP
Mah	Talat	NMCP Pakistan
Meghan	Tammaro	Abt Assoc
Serigne Amdy	Thiam	PNLP Senegal
Fazizi Bah	Traore	PNLP Togo
Mollie	Van Gordon	Bill and Melinda Gates Foundation
Daniel	Weiss	MAP - Telethon Kids
Anna	Winters	Akros

Annex 2. Improving population estimations: Case study

In one country, the NMP, EPI and the NSO were using different population estimates for the same target groups, resulting in inconsistencies in planning, quantification and resource allocation. In this context, the NMP relied on population data collected through ITN household enumeration, while the immunization programme used separate population estimates for planning and delivery. This resulted in significant discrepancies, with ITN-derived population figures often substantially higher, likely reflecting overestimation during ITN microplanning and/or household registration driven by incentives for households to report larger populations in order to receive more nets. At the same time, the NSO raised concerns about programmes generating their own population estimates outside official processes, while different donors were independently supporting these parallel efforts (e.g. Global Fund for malaria household registration and Gavi for immunization population estimates).

To address these challenges, malaria and immunization programme stakeholders convened to jointly review their population estimates, data collection methods and underlying assumptions. Through this process, the stakeholders agreed to align their approaches and engage the NSO as the central body responsible for population estimation. With coordinated support from partners, including Gavi and the Global Fund, resources were pooled to enable the NSO to lead a unified population data collection effort that would serve both malaria and immunization programmes. In parallel, the national digital health authority was engaged to develop scopes of practice governing population data across the MoH and NSO, helping to clarify roles, responsibilities and standards.

Technical partners were also engaged to strengthen implementation. This included support for the collection and validation of geospatial population data, as well as preparation of the national health information system, DHIS2, to serve as the central repository for harmonized population estimates. In practice, this coordinated approach enabled the country to move towards a single, standardized population dataset with agreed-upon denominators for key target groups at a lower cost than previously implemented approaches. These shared estimates were then used across programmes for planning, quantification and monitoring, while reducing duplication of data collection efforts. By reinforcing NSO leadership, aligning donor support and integrating systems, this approach improved consistency, strengthened national ownership and created a more sustainable and efficient foundation for population estimation across programmes.

Annex 3. Sample population estimates sources table

Department or programme	Purpose	Data source	Collection method	Calculation method	Time period	Geographic coverage	Population subgroups	Quality factors
Malaria, SMC campaign	Planning and commodity allocation	SMC household registration	Door-to-door enumeration conducted by community health workers and local teams	Direct counting of registered individuals at household level	Nov–Dec 2025	Four districts: X, Y, Z, O (subdistrict-level available)	Total population; children <5 disaggregated by sex	Validated by village chiefs; may overcount due to incentives for inclusion; limited to campaign areas
Malaria, ITN campaign	Macroplanning; initial ITN order placement	Census projections	National census	From census report, projected forward using official annual growth rates; divided by 1.8 to estimate ITN needs; often adjusted due to old census information/newer data from previous campaign household registration	Based on last census (e.g. 2015) with annual projections up to 2026	National and sub-national to district-level	Total population	May be outdated; may not reflect recent population changes (migration, urbanization); dependent on census quality; adjustments often based on data that overcounts due to incentives for inclusion
Malaria, ITN campaign	Microplanning; refine ITN quantification and allocation at local level and plan distribution; update macroplanning population figures and support operational planning	Population updates by health facility directors (or district health teams) for catchment areas	District teams support health facility directors to update existing (census, previous campaign) lists of health facilities and villages/population in their catchment areas; listing based on hand drawn or GIS maps	Listing of villages and estimated population from health facility records, DHIS2, other sources	May–Jun 2025	Community up to national level – bottom-up data collection	Population by health facility catchment area	Risk of inflation due to uncertainty about population numbers/fear of underestimation and/or incentives; variable quality particularly for urban areas or areas with population movement; potential for missed communities depending on sources of information and knowledge of people involved at lowest levels
Malaria, ITN campaign	Household registration; determine the number of ITNs needed per household and per catchment area for ITN pre-positioning and distribution	ITN household registration	Door-to-door enumeration conducted by community health workers and campaign teams	Direct count of individuals or sleeping spaces; aggregated and converted into ITN needs using programme ratios	July–Aug 2025	National and sub-national to community level	Total population; household size, sleeping spaces	Risk of inflation due to incentives; variable quality across locations; more locally accurate but less standardized
Malaria, ITN campaign	Adjust or validate estimates using prior campaign experience	Previous ITN campaign data	Compiled from past campaign registration and distribution records	Adjusted based on distribution coverage, leftover stock and population growth assumptions	Oct–Dec 2022	National and sub-national to community level	Total population	Dependent on prior data quality and may propagate past errors; does not account for changes in population distribution
EPI	Estimation of DPT3 ¹ target population for forecasting vaccines and monitoring coverage	Modelled projections (WHO; based on DHS)	Derived from statistical modelling using historical survey data and demographic assumptions	Extrapolation using growth rates and demographic structure from DHS and census inputs	Projected for 2026 (based on older underlying	National (limited sub-national granularity)	Children <1 (DPT3 target), <2, and <5	Estimates disputed; outdated inputs; coverage sometimes exceeds 100%, suggesting denominator issues

¹ The DTP3 vaccine is the third dose of the diphtheria, tetanus, and pertussis combination vaccine. It is used globally as an indicator to measure childhood immunization coverage and health system performance.

		2016 and other inputs)			data, e.g. 2016 DHS)			
Education	Estimation of school-aged population (5–10 years) for planning enrolment, infrastructure and resource allocation	Census data (last available) combined with administrative school records and projections	Original census enumeration; administrative data from school registries; projections applied by Ministry of Education	Age-specific cohort projection using census base and assumed growth rates; adjusted using enrolment patterns	Based on last census (e.g. 2015) with annual projections to 2026	National and district levels (limited availability at subdistrict level)	Children aged 5–10 (sometimes further disaggregated by sex)	Potential inaccuracies due to outdated census; migration and urban growth not fully captured; discrepancies between enrolment and population estimates

Annex 4. Population estimates comparison table

Option 1: Total population, wide structure

Region	District	Census	Health facility catchment	Household enumeration	Geospatial
Region A	District A	112,525	102,867	118,192	129,459
Region A	District B	147,514	147,514	185,301	139,281
Region A	District C	90,132	87,428	232,293	187,392
Region A	District D	64,199	64,199	102,675	167,978
Region A	District E	124,576	124,576	141,670	126,957
Region A	District F	227,719	227,719	303,083	351,581
Region A	District G	169,481	169,481	285,126	285,126
Region B	District A	96,353	48,177	19,208	110,394
Region B	District B	55,874	43,168	59,950	71,942
Region B	District C	57,058	57,058	65,554	93,978
Region B	District D	136,627	136,627	238,778	247,521
Region B	District E	50,407	50,407	118,197	140,203
Region B	District F	66,108	66,108	78,763	78,763
Region B	District G	54,314	54,314	58,180	68,563
Region B	District H	154,886	151,788	212,823	178,825
Region B	District I	27,900	27,900	41,051	62,834
Region B	District J	262,178	262,178	473,003	518,213

Option 2: Population by age group, long structure

Region	District	Data source	Age group	Population value
Region A	District A	Census	0—1 yrs old	5,626
Region A	District A	Census	2—5 yrs old	16,879
Region A	District A	Census	5+	90,020
Region A	District A	Health facility catchment	0—1 yrs old	5,143
Region A	District A	Health facility catchment	2—5 yrs old	15,430
Region A	District A	Health facility catchment	5+	82,294
Region A	District A	Household enumeration	0—1 yrs old	5,910
Region A	District A	Household enumeration	2—5 yrs old	17,729
Region A	District A	Household enumeration	5+	94,554
Region A	District A	Geospatial	0—1 yrs old	6,473
Region A	District A	Geospatial	2—5 yrs old	19,419
Region A	District A	Geospatial	5+	103,567

Annex 5. Managing political and operational pressures

Population estimates can be influenced by political, administrative or programmatic incentives, including resource allocation formulas, commodity procurement requirements, representation or funding decisions. The PopWG should therefore operate according to explicit principles of transparency, technical independence and evidence-based decision-making.

When substantial concerns arise regarding the validity of official estimates, census projections or locally generated figures, the PopWG should:

- Document the evidence supporting the concern
- Conduct or commission an independent technical review
- Compare estimates against alternative data sources and historical trends
- Quantify uncertainty where feasible
- Elevate unresolved technical concerns to senior leadership within the NSO and MoH for review

The PopWG should serve as a forum for technical discussion rather than political negotiation, ensuring that methodological concerns are identified and addressed before population estimates are adopted for planning or reporting.

Considerations for fragile and data-scarce settings

In some countries, census data may be outdated, incomplete or unavailable, and the NSO may have limited capacity to lead population estimation activities. In these contexts, alternative governance arrangements may be required.

Where necessary, leadership may be shared between the MoH, NSO and other designated national institutions, with support from technical partners. Greater reliance may also be placed on triangulation of multiple data sources, including household registration exercises, CRVS systems, humanitarian population tracking systems, geospatial models and programme-generated datasets.

Regardless of the specific governance arrangement, the PopWG should remain country-led, inclusive and accountable, with a clear mandate to strengthen population estimation processes and promote consistent use of population data across programmes and sectors.

Annex 6. Population estimate quality assessment scoring

The PopWG may apply different weights to assessment criteria depending on the intended use of the population estimate. For example, commodity procurement may place greater emphasis on completeness and validation, while campaign microplanning may place greater emphasis on geographic detail and timeliness. Applying weighted scores allows estimates to be assessed in relation to their intended purpose while maintaining a transparent and consistent evaluation process. All weights and scoring decisions should be documented and agreed upon by the PopWG prior to conducting the assessment.

Step 1. Creating scoring criteria

Example

For each population estimate, assign a score from **1 (poor)** to **5 (excellent)** across the criteria below.

Assessment criteria	1	3	5
Timeliness	>10 years old	5-10 years old	<2 years old or routinely updated
Geographic detail	National only	District level	Health facility catchment or community level
Population disaggregation	Total population only	Basic age/sex groups	Full disaggregation including vulnerable populations
Methodological transparency	Methods undocumented	Partial documentation	Fully documented methods and assumptions
Data quality and validation	No validation	Some validation checks	Independent validation and triangulation
Coverage and completeness	Significant missing areas/groups	Moderate gaps	Comprehensive coverage
Representation of vulnerable populations	Not captured	Partially captured	Systematically incorporated
Alignment with official boundaries	Major inconsistencies	Some inconsistencies	Fully aligned with official boundaries
Ability to quantify uncertainty	No uncertainty assessment	Qualitative limitations noted	Quantitative uncertainty estimates available
Programmatic fitness for purpose	Poorly suited to intended use	Moderately suitable	Highly appropriate for intended use

Total score

Maximum score = 50

Score	Confidence rating	Interpretation
40-50	High confidence	Suitable for most planning and reporting purposes
30-39	Moderate confidence	Usable but limitations should be documented
20-29	Low confidence	Use cautiously and validate against other sources
<20	Very low confidence	Not recommended as primary denominator

Step 2. Score population estimates based on established criteria

Example: Simple scoring

Assessment criteria	Census projection	ITN registration	WorldPop
Timeliness	2	5	5
Geographic detail	3	5	5
Disaggregation	3	2	3
Transparency	5	3	4
Validation	4	2	4
Completeness	5	4	4
Vulnerable populations	2	2	2
Boundary alignment	5	4	3
Uncertainty assessment	2	1	5
Fitness for purpose	4	5	4
Total	35	33	39

Interpretation:

- **WorldPop** = Highest overall score (39)
- **Census projection** = Similar confidence (35)
- **ITN registration** = Useful locally but weaker methodological confidence (33)

The PopWG could then conclude:

"WorldPop and census projections represent the preferred national denominator sources. ITN registration data should be used as a supplementary source for local validation, microplanning and identification of recent population changes."

Example: Weighting by use case (optional)

Different programmes may value different characteristics.

Domain	Procurement	Coverage monitoring	Microplanning
Timeliness	20%	10%	25%
Geographic detail	15%	15%	25%
Validation	25%	25%	15%
Vulnerable populations	10%	15%	10%
Completeness	30%	35%	25%

This allows the same estimate to rank differently depending on whether you are:

- Forecasting commodities
- Estimating coverage
- Conducting campaign microplanning

Step 3. Calculate a weighted score (optional)

Formula:

Weighted score = (Score × weight) for each criterion, summed across all criteria

Example:

Criterion	Score	Weight	Weighted score
Timeliness	5	20%	1.00
Geographic detail	4	10%	0.40
Validation	3	25%	0.75
Completeness	5	30%	1.50
Vulnerable populations	2	15%	0.30

Total			3.95 / 5.0
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Convert to a percentage: $3.95 \div 5 \times 100 = 79\%$

Example: Interpreting weighted results

Weighted score	Confidence
85-100%	High confidence
70-84%	Moderate confidence
50-69%	Low confidence
<50%	Very low confidence

Annex 7. Population estimation maturity model and scoring methodology

How to use the population estimation maturity model

The maturity model should be scored through a facilitated, evidence-based self-assessment by the PopWG. Each category is rated from 1 to 5 using the descriptors in the model. The scoring process is designed to identify the current level of institutional capability and priority improvements; it is not a ranking of countries or institutions.

Score	Maturity level	Scoring rule
1	Ad-hoc/Fragmented	Practices are absent, informal, inconsistent or dependent on individuals.
2	Basic/Emerging	Some practices exist, but coverage, standardization or implementation is limited.
3	Functional/Intermediate	Defined practices are implemented routinely in major institutions or programmes.
4	Strong/Advanced	Practices are institutionalized, coordinated, quality-assured and broadly implemented.
5	Optimized/Gold standard	Practices are integrated, interoperable, continuously improved and demonstrably used.

Evidence and scoring rules

- **Score the current state.** Rate what is implemented at the time of assessment, not what is planned or funded.
- **Require evidence.** Record at least one verifiable source for each score, such as an endorsed policy, dataset, metadata record, system demonstration, meeting record, published output or documented example of use.
- **Use the lower score when evidence is mixed.** Award a level only when all essential elements of its descriptor are met; otherwise assign the next lower level and document the gap.
- **Allow intermediate scores sparingly.** A score of 2 or 4 represents the corresponding descriptor, not an average between adjacent descriptors. If useful for analysis, half-points may be used only when the evidence clearly falls between two levels.
- **Record disagreement.** Where assessors cannot reach consensus, document both views, seek additional evidence and use the lower score provisionally.
- **Mark genuinely non-applicable categories as N/A.** Exclude N/A categories from the denominator and explain why they are not applicable. Missing evidence is not N/A and should normally result in a score of 1.

Calculating results

1. **Category score:** assign one score from 1 to 5 for every applicable row in each principle.
2. **Principle score:** calculate the arithmetic mean of all applicable category scores within the principle and report it to one decimal place.
3. **Overall score:** calculate the mean of the four principal scores so that **Availability, Accuracy, Accessibility** and **Ability to take action** each contribute 25% of the overall result.

4. **Coverage check:** report the number and percentage of applicable categories that were scored and supported by evidence. Do not report an overall maturity level when fewer than 80% of applicable categories have been assessed.

Mean score	Reported maturity level
1.00–1.49	Ad-hoc/Fragmented
1.50–2.49	Basic/Emerging
2.50–3.49	Functional/Intermediate
3.50–4.49	Strong/Advanced
4.50–5.00	Optimized/Gold standard

Interpretation safeguards. Report both the overall score and the four principal scores, because an overall average can conceal a critical weakness. A system should not be classified above *Functional/Intermediate* if any principle scores below 2.50. A system should not be classified as *Optimized/Gold standard* unless every principle scores at least 4.00. Assessments should be repeated annually or after a major census, system reform, boundary change or population shock, using the same criteria and retaining the evidence record to show progress over time. **Annex 8** provides an example of how to use the scoring to develop a costed population estimation improvement plan.

Population estimation maturity model

Principle 1. Availability

Category	Ad hoc/Fragmented	Basic/Emerging	Functional/ Intermediate	Strong/Advanced	Optimized/Gold standard	SCORE
Population sources and recency	Only old census or outdated headcounts used; health programmes each use their own numbers.	Census available but >10 years old; some programmes conduct microplanning or registration headcounts.	Census within last 10 years; annual national population projections exist but may not be sub-national or disaggregated.	Census within last 10 years; annual sub-national projections (admin. levels 1/2).	Census within last 10 years; annual sub-national projections down to admin level 3/health facility catchment and urban/peri-urban/rural disaggregation.	
Required disaggregation (births, surviving infants, single-age, 5-year, pregnant women)	No demographic disaggregation; total population only.	Census includes 5-year age groups only; no births or surviving infants.	Census includes births and 5-year age groups; surviving infants estimated separately by programmes.	Census includes births, surviving infants, pregnant women, and single-age (0–4) groups annually.	Census includes full demographic disaggregation (single-age, women of reproductive age, births, surviving infants, pregnant/lactating women) officially produced and quality-assured.	
Special population enumeration and vulnerable groups (refugees, IDPs, nomads)	Not available; programmes rely on informal numbers or rough guesses.	Some data exist but incomplete; no harmonization with UNHCR/IOM.	Partial integration; refugees counted from UNHCR; IDPs from IOM; nomadic populations included in some estimates, key populations counted are available from capture-recapture or other standardized methods.	NSO incorporates UNHCR/IOM data and key populations data into sub-national population projections annually.	Fully integrated special-population module: dedicated enumeration strategies + regular updates + geospatial modelling for nomadic groups and other key populations.	

Category	Ad hoc/Fragmented	Basic/Emerging	Functional/ Intermediate	Strong/Advanced	Optimized/Gold standard	SCORE
Geographic boundary data	Boundaries exist only in PDFs or static maps; outdated.	Digital boundaries exist but inconsistent across sectors.	NSO provides standard boundary files (i.e. Shapefile, GeoJSON, GPKG) for admin levels 1–2.	Official boundaries regularly updated; include admin level 3/health facility catchments; shared in open formats (i.e. Shapefile, GeoJSON, GPKG).	National spatial data infrastructure exists; boundaries linked with unique identification (IDs), versioned, interoperable across all ministries.	
Health service delivery points (lists and geolocations)	No national list; programmes maintain their own.	Partial list exists but outdated.	National master facility list exists; semi-annual updates.	Facility list standardized, geocoded, linked to administrative boundaries.	Fully geospatial master facility list integrated with DHIS2, national spatial data infrastructure and census boundaries.	

Principle 2. Accuracy

Category	Ad hoc/ Fragmented	Basic/Emerging	Functional/ Intermediate	Strong/Advanced	Optimized/Gold standard	SCORE
Quality of population estimates	No quality checks; internal inconsistencies common.	Some internal checks but no documentation.	Quality standards exist; NSO reviews internal consistency.	Standard methodology (cohort-component) + validation + triangulation across surveys/CRVS.	Fully documented quality assurance with transparent metadata, uncertainty estimates and external expert review.	
Updates triggered by events (boundary changes, displacement, demographic shocks)	No updates between censuses.	Occasional updates but not systematic.	Annual projections produced; limited responsiveness to shocks.	Updates triggered by boundary changes, displacement or demographic shocks.	Proactive, dynamic updates incorporating administrative data, CRVS, geospatial models and humanitarian data.	
Methods used	Manual extrapolation; simple growth rates; Excel-only.	Cohort-component model used irregularly.	Standardized annual projections using robust demographic modelling.	Integration of GIS, WorldPop/GRID3, satellite imagery and statistical modelling.	CRVS-integrated dynamic population estimation + geospatial modelling + machine learning for special populations.	
Methodological leadership and coordination	No NSO–MoH coordination; each programme makes its own estimates.	Informal coordination; no formal roles.	NSO responsible for projections; ministries receive annual figures.	Formalized coordination framework + joint technical working group.	Fully institutionalized governance body producing harmonized population denominators across all sectors.	
National action plan for population estimation	None.	Draft exists but not implemented.	Plan exists; partial implementation.	Operational plan with clear roles, timelines and methods.	Fully implemented, updated plan with monitoring, validation and annual reporting.	
Triangulation across programmes	No triangulation; programmes contradict one another.	Occasional comparisons; no corrections made.	NSO compares and harmonizes with health programme estimates.	Routine triangulation across all health programmes + historical trends.	Fully integrated cross-sector reconciliation process that is documented; discrepancies surfaced and corrected.	

Principle 3. Accessibility

Category	Ad hoc/Fragmented	Basic/Emerging	Functional/ Intermediate	Strong/Advanced	Optimized/Gold standard	SCORE
Storage	Data stored inconsistently across ministries; no official source.	Population estimates stored centrally but not widely used; multiple sources still exist and are used.	NSO maintains a public repository; most programmes use it.	Single official national population portal (digital).	Fully integrated national data platform (API-enabled, machine-readable).	
Accessibility and formats	Data only available in PDFs or reports; long delays for receiving requests.	Data only available in PDFs or reports provided to health programmes; available within a few weeks on request.	Machine-readable Excel/CSV format is available	Machine-readable Excel/CSV format provided to health programmes on request and made public according to national data sharing policies.	Open data platform with versioned releases in a machine-readable format.	
Disaggregation accessible to programmes	Only national totals.	Admin level 1 + some age groups.	Admin level 2 with births/surviving infants.	Admin level 3, single-age, special populations available.	Facility catchment-level, fully disaggregated (age, sex, special groups).	
Shared across programmes	Programmes use different denominators.	Some coordination but inconsistencies remain.	Most programmes use NSO-produced denominators.	Full alignment across EPI, malaria, NTDs, nutrition, and supplementary immunization activities (SIAs).	100% unified denominators across all ministries and development partners.	
Feedback loop back to NSO	Field updates never flow back to NSO.	Some ad hoc sharing.	NSO receives routine updates from MoH/partners.	Formal mechanism to adjust projections based on programme headcounts/microplanning/registration.	Continuous two-way integration: NSO updates and programme adjustments both feed into official projections.	

Principle 4. Ability to use data for action

Category	Ad hoc/Fragmented	Basic/Emerging	Functional/ Intermediate	Strong/Advanced	Optimized/Gold standard	SCORE
Use cases defined	None: programmes unclear how population data are used.	Partial: some use cases but inconsistently applied.	Clear programmatic use cases (EPI, SMC, ITN, SIAs).	Fully documented use cases across all health programmes.	Used for planning, microplanning, monitoring, forecasting and geospatial targeting.	
Documentation and bias tracking	No documentation.	Minimal: basic source references.	Population source and date documented.	Biases and limitations explicitly noted.	Full metadata and methodological transparency with uncertainty bounds.	
Capacity to use population data	None: staff lack basic numeric or mapping skills.	Basic Excel: some staff have Excel-level skills.	District-level staff capable; district teams can use basic GIS/Excel for planning.	GIS capacity at national + subnational; strong capacity for mapping, facility microplanning and interpreting projections.	Fully geospatially literate system (QGIS/ArcGIS, modelling, mapping); fully geospatially literate health workforce able to integrate population modelling, maps and microplanning tools.	
Population data integration within Health Information Systems	No population data formally incorporated into health information systems.	Population estimates shared informally with HIS or on an ad hoc basis, with limited documentation or standardization.	Routine incorporation of population data into at least one system (e.g. DHIS2), though updates and integration are manual.	Population data systematically integrated into multiple systems (e.g. DHIS2, logistics management information system [LMIS]), with defined processes for updating and version control.	Automated, interoperable integration of population data across systems (e.g. DHIS2, LMIS, CRVS), with synchronized updates and minimal manual intervention.	

Annex 8. Example costed population estimation improvement plan

This fictional example illustrates how a PopWG could translate maturity scores into a prioritized, costed plan. The example follows the logic of the [World Bank Statistical Performance Indicators framework](#), which links statistical-system improvement to data use, services, products, sources and infrastructure. It also draws from the immunization guidance on population by WHO; the [WHO target population estimates manual](#), which distinguishes immediate improvements from longer-term system strengthening, and the [WHO national strategy guidance](#), which recommends translating prioritized strategies into resource requirements.

Worked example: Two-year costed population estimation improvement plan for a lower-middle-income country

Brief situational assessment: The country has approximately 25 million people, 12 regions and 120 districts. Its latest census is 11 years old; programmes use different denominators; digital boundaries and facility lists are incomplete; and population data are manually loaded into health information systems. Costs are illustrative 2026 US dollars and exclude a full population and housing census.

Population estimation maturity model results and target setting

Principle	Baseline score	Two-year target	Priority gap
Availability	2.0	3.2	Outdated projections; incomplete boundary and facility data; limited inclusion of mobile and displaced populations.
Accuracy	1.8	3.0	No documented quality assurance or routine cross-programme triangulation process.
Accessibility	1.6	3.0	Multiple spreadsheets and reports; no versioned national repository or standard release process.
Ability to take action	2.0	3.2	Weak district analytical capacity and manual incorporation of denominators into health systems.
Overall	1.9	3.1	Move from Basic/Emerging to Functional/Intermediate

Priority activity table and related costs

Priority activity linked to maturity gap	Lead and supporting institutions	Timing	Output/milestone	Activity budget assumptions	Year 1 (USD)	Year 2 (USD)	Total (USD)
1. Formalize the PopWG, endorse terms of reference and complete a detailed baseline assessment and data inventory.	NSO and MoH; planning units and health programmes	Months 1–3	Endorsed governance structure, evidence register, baseline scores and prioritized work plan.	Quarterly (Year 1) and annual (Year 2) PopWG meeting held; 30 participants in capital	35,000	10,000	45,000
2. Reconcile census projections, programme headcounts and humanitarian estimates; produce interim annual district projections with documented assumptions and uncertainty.	NSO; MoH, CRVS, humanitarian agencies and technical partners	Months 2–12, then annual update	One agreed, quality assured national and district denominator series, disaggregated for key health target groups.	Three national data reconciliation workshops	120,000	70,000	190,000
3. Standardize and update administrative boundaries, geographic codes and the master facility list; geolocate missing facilities in priority districts.	National mapping agency and NSO; MoH GIS/HIS teams	Months 3–15	Administrative level 1–3 boundary files, unique codes and at least 95% of service delivery points geolocated.	GIS mapping exercise; short-term GIS expert engaged	150,000	65,000	215,000

Priority activity linked to maturity gap	Lead and supporting institutions	Timing	Output/milestone	Activity budget assumptions	Year 1 (USD)	Year 2 (USD)	Total (USD)
4. Establish documented quality assurance and triangulation procedures, including outlier checks, aggregation checks, annual comparison across programmes and an event-trigger protocol.	NSO; PopWG technical subgroup	Months 4–18	Approved methods manual, reproducible validation files and two completed triangulation cycles.	Two triangulation exercises	55,000	45,000	100,000
5. Develop a secure, versioned population data repository and publish approved machine-readable releases with metadata.	NSO ICT unit; MoH digital health team	Months 6–20	Operational repository with access controls, release calendar, archived versions and downloadable district datasets.	Server support; website updated; engage Digital Health Authority (DHA) staff	135,000	60,000	195,000
6. Integrate approved denominators into DHIS2 and priority logistics and campaign-planning systems, with documented update and rollback procedures.	MoH HIS; NSO and programme teams	Months 9–21	One controlled annual update process used by malaria, immunization, maternal and child health and nutrition programmes.	Engage HIS staff and partners to update data; no related costs	0	0	0

Priority activity linked to maturity gap	Lead and supporting institutions	Timing	Output/milestone	Activity budget assumptions	Year 1 (USD)	Year 2 (USD)	Total (USD)
7. Train national and district teams in denominator selection, spreadsheet checks, GIS, metadata, uncertainty and use for forecasting and microplanning; provide follow-up mentoring.	MoH and NSO training units; universities and partners	Months 6–24	40 national and 240 district staff trained; at least 80% demonstrate competency and produce a supervised planning output.	Five national and eight district training workshops, including travel and per diem	105,000	85,000	190,000
8. Conduct targeted verification in 20 high-discrepancy or rapidly changing districts, including urban growth, displacement and mobile populations.	NSO and district authorities; health programmes and humanitarian partners	Months 8–18	Verified adjustment factors and documented decisions for all 20 priority districts.	Travel to 20 districts, workshop to review and validate results	165,000	35,000	200,000
9. Monitor implementation, repeat the maturity assessment and complete an independent technical review.	PopWG secretariat; independent reviewer	Quarterly; months 12 and 24	Quarterly dashboard, annual expenditure report and endline maturity assessment.	Quarterly and annual PopWG meeting held	35,000	55,000	90,000
Direct activity costs					800,000	425,000	1,225,000
Programme management and audit (8%)					64,000	34,000	98,000
Equipment and supplies (7%)					56,000	29,750	85,750
Total financing requirement					920,000	448,750	1,408,750

Illustrative financing plan. Government funds 40% (USD 625,600), pooled health sector grants fund 35% (USD 547,400), and technical partners fund 25% (USD 391,000). Government financing prioritizes staff time, hosting, routine updates and recurrent system maintenance; external financing is concentrated on initial technical assistance, software configuration, field verification and training.

Costing assumptions and boundaries. Estimates use an ingredients approach: quantity multiplied by the applicable unit cost for personnel, workshops, travel, fieldwork, equipment, hosting and technical assistance. The plan assumes use of existing government offices and open-source tools where feasible. It excludes the cost of a full census, nationwide household enumeration, major civil registration reform and routine salaries already financed by government. Recurrent hosting, maintenance, data-release and refresher-training costs should be incorporated into annual NSO and MoH budgets from Year 2 onward.

Annex 9. Improving public health population estimates: Mini case studies

This section includes a set of mini case studies of how governments and organizations are assessing and improving population estimates.

Automating identification of low/high vaccination coverage rates

UNICEF has developed methodology to flag potential EPI denominator (population) and numerator (vaccination coverage) issues, including very low coverage and coverage above 100%. This methodology is being incorporated into national DHIS2 instances to support investigation and rectification of flagged denominator issues.

See: [WHO/UNICEF estimates of national immunization coverage](#)

Adjusting denominators and bounding vaccination coverage

In Ethiopia, large swings in reported vaccination coverage, including implausible values near or above 100%, were driven by inaccurate population denominators and inconsistent reporting. To address this, researchers combined DHIS2 data with census and WorldPop population estimates, applied data-quality checks, calibrated results using survey data and constrained coverage to a 0–100% range to produce more reliable district-level estimates for targeted planning.

See: [Estimating immunization coverage at the district level: A case study of measles and diphtheria-pertussis-tetanus-Hib-HepB vaccines in Ethiopia](#)

Improving malaria coverage estimates through digital microplanning

In Zambia, malaria IRS coverage was often overestimated due to incomplete counts of eligible households and weak population denominators. A geo-enabled digital tool used satellite imagery to enumerate all structures and track spraying in real time, enabling calculation of true coverage and correction of inflated estimates, revealing overestimation of about 31 percentage points on average.

See: [A geo-enabled digital tool for microplanning and delivery of indoor residual spray in Zambia: A case study, 2016–2020](#)