1 Module 4: Coverage Estimates

1.1 Background

Coverage estimates provide a way to assess the performance of health service delivery by comparing reported service volumes to the expected target population.

1.2 Overview

This module estimates health service coverage by integrating adjusted health service volume data, population projections, and survey data (MICS/DHS). Coverage estimates are calculated for key health indicators using multiple denominator sources, and the optimal denominator is selected by minimizing the error relative to survey data. The final estimates are used to analyze trends in service coverage at national and sub-national levels.

1.2.1 Overview of the additional data used in the module

Population projections

Sourced from the United Nations World Population Prospects (WPP), these estimates provide age-specific and total population figures used to calculate denominators for coverage estimates. These projections account for demographic trends, including fertility, mortality, and migration.

Survey data - MICS

The Multiple Indicator Cluster Surveys (MICS), conducted by UNICEF, provide household survey-based estimates for key health indicators, including coverage of maternal and child health services.

Survey data - DHS

The Demographic and Health Surveys (DHS), conducted by USAID, provide survey data on health service utilization, including immunization rates and maternal care coverage.

1.2.1.1 Detailed analysis steps Step 1: Load and map adjusted service volumes

Health service volume data is loaded (output from Module 2). The selected count variable (e.g., count adjusted for both outlier and completeness) is mapped to coverage indicators. The data is aggregated at the annual level for each administrative area.

Step 2: Merge and extend survey data

The survey data from MICS, DHS, and UNWPP is loaded and filtered to match available HMIS data. The missing years in survey data are forward-filled to ensure continuous time series. The survey estimates are merged, prioritizing DHS over MICS when both exist.

Step 3: Calculate denominators

For each indicator, denominators are estimated based on service volumes and reported survey coverage. The general formula is:

$$\text{Denominator} = \frac{\text{Service volume}}{\text{Survey-based coverage}/100}$$

Denominators are derived from two sources:

1. HMIS-based denominators – computed from health facility service volumes.
2. UNWPP-based denominators – derived from population projections.

Each denominator is adjusted using pregnancy loss rates, stillbirth rates, twin birth rates, and mortality rates.

Default Adjustment Rates

The following default rates are applied when adjusting denominators:

- **Pregnancy loss rate** = 3%
- **Twin rate** = 1.5%
- **Stillbirth rate** = 2%
- **Neonatal mortality rate** = 3%
- **Infant mortality rate** = 5%

These rates account for losses at different stages (pregnancy, birth, early infancy) and are used to refine denominator estimates.

1.2.1.2 HMIS-based denominator calculations ANC1 denominator

$$d_{\text{anc1, pregnancy}} = \frac{\text{count}_{\text{anc1}}}{\text{coverage}_{\text{anc1}}/100}$$

$$d_{\text{anc1, livebirth}} = d_{\text{anc1, pregnancy}} \times (1 - \text{pregnancy loss rate}) \times (1 - \frac{\text{twin rate}}{2}) \times (1 - \text{stillbirth rate})$$

$$d_{\text{anc1, dpt}} = d_{\text{anc1, pregnancy}} \times (1 - \text{pregnancy loss rate}) \times (1 - \frac{\text{twin rate}}{2}) \times (1 - \text{stillbirth rate}) \times (1 - \text{neonatal mortality rate})$$

$$d_{\text{anc1, mcv}} = d_{\text{anc1, pregnancy}} \times (1 - \text{pregnancy loss rate}) \times (1 - \frac{\text{twin rate}}{2}) \times (1 - \text{stillbirth rate}) \times (1 - \text{infant mortality rate})$$

Delivery denominator (live births)

$$d_{\text{delivery, pregnancy}} = \frac{\text{count}_{\text{delivery}}}{\text{coverage}_{\text{delivery}}/100} \times (1 - \text{pregnancy loss rate})$$

$$d_{\text{delivery, dpt}} = d_{\text{delivery, pregnancy}} \times (1 + \text{twin rate}) \times (1 - \text{stillbirth rate}) \times (1 - \text{neonatal mortality rate})$$

$$d_{\text{delivery, mcv}} = d_{\text{delivery, pregnancy}} \times (1 + \text{twin rate}) \times (1 - \text{stillbirth rate}) \times (1 - \text{infant mortality rate})$$

BCG denominator

$$d_{\text{bcg, pregnancy}} = \frac{\text{count}_{\text{bcg}}}{\text{coverage}_{\text{bcg}}/100} \times (1 - \text{pregnancy loss rate}) \times (1 + \text{twin rate}) \times (1 - \text{stillbirth rate})$$

$$d_{\text{bcg, dpt}} = d_{\text{bcg, pregnancy}} \times (1 - \text{neonatal mortality rate})$$

$$d_{\text{bcg, mcv}} = d_{\text{bcg, pregnancy}} \times (1 - \text{neonatal mortality rate}) \times (1 - \text{post-neonatal mortality rate})$$

Penta1 denominator

$$d_{\text{penta1, pregnancy}} = \frac{\text{count}_{\text{penta1}}}{\text{coverage}_{\text{penta1}}/100} \times (1 - \text{pregnancy loss rate}) \times (1 + \text{twin rate}) \times (1 - \text{stillbirth rate}) \times (1 - \text{neonatal mortality}$$

$$d_{\text{penta1, livebirth}} = d_{\text{penta1, pregnancy}} \times (1 - \text{stillbirth rate}) \times (1 - \text{neonatal mortality rate})$$

$$d_{\text{penta1, mcv}} = d_{\text{penta1, pregnancy}} \times (1 - \text{post-neonatal mortality rate})$$

1.2.1.3 UNWPP-based denominator calculations Some denominators can also be derived from World Population Prospects (WPP) projections instead of service volumes.

Estimated pregnancies based on crude birth rate (CBR) and total population

$$d_{\text{wpp, pregnancy}} = \left(\frac{\text{CBR}}{1000}\right) \times \text{Total population} \times \frac{12}{\text{months reported}}$$

Estimated live births

$$d_{\text{wpp, livebirth}} = \text{Total live births from WPP} \times \frac{12}{\text{months reported}}$$

Estimated population eligible for DPT1 (under 1 year)

$$d_{\text{wpp, dpt}} = \text{Total under-1 population from WPP} \times \frac{12}{\text{months reported}}$$

Estimated population eligible for MCV (under 5 years)

$$d_{\text{wpp, mcv}} = \text{Total under-5 population from WPP} \times \frac{12}{\text{months reported}}$$

HMIS data can contains incomplete or partial reporting, where service volumes are only available for a subset of months in a given year. If fewer than 12 months of data are reported, directly using the raw count would underestimate the total number of pregnancies. To adjust for this, we scale the reported number up to a full year equivalent by applying the factor $\frac{12}{\text{months reported}}$.

Step 4: Select the best denominator

Both HMIS-based and UNWPP-based denominators are computed, but only one denominator is used per indicator-year based on squared error minimization.

The survey-derived coverage estimates (`avgsurvey_*`) are used as reference values for comparison. These values are extracted for each year and admin area.

For each denominator option (HMIS-derived and WPP-derived), a squared error is calculated:

$$\text{Squared error} = (\text{HMIS-derived coverage} - \text{Survey coverage})^2$$

where:

$$\text{HMIS-derived coverage} = \frac{\text{HMIS service volume}}{\text{denominator}} \times 100$$

For each year, indicator, and admin area, the denominator with the smallest squared error is selected:

$$\text{Best denominator} = \arg\min_{\text{denominator}} (\text{squared error})$$

Step 5: Compute coverage estimates

Once the best denominator is selected, final coverage is calculated as:

$$\text{Coverage} = \frac{\text{service volume}}{\text{selected denominator}} \times 100$$

Step 6: Extrapolate missing estimates

For years where survey estimates are unavailable, coverage is projected using the year-over-year coverage change (Δ coverage) derived from HMIS data. The assumption is that the trend in coverage observed in HMIS data can be used to estimate missing survey values.

This is done by applying the coverage delta, which represents the annual change in coverage, to the most recent available survey estimate.

$$\text{Projected coverage}_t = \text{Survey coverage}_{t-1} + \Delta\text{coverage}_{\text{HMIS},t}$$

where: - Survey coverage$_{t-1}$ = last available survey-based coverage estimate - Δcoverage HMIS$_t$ = annual change in coverage derived from HMIS data - Projected coverage$_t$ = estimated coverage for the missing year

Step 7: Combine results and finalize output

The coverage estimates from HMIS-derived calculations, survey estimates, and projections are merged.

The final results are exported in a structured format for visualization and reporting.

Last edit 2025 September 3