Annex: Programme Performance

National Level

3

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

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

TRIANGULATION FOR IMPROVED DECISION-MAKING IN IMMUNIZATION PROGRAMMES
Working document: July 2020

Background

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

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

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

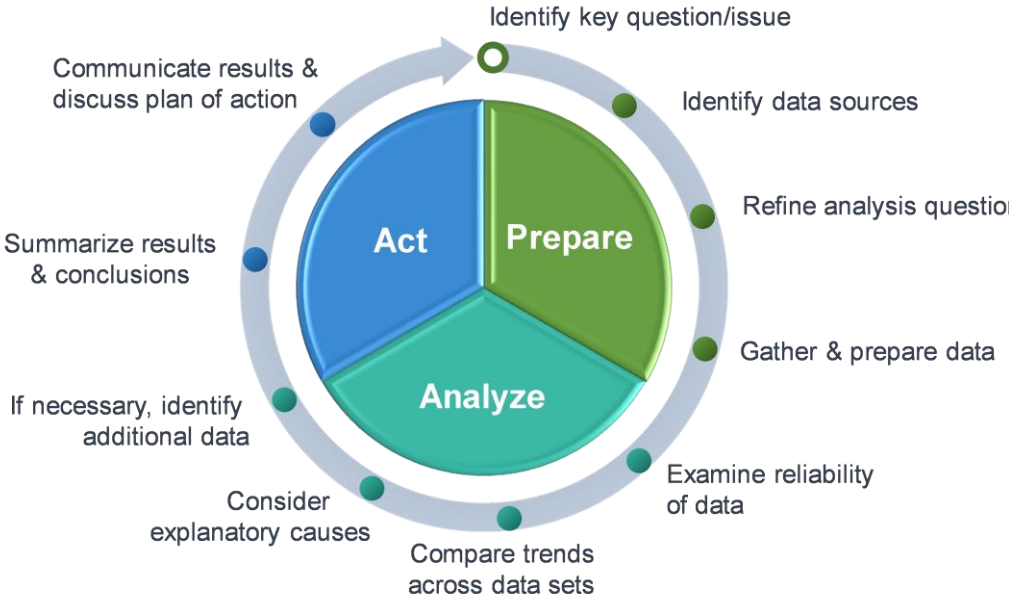


Fig. The 10-step EPI data triangulation process, starting with a key question and ending with a plan of action. The process can be repeated in an iterative fashion.

Introduction

Routine data monitoring is needed for planning and continuous quality improvement of immunization programmes. Issues with the quality of administrative data can obscure gaps in immunization coverage and challenge the identification of missed children. In October 2019, the Strategic Advisory Group of Experts (SAGE) recommended to embed monitoring of data quality and use into monitoring of immunization and VPD surveillance.[1] For this reason, data quality monitoring is being included here as an essential part of programme monitoring. We should also note that assessment of data quality is built into the 10-step triangulation process for all analyses (*step 5*).

Countries with improved programme performance have been noted to have improved data quality — likely related to continued data use for quality improvement (both of data and program). A recent review observed there was some evidence that improving data use results in improved data quality, but not necessarily the other way around.[2] Increased use of the data can generate demand for higher-quality data,

[1] World Health Organization. Meeting of the Strategic Advisory Group of Experts on Immunization, October 2019: Conclusions and Recommendations. Wkly Epidemiol Rec 94 (2019).

[2] Immunization Data: Evidence for Action (IDEA). A Realist Review of What Works to Improve Data Use for Immunization, Evidence from Low- and Middle-Income Countries. Seattle: PATH; Washington, DC: PAHO; 2019. https://www.technet-21.org/en/topics/idea

which in turn drives actions to improve data quality; as data quality improve, users trust the data more, thus reinforcing data use.[2]

Because each data source has limitations, triangulation of administrative data (numerator, denominator, coverage) with coverage survey, stock, surveillance, and other programme data can provide insights into immunization programme performance, as well as data quality. Potential targeted follow-up actions include supportive supervision or more in-depth field assessments including root-cause analysis in areas identified to have performance issues. Other possible actions are developing or revising programme guidance and processes, such as monitoring processes, data validation checks, or supportive supervision checklists for more effective data use, based on the findings of the analysis. Implementation of targeted coverage and data quality improvement activities may also be relevant.

Country Example: What is the Problem?

Country X reports high national coverage (98% and over 100% in some areas) across multiple antigens. However, measles outbreaks continue to occur and frequent stockouts of some vaccines have been noted at the subnational level. Data quality issues, such as discrepancies in the number of antigen doses reported to be given at the same vaccination opportunity, and negative drop-out or vaccine wastage rates have also been noted. The country is proud of its high coverage, but is struggling with how to monitor and prioritize areas for improving the performance of the immunization programme.

How can data triangulation help address performance monitoring challenges?

The triangulation process (see Background box above) can be used for performance monitoring with a wide range of immunization programme data sources (e.g., administrative coverage, coverage survey, stock, surveillance) as well as data from other programmes to reach a deeper understanding of:

- Reasons underlying subnational variation in vaccination coverage and performance
- Data sources and indicators that are useful to monitor, but not in current routine use
- Data quality issues and underlying limitations of the data
- The need to change processes for routine analysis and data monitoring

Note: Assessment of programme targets (denominators) is covered in-depth in **Annex 4**. In depth guidance on each of the 10 triangulation steps is included in **Appendix A** of the general triangulation guidance for the national and regional/provincial level.

Prepare

Identify the key question

From the beginning, it would be useful to form a collaborative team consisting of persons from different programme areas and skillsets (see **General Guidance for national level**). One of the early tasks of the team would be to direct and limit the scope of the analysis by identifying one or two key questions. Example key questions are listed below.

Key questions	
?	Which districts with low performance and/or inconsistencies in data quality require follow-up?
?	What data quality analyses are most relevant for routine monitoring?
?	Is administrative data compatible with other measures of program performance (e.g., stockouts, sessions) and impact (reduction in disease)?

Identify data sources

The team should gather all relevant data for monitoring immunization performance and assess any gaps that may exist. Data sources for both national and subnational data (where available) should be reviewed. Sources which have at least 3–5 years of data are useful for understanding trends within and between different data sources. If interested in potential changes happening since an intervention was introduced, then the data from 2 years before the intervention and at least 2 years after the change should be analyzed; more years of data is better in terms of making reliable conclusions. Issues of timing such as the start of a new reporting system (DHIS2) or the start of case-based surveillance may limit the scope of the analysis. The list below summarizes the different types of data that may be useful for assessing immunization performance; the list is not comprehensive and other types of data may be relevant.

- Administrative vaccination reports: coverage, doses administered (numerator), target population (denominator), dropout rates
- Supplementary immunization activities (SIA): time-period of implementation, age-groups targeted, administrative coverage, survey coverage (see Immunity Gaps Annex 2B)
- Population data: microplan, census projections, World Population Prospects, geospatial estimates (see Programme Target Annex 2D)
- Vaccine stock/supply: stock-outs of vaccines or related injection supplies, vials used (stock), vials available, closing balance, wastage rates, vials shipped (supply)
- WHO/UNICEF Estimates of National Immunization Coverage (WUENIC)
- Vaccination coverage surveys: coverage from EPI, DHS or MICS; subnational coverage estimates (if available); reasons for non-vaccination
- Programme management: vaccination sessions, human resources, cold chain adequacy, temperature monitoring incidents (e.g., freezing)
- Case-based VPD surveillance: confirmed cases of measles, rubella, neonatal tetanus, diphtheria; age and vaccination status of reported cases (% vaccinated); performance indicators; confirmed outbreaks
- Evaluations: EPI reviews, Gavi joint appraisal (JA) desk reviews, post-vaccine introduction evaluations (PIEs), data quality assessments or reviews (DQA/DQRs)
- Special studies: missed opportunities, vaccine hesitancy studies, serosurveys, etc.

Gather and prepare data

It may take considerable effort to compile data across various sources and years in usable format. The help of someone experienced in data management could be enlisted for this step. As you gather and compile different data sources, it is important to also gather and review available background and documentation regarding each data source and associated methodology. Data of the same type for different years can be compiled into one electronic file to allow analysis. Other specific considerations are described in Table 1.

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

Data source	Key considerations for preparing data *(Step 4)*	Key issues for assessing data reliability *(Step 5)*
Administrative vaccination coverage	○ Compile national and subnational data across years (and potentially different databases/systems) ○ Pay attention to any changes in administrative reporting systems & what system should be used for which years. ○ Pay attention to what denominator source is used at national and subnational level. See also Annex 1.	• Completeness of reporting? Completeness of data? • Are all vaccination sites included in reporting (including private providers)? What proportion is left-out? (e.g., % population seeking care at facilities not reporting) • Change in reporting system, completeness, or representativeness over time? • Presence of improbable values, e.g., ending in 0, 5 & coverage >100%? • Comparisons of antigens given at same time, negative drop-out rates
WUENIC	○ Available online in Excel format: https://www.who.int/immunization/monitoring_surveillance/data/en/ ○ Subnational estimates using WUENIC-like draft methodology from WHO may be available	• Should be complete for all years, but Grade of Confidence may vary. Review the Grade of Confidence and assumptions underlying estimates in country summaries: http://apps.who.int/immunization_monitoring/globalsummary/wucoveragecountrylist.html
Vaccination Coverage Surveys	○ Retrieve all coverage survey reports ○ Summary of national data is available in excel sheet at: https://www.who.int/immunization/monitoring_surveillance/data/en/ ○ Subnational data should be used where available ○ Put coverage estimates & 95% confidence intervals (if available) into a spreadsheet by year & geographic area ○ Extract key characteristics of survey (methodology, strata, birth cohorts targeted, % vaccine card seen)	• For which years are coverage survey estimates available? • What are the differences in methodology by survey? ○ Are subnational coverage survey estimates available? At what level? ○ Is it a representative sample or a convenience sample? • What % of respondents had cards to verify vaccination status?
Vaccine stock	○ See suggestions for administrative coverage ○ Ability to use these data may vary based on the existence and design of the Logistic Management Information system and what data is available centrally.	• What levels of vaccine stock data are available at central level? • Change in reporting system, completeness, or representativeness over time? • Completeness of reporting? Completeness of data? • Presence of improbable values (outliers)?
Programme management	○ Some of the data (e.g., human resources, cold chain) may need to be located/requested.	• What levels of data are available? • What is the quality of the data, e.g., completeness, outliers, etc.?
Case-based surveillance	○ Use of case-based surveillance with laboratory confirmation is preferred (does not apply to tetanus) ○ Ensure you use consistent definitions of 'confirmed cases.' Usually this includes laboratory confirmed and epi-linked/line-listed cases, and may include clinically compatible cases.[3]	• When did the system start? Any change in reporting system, case definition, or representativeness of reporting over time? • Is the surveillance system adequately sensitive at the national level and in all subnational regions/provinces? Which subnational areas have poor sensitivity? • Adequate rates of lab testing? Subnational variation? • % of cases missing key variables: 1) date of rash onset, 2) DOB or age, 3) vaccination status, 4) final classification

[3] Clinically compatible cases are usually cases meeting the suspect case definition without an adequate lab specimen or testing. Some countries are unable to process all of the lab specimens in a given time, and ultimately classify all untested cases as "clinically compatible." In this situation, it may be necessary to give special consideration on how to classify these cases. For analyzing trends, consistency of definitions is important to consider when interpreting results.

Analyze

Examine reliability of data

Look at each of the datasets to assess reliability, identify outliers, missing values, and potential data quality concerns, as part of a desk review. The quality/reliability of the data must be considered as well as the strengths, weaknesses and best usages for each type of data. See Table 1 and Appendix C of the general guidance for specific considerations for different types of data. See the Toolkit below for other documents that may be helpful references for this step. Included below are a list of suggested data reliability checks and examples.

Toolkit of Available Resources

World Health Organization (WHO). Handbook on the use, collection, and improvement of immunization data (2018 draft): https://www.dropbox.com/s/8ivdiu0g5xvnlbc/handbook.pdf?dl=1

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

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

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

Gavi, the Vaccine Alliance. Analysis Guidance (2020): https://www.gavi.org/our-support/guidelines/report-and-renew

John Snow Inc. Data Triangulation: Use of Health Facility Immunization Reporting Tools (2017): https://www.jsi.com/resource/data-triangulation-use-of-health-facility-immunization-reporting-tools/

Suggested data reliability checks
A. Completeness and timeliness of reporting.
B. Trends in reported program denominators (targets), numerators, and coverage over time for any unlikely trends or outliers (>100% coverage, large annual variation, zero/missing reports).
C. Consistency between the same antigens given in a series, different antigens recommended at same age/opportunity for any unlikely trends (negative drop-out, large differences).
D. Key surveillance performance indicators (sensitivity, representativeness, and adequacy of specimen collection and testing), if using surveillance data.[4]

[4] See the WHO Vaccine Preventable Diseases Surveillance Standards (or Regional indicators, if available) for additional guidance on calculation of disease-specific indicators available at: https://www.who.int/immunization/monitoring_surveillance/burden/vpd/standards/en/
Also, see Triangulation Guidance Immunity Gap Annex 2 for more information.

While making observations about each data source, consider the following questions:

- Is the trend as expected? Is the recent trend increasing or has it decreased/plateaued?
- Do any changes coincide with any interventions/changes to the data collection methods or data used?
- How frequently are key data fields left blank? How will any challenges noted with reporting completeness affect your interpretations of the data?
- What is the extent of anomalies in reporting across subnational areas, e.g., >100% coverage, negative drop-out, outliers?
- For sub-national areas with anomalies in reporting, what is the reason for observed differences, e.g., missing reports, obvious data recording/entry errors?

A. Completeness and timeliness of reporting

Reporting completeness may be an existing indicator available for the reporting system or may need to be calculated as the number of reports received divided by the number of reports expected for the reporting period. Timeliness is defined as the fraction of expected reports that were received on time, or before a cut-off date that is set in the national or district-level reporting policy. Please note that it is possible to be counted as complete or timely for reporting while still leaving key immunization data elements blank.

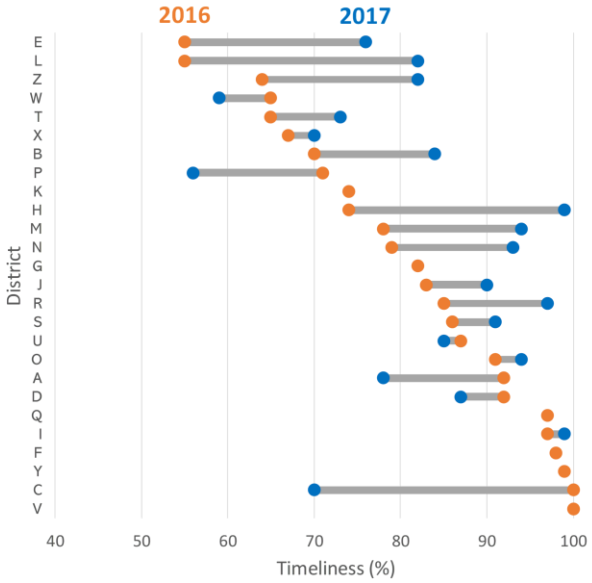
Data required: Percentage of districts and health facilities with report forms completed and/or received in a timely manner over the span of the analysis period (% completeness and % timeliness).

Potential outputs:

- A bar graph of health facility reporting completeness/timeliness by year, with years on the x-axis; reporting completeness/timeliness on the y-axis.
- Clustered bar graphs of health facility reporting completeness/timeliness by year and district, with districts on the x-axis and reporting completeness/timeliness on the y-axis.
- Barbell graph of health facility reporting completeness/timeliness by district is an alternative to show change between 2 years (Example 1, tutorial available at: https://stephanieevergreen.com/how-to/)

Notes:

- Depending on the organization of the reporting system, assessing reporting from health facilities (or the lowest unit of reporting) is preferred. In some systems, districts could report 100% complete and timely, without receiving all the reports from facilities.
- It is important to understand the role of the private sector (including NGOs) and their contribution to immunization, i.e., is the reporting network complete, or what % is estimated to be missing?
- Assessing the frequency of key data fields left blank (e.g., Penta3 doses given, monthly target, Penta doses used) on the monthly facility reporting form (or lowest reporting level) is also helpful.



Example 1. Dumbbell plot of timeliness of health facility reporting by district 2016-2017. The ends of the dumbbell correspond to the % timeliness for both years, and the length of the dumbbell corresponds to the % difference between the two years, with longer lines meaning higher % change between years. Most districts had similar or improved reporting timeliness in 2017, compared with 2016. Five districts had decreased timeliness in 2017. To make the dumbbell plot, a tutorial was used from: https://stephanieevergreen.com/how-to/

B. Trends in reported program denominators (targets), numerators, & coverage

Reviewing administrative coverage, as well the component numerator (doses) and denominator (target) is helpful to uncover any unlikely trends or outliers (>100% coverage, large annual variation, zero/missing reports). Coverage >100% may reflect an inaccurate microplan target, a lack of reported target for a given month, or a possible recording or data entry error (doses or target). Anomalies at lower levels are usually obscured by just looking at the national level, so review of data from the lower levels is suggested.

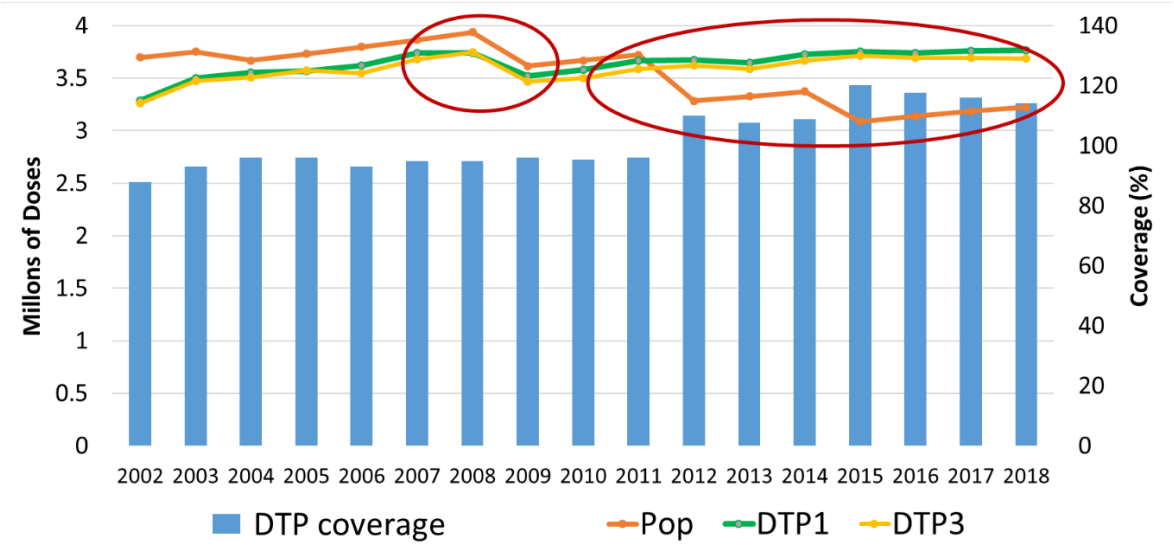
Data required: Number of vaccinations for DTP1, DTP2, DTP3; target population estimates; and reported administrative immunization coverage monthly and yearly over the span of 2-3 years.

Potential output:

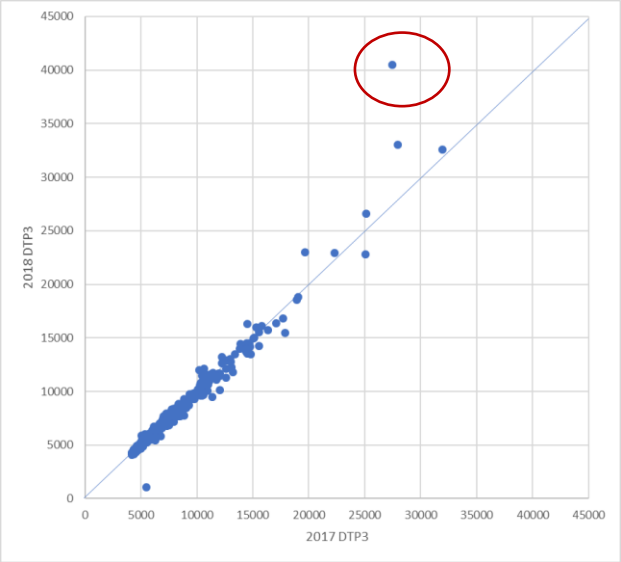
- A combination graph of doses administered, target population, and reported administrative immunization coverage. Years on the x-axis, number of children on the left y-axis, percent coverage on the right y-axis.
- Scatter plot of reported doses/target by subnational area across years.

Notes:

- When anomalies in reporting are identified, drill down in terms of the area (e.g., sub-district to health facility) and/or time period (e.g., yearly to monthly) to see if obvious data entry errors or gaps in reporting can be identified either for doses or target.
- Analysis of DTP2 may be helpful to understand when drop-outs occur.



Example 2. Combination graph of national DTP3 coverage, doses administered and population denominator, 2005-2012. In one year, a decrease in target and number of DTP3 doses resulted in no change to coverage. In other years, decreases in target resulted in increased coverage.



Example 3. Scatter plot comparison of DTP3 doses administered by health facilities, 2017 and 2018. Falling on the equality line (diagonal) indicates no difference between years. Drilling down by facility and period, one outlier, circled in red, was related to inconsistent monthly reporting in 2017 (i.e., missing data).

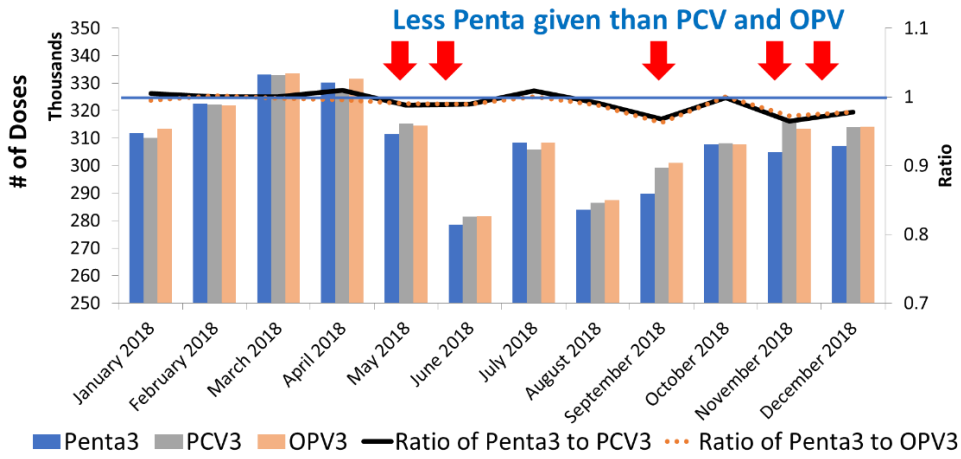
C. Consistency between the same antigens given in a series or different antigens recommended at the same age/opportunity

Antigen doses given close in age (e.g., DTP1 and DTP3) are expected to be close, if not decline, related to loss to follow-up, so negative drop-out trends should be investigated. Antigen doses given at the same age should have similar reported data because of being provided at the same healthcare opportunity, but can differ because of stockouts of particular antigens, false contraindications to providing a particular vaccine, or reporting errors. Consult the national immunization schedule for what comparisons may be helpful.

Data required: Number of vaccinations for DTP1, DTP3 and doses given at the same opportunity (e.g., PCV, OPV); target population estimates; reported administrative immunization coverage; and drop-out rates monthly and yearly over the span of 2–3 years.

Potential output:

- Scatter plot of reported doses/target by subnational area across years, or antigens given at the same opportunity (e.g., DTP3 and PCV3).
- Bar graph of differences in annual reported doses given at the same opportunity by subnational area.
- Combination graph of reported doses given at the same opportunity and ratios of these doses for a single area by month.



Example 4. Ratio of Penta3 vs PCV3 and OPV3 doses given by month, 2018. In several months (red arrows), fewer Penta3 doses were given than PCV3 and OPV3 doses. This turned out to be related to stock-outs of pentavalent vaccine in 2018.

D. Key surveillance performance indicators

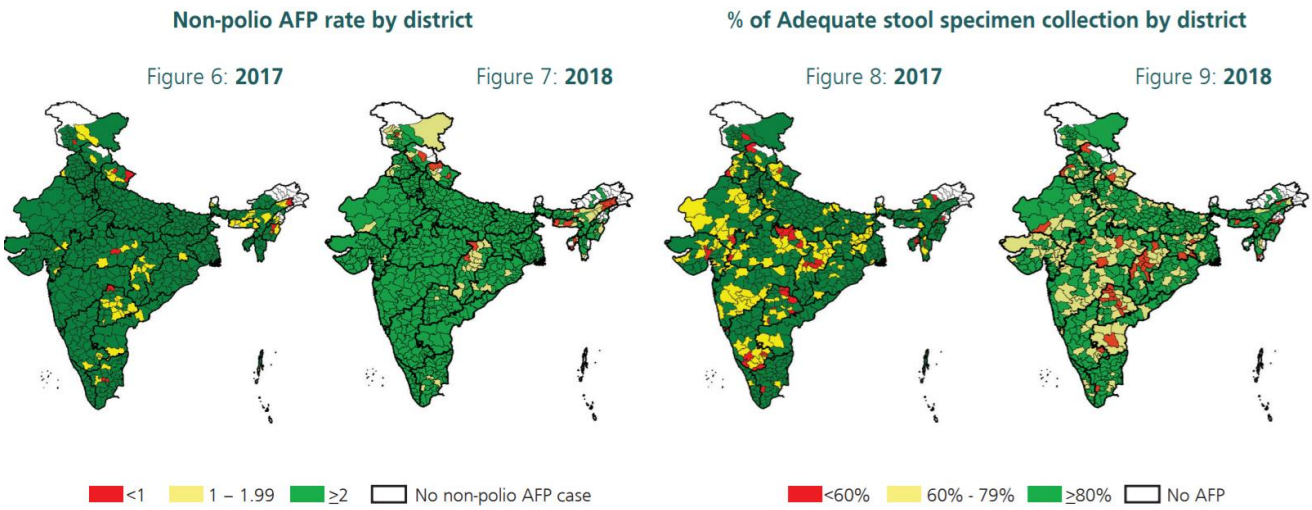
For the purposes of triangulation, the completeness and timeliness of aggregate surveillance reporting and performance of the case-based surveillance system should be evaluated in at least three areas: sensitivity, representativeness, and adequacy of specimen collection and testing[5]. See Immunity Gap Annex (Annex 2) for more information.

Data required: Case-based surveillance performance indicators for relevant diseases (e.g. polio, measles, neonatal tetanus, diphtheria)

Potential output:

- Series of maps of performance indicators by subnational area.
- Bar graph performance indicators by subnational area.

[5]Full standards with additional guidance on calculation of indicators available at: https://www.who.int/immunization/monitoring_surveillance/burden/vpd/standards/en/



Example 5. Map of acute flaccid paralysis (AFP) surveillance performance indicators for 2017-2018, India. Gaps in surveillance performance are noted in some districts, suggesting subnational variation in data reliability. (Source: SEARO Country Profiles. Available at: https://www.who.int/southeastasia/health-topics/immunization)

Compare trends across data sets (triangulation analyses and synthesis)

Next, focus on simple descriptive analyses and data visualizations. Consider different explanatory causes for observations, including sources of error. Consider integrating contextual information within the data analyses/visualization (e.g. arrows and comment bubbles overlaid on graphs). Attempt to explain areas of agreement, disagreement. Lastly, state any limitations of analysis.

Suggested data comparisons
E. Trends in vaccination coverage and un- and under-immunized persons
F. Administrative coverage, WUENIC and coverage surveys
G. Coverage survey results and differences in methodology
H. Vaccine stock/supply with administrative vaccination or population data
I. Vaccination coverage and programme management data
J. Suspected cases reported through case-based and aggregate surveillance
K. Vaccination coverage to VPD Surveillance

While making observations across data sources, consider the following questions:

- Is the trend as expected? Is the recent trend increasing or has it decreased/plateaued?
- Which data sources and indicators appear more reliable or inconsistent? Why might this be?
- Do any changes coincide with any interventions/changes to the data collection methods or data used?
- Which subnational areas have greatest discrepancy between administrative coverage and external data sources? What are the possible explanations?
- Does disease incidence data highlight any areas of unreliable coverage? Are cases occurring in young children who should have been recently vaccinated?

Triangulation to target regions with high numbers of un- and under-immunized children

In country Y, a triangulation analysis between the (1) DTP administrative data, (2) coverage projections based on WUENIC and UNPD population projections, and (3) average yearly doses shipped by UNICEF led to an in-country discussion about the quality of administrative data. Recommendations were to foster activities for improving data quality availability and use at lower levels of the system.

The country has decided to change the methods for estimating the official coverage, adjusting the data with the last available survey results, instead of aligning with administrative numbers. Triangulation has been incorporated into country analysis and recently led to the prioritisation of geographic areas based on triangulation of survey results, administrative data, population estimates, surveillance, and operational data, which will likely be better able to target regions with high numbers of un- and under-immunized children.

E. Trends in vaccination coverage and un- and under-immunized persons

Analysis of un- and under-immunized persons (left-outs and drop-outs) alongside coverage are particularly useful for targeting of resources. This is because low coverage of a small population may result in a small number of unprotected children, while high coverage of a large population may result in a large number of unprotected children. Many countries with subnational coverage surveys have found these results useful for estimating numbers of un- and under-immunized persons sub-nationally. Consider comparing numbers calculated from different coverage (administrative vs. survey coverage) and population data sources (e.g., census, microplan). Trends in vaccination status of young children from rapid coverage assessments or surveillance may also be relevant.

Data required: Subnational Penta1/2/3 and MCV1/2 vaccination coverage (preferably from survey data), and population estimates for the past 3−5 years. Formulas for calculating the number of un- and under-immunized children are below. If available, trends in the number of zero-dose children from rapid coverage assessments (e.g., during campaigns) or from case surveillance (e.g., discarded cases <5 years).

- Number unvaccinated + under-vaccinated children = (1 – % Penta3) × population target estimate
- Number unvaccinated children = (1 – % Penta1) × population target estimate
- Number under-vaccinated children = (% Penta3 – % Penta2) × population target estimate

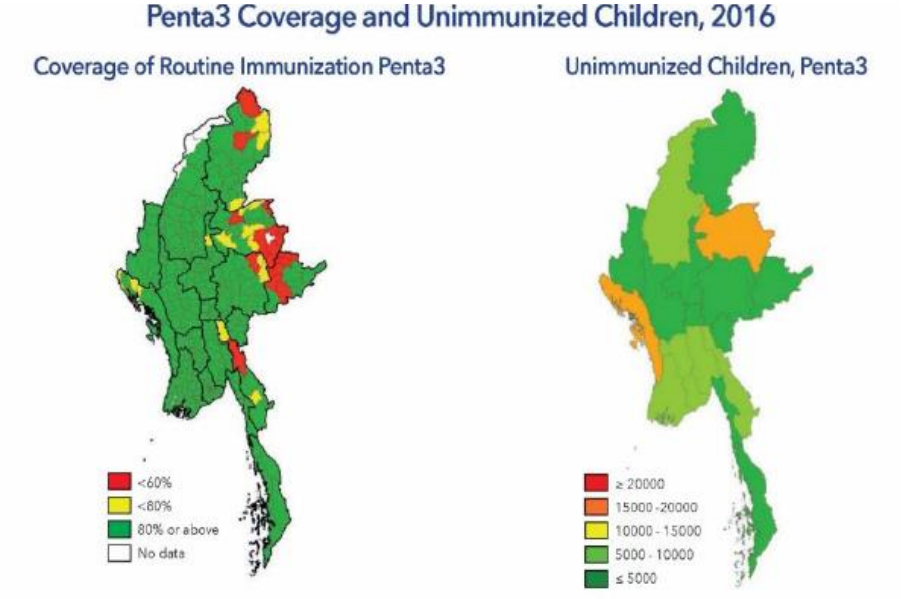
Potential outputs:

- Side-by-side subnational maps comparing administrative coverage and number of zero-dose and under-immunized children.
- Ranked order/heat map of subnational areas with coverage and number of zero-dose and under-immunized children (see example 14 of a heat map).[6]

Notes:

- If there are known issues with the quality of reported vaccination coverage (e.g., coverage >100%), it will make it challenging to perform this type of analysis; for this reason, use of survey coverage is recommended, where available.
- The vaccination status from surveillance cases is not expected to directly correlate to coverage, but increasing or decreasing trends in zero-dose or fully-vaccinated are relevant for comparison. See Immunity Gaps for notes on use of vaccination status from surveillance cases.

[6] Making a heat map in Excel: https://trumpexcel.com/heat-map-excel/



Example 6. Maps of Penta3 vaccination coverage (left) and number of unimmunized children (right), 2016. Areas with the highest number of unimmunized children may not always correlate to those with the lowest coverage because of differences in population density. (Source: Myanmar Joint Appraisal, 2017).

WHO and UNICEF Estimates of National Immunization Coverage (WUENIC)

Because of data quality challenges with annual vaccination coverage reports received from countries, WHO and UNICEF jointly developed triangulation methods based on computational logic, or decision rules, to derive best estimates of national immunization coverage (WUENIC). Currently, data sources reviewed are coverage surveys reported coverage, and contextual information like major disruptions to the health system and vaccine stock-outs.[7] Draft methods for subnational WUENIC-like coverage estimation have been developed and exercises completed in India[8], Indonesia, Ethiopia, and Pakistan with support by WHO/UNICEF.

More information about WUENIC and the data are available online: https://www.who.int/immunization/monitoring_surveillance/routine/coverage/en/index4.html.

F. Administrative coverage, WUENIC and surveys

Estimates from coverage surveys can be more reliable than administrative reporting, but that depends on having a representative sample, quality survey implementation and the availability of documented evidence of vaccination (see G below). WUENIC estimates are also typically considered more accurate than administrative estimates as they have already undergone a standardized triangulation process. Survey estimates often relate to children 12−23 months while administrative data relate to <12 months. For this reason, it is proper to compare survey coverage to administrative coverage from the year prior to the year the survey was conducted.

Data required: For national level, administrative coverage, survey coverage, and WUENIC estimates of coverage going back as far as possible (10−20 years). For subnational levels, administrative coverage, any survey estimates of coverage at the subnational level, and any estimates of subnational coverage developed through a WUENIC-like process, going back as far as possible.[9] For antigens, Penta3 is a common indicator to use for monitoring

[7] Burton A, Kowalski R, Gacic-Dobo M, Karimov R, Brown D. A formal representation of the WHO and UNICEF estimates of national immunization coverage: a computational logic approach. PLoS One. 2012;7(10):e47806.
[8] Bhatnagar P, Gupta S, Kumar R, Haldar P, Sethi R, Bahl S. Estimation of child vaccination coverage at state and national levels in India. Bull World Health Organ. 2016; 94: 728–734.
[9] A draft WHO method for estimating subnational immunization coverage has been drafted and piloted in several countries: https://www.who.int/immunization/monitoring_surveillance/routine/coverage/en/

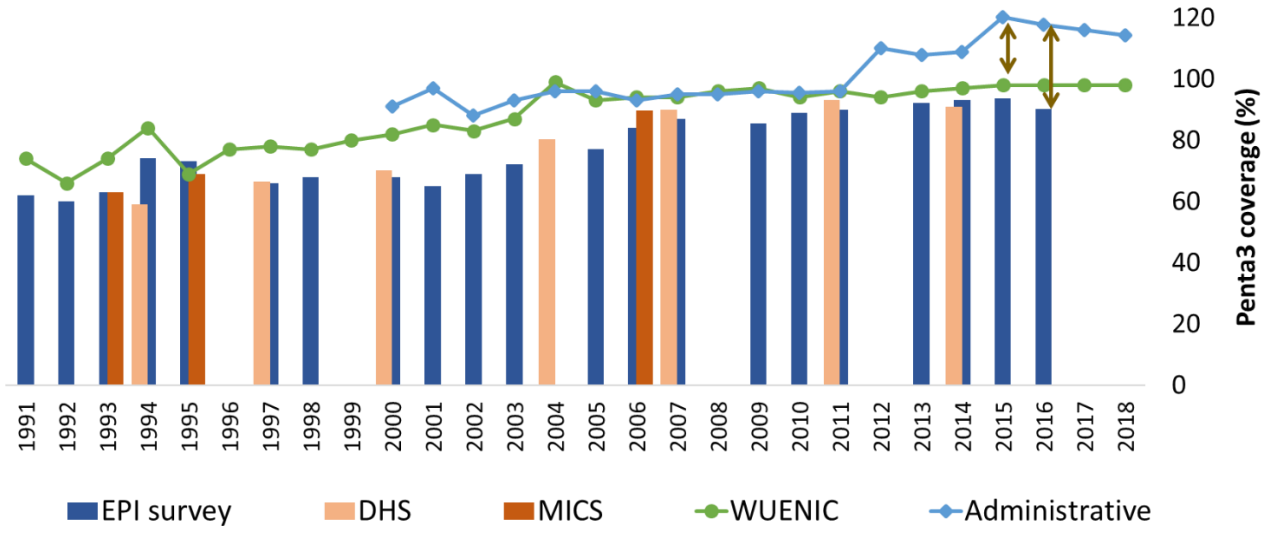
routine immunization performance, and including other marker antigen doses across the national immunization schedule (e.g., BCG, Penta1, MCV1, MCV2), as well as explorations of drop-out rates (Penta1-Penta3, MCV1-MCV2) would be relevant.

Potential outputs:

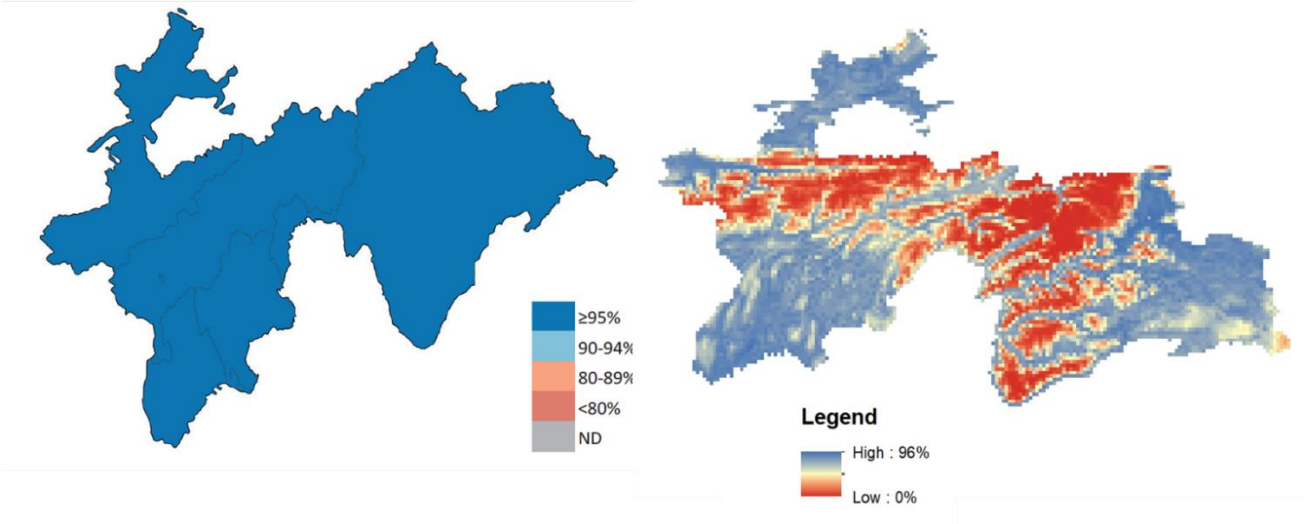
- A combination graph overlaying national administrative coverage and WUENIC estimates as lines, with any survey estimates of vaccination coverage represented as bars or points (preferably with display of 95% confidence intervals). This is to draw attention to the different data collection methods.
- Scatter plot and/or side-by-side subnational maps comparing administrative coverage and survey estimates of vaccination coverage from the most recent vaccination coverage survey.
- To compare across administrative levels, survey estimates for the higher administrative level might be represented as points in a combo chart with bars or box-and-whiskers summarizing the distribution of administrative coverage from the lower levels within the corresponding units (Example 9).
- Differences between admin-survey and admin-WUENIC might also be calculated and plotted as a bar graph by year or subnational areas to explore trends. For subnational areas, heat maps can be created by sorting in order of difference and coloring using conditional formatting to aid interpretation.[6]

Notes:

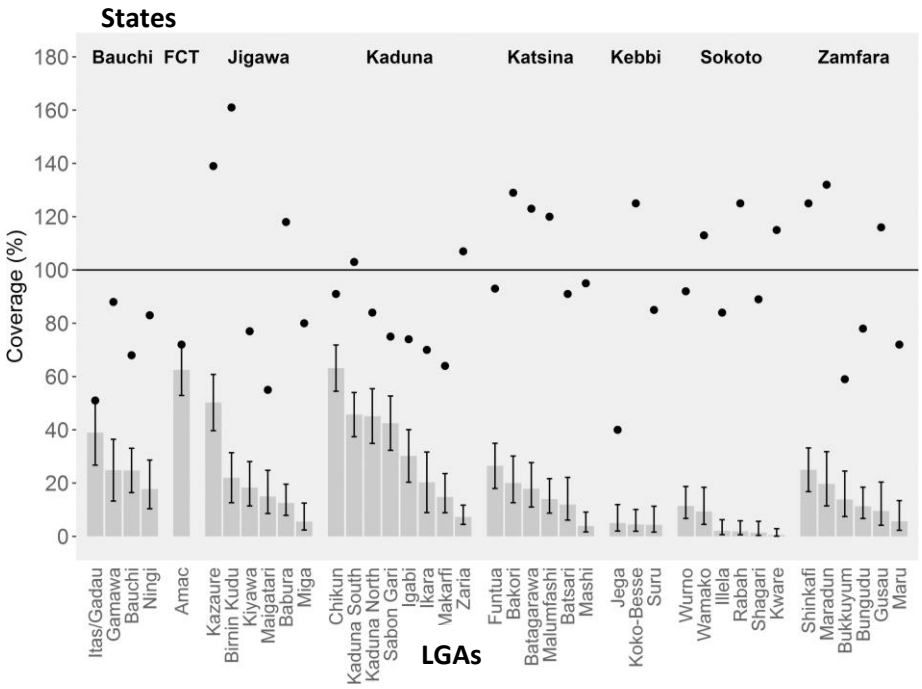
- WUENIC already takes survey data into account, which is important for interpretation.
- Because coverage surveys have different methods, representing different coverage survey types (e.g., DHS, MICS, EPI) as different series is helpful for observing any associated differences in coverage trends.
- Including the 95% confidence intervals of survey estimates as error bars to indicate the data uncertainty aids interpretation, e.g., 83% by admin coverage compared with 74-85% survey confidence interval.



Example 7. Combination chart of administrative Penta3 coverage vs Penta3(?) coverage by surveys and WHO/UNICEF estimates of national immunization coverage (WUENIC), 1991-2018. All data sources show increasing trends until recently. In general, administrative coverage estimates are greater than WUENIC estimates, which in turn are greater than coverage survey. (EPI=Expanded Programme on Immunization, DHS=Demographic Health Survey, MICS=Multiple Indicator Cluster Survey).



Example 8. Map of administrative Penta3 coverage (left) vs modeled Penta3 coverage from Demographic Health Survey (DHS, right), 2017. High resolution maps are produced through small area estimation analysis of recent DHS and are useful for seeing where coverage might be low. One limitation is higher uncertainty of estimates at country borders where there are sparse data points. Source: WHO-EURO. Routine immunization country profiles. http://www.euro.who.int/en/health-topics/disease-prevention/vaccines-and-immunization/data-and-statistics. DHS. Spatial Data Repository. https://spatialdata.dhsprogram.com/modeled-surfaces/).



Example 9. Coverage survey estimates with Penta3 across 40 local government areas (LGAs), by state — Northern Nigeria, 2014–2015. LGAs are grouped by state to illustrate variability in coverage across LGAs within the same state. These data are not representative of state-level coverage since LGAs were purposefully selected. Black vertical lines depict 95% confidence intervals. For comparison, 2013 administrative coverage for each LGA is represented with a black dot. (Source: Gunnala et al. PLoS One. 2016;11(12):e0167835.)

Triangulation exercise in a county with several different coverage surveys

Country X had several different types of vaccination coverage surveys available, e.g., Demographic Health Survey (DHS), Multiple Indicator Cluster Survey (MICS), as well as EPI coverage surveys. However, only the EPI coverage surveys were being regularly used for triangulation. Data from other historic surveys were not compiled in a database. Questions were raised during a workshop about why the results were different and whether some surveys were less reliable. Based on the discussion, the triangulation team agreed to look more into the differences in coverage survey results and differences in methodology (sampling frame, sample size, use of probability-based sampling methods, analysis methods, documented vaccine card availability). There were differences in results and methodology observed during the analysis. As a result of the discussion, the team felt more informed and made plans to compare vaccination coverage survey results from DHS, MICS and EPI surveys occurring during 2018-2019. The team also appreciated learning more about geospatial coverage estimation and looked forward to using the coverage estimated on the DHS Spatial Data Repository.[10]

G. Trends in coverage survey results and differences in methodology

The different coverage surveys available (DHS, MICS, EPI) have different scopes (e.g., measuring vaccination coverage only vs. many indicators) that can impact the amount of training or time in the field devoted to collecting a proper vaccination history (e.g., amount of time interviewers allow caretakers to find their vaccination cards). The surveys may also have important differences in their methodology (sampling frame, sample size, sampling method) and design (national vs provincial estimates), or rigor of implementation. For example, the most recent WHO guidance recommends a probability-based sample at both the cluster and household levels (e.g., systematic sampling), while the older "30 x 7" cluster design allowed use of a quota sample of children, resulting in biased estimates in either direction.[11]

Data required: For national level, need summary data for each coverage survey on vaccination coverage for key antigens, survey methodology (sampling frame, sample size, design, birth cohorts targeted), any geographic areas excluded (e.g., due to insecurity), % vaccine cards seen. For comparison, any existing national data on Home-Based Records (HBR) for children (e.g., printing, ownership and availability) would be helpful. Recent data on stock-outs of HBR reported through the Joint Reporting Form is available through WHO.[12] For subnational level, also consider detailed comparison of coverage survey results and methodology for a few well-performing and poorly performing areas, where equivalent subnational data is available across surveys.

Potential outputs:

- Summary chart of different surveys by year, methodology and HBR seen, and/or summary bullets of key differences in methodology or changes in methodology
- Comparison of trends in children's HBR availability from the different survey and nationally reported data (e.g., printing, ownership, use, stockouts)
- Bar graph comparison of coverage and 95% confidence intervals for key antigens (Penta3) by year and coverage survey type (e.g., DHS, MICS, EPI) represented as different series (colors).
- Where multiple surveys are completed in a single year, detailed comparison of coverage differences, children's HBR seen would be helpful to show as illustrative case studies.

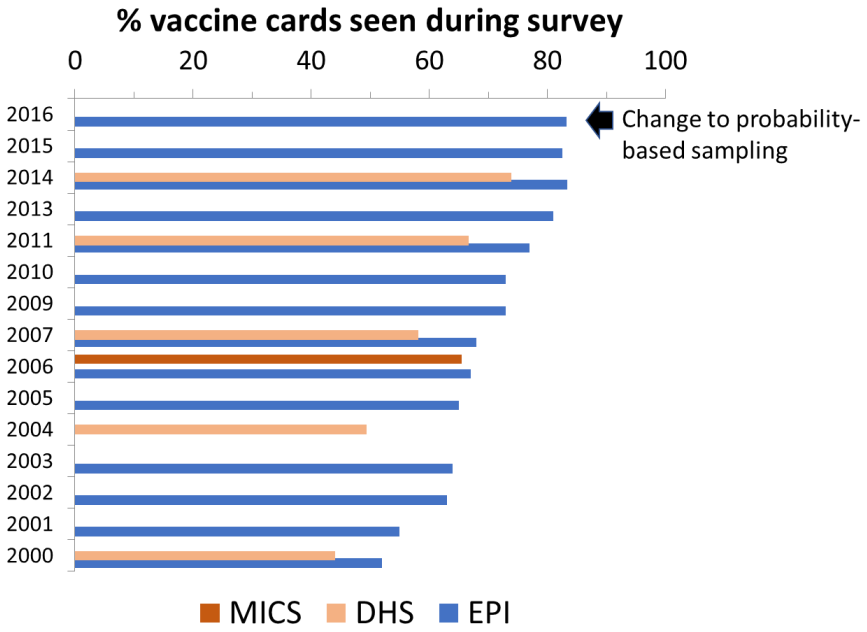
[10] The Demographic Health Survey (DHS) Program provides a standard set of spatially modeled map surfaces for recent population-based surveys in various countries. https://spatialdata.dhsprogram.com/modeled-surfaces

[11] WHO coverage survey guidance and other materials are available at: https://www.who.int/immunization/monitoring_surveillance/routine/coverage/en/index2.html

[12] Stock-outs of home-based records are available in the Immunization Systems Indicator sheet of the JRF at WHO website: https://www.who.int/immunization/monitoring_surveillance/data/en/

Notes:

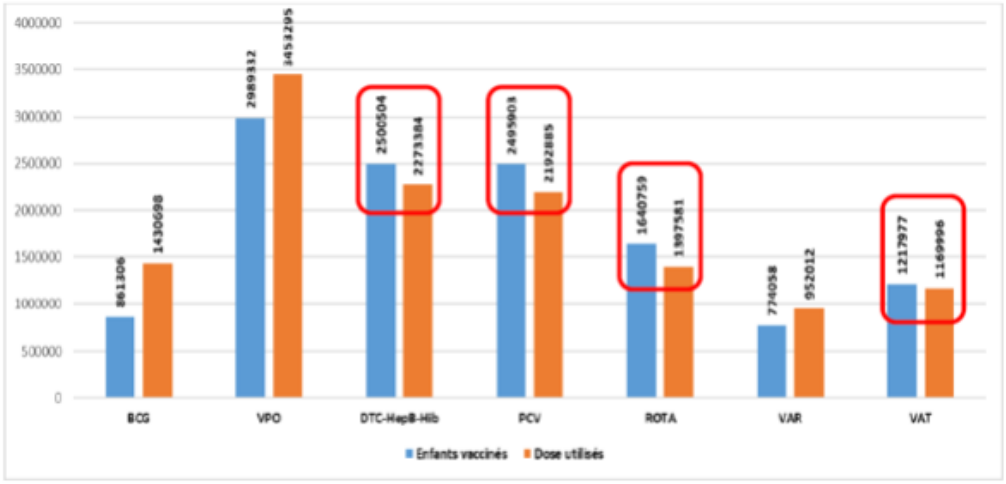
- In general, DHS/MICS are large-scale surveys that tend to have more rigorous methodology and cover many topic areas including immunization. But these surveys tend to have lower rates of HBR seen than EPI surveys, leading to questions of suboptimal training and/or time devoted to taking a proper vaccination history (the immunization section is also often last in a long interview process).
- By comparison, EPI surveys have the potential for bias related to non-probability-based methods (especially before the current WHO Survey Manual[11] was fully adopted) and poor implementation (e.g., not going to hard-to-reach households). However, training of surveyors tends to focus on observation of vaccination cards.



Example 10. Vaccination cards seen during coverage surveys in Country X. Prior to 2016, the EPI survey used a 30 x 7 cluster design, subject to bias, but starting in 2016, EPI changed to a more robust survey design used by DHS & MICS. The higher percentage of vaccine cards seen in EPI surveys likely reflects more time devoted to training and taking vaccination history or more robust design and implementation by DHS & MICS. (EPI=Expanded Programme on Immunization, DHS=Demographic Health Survey, MICS=Multiple Indicator Cluster Survey).

Triangulation exercise with coverage and vaccine stock data

During the 2019 Joint Appraisal discussions in Madagascar, the triangulation of stock and administrative data at the national level prompted further discussion on stock management problems. The number of doses used was lower than the number of children immunized for some antigens and geographic areas in 2018. Based on this analysis, the country decided to prioritise capacity building for the logistics system in order to improve the quality of stock data at regional and district levels.



Example 11. Comparison of number of children given different vaccines with number of vaccines available to health regions, 2018. (Source: *Madagascar Joint Appraisal, 2019)*

H. Comparison of vaccine stock/supply and administrative vaccination or population data

Reported vaccine stock data (e.g., vials used) are a commonly available data source and provide a ready opportunity for comparison with doses administered and programme targets. Analysis of levels stock data reported from the service delivery level should most closely match vaccine delivery data, but there may also be challenges with data quality (e.g., gaps in reporting). The comparisons are especially easy for vaccines given in a single dose vial or where vaccine wastage is low, but the comparison can be made for all vaccines. The premise is that the number of doses administered should never exceed the number of doses used or stock available; negative or excessive wastage rates should be viewed skeptically.

Data required:

You may have to do basic calculations to obtain the measures below. For multi-dose vials, you can covert vials to doses by multiplying by the number of doses in vial presentation (e.g., multiply by 2 for 2-dose vial).

- Total vaccine doses administered/given (e.g., Penta1 + Penta2 + Penta3 at 0-11 months & 12-23 months; MCV1 + MCV2 at 0-11 months & 12-23 months)
- Immunization programme targets (e.g., microplan)
- Vials received, used/opened, available (opening balance/previous stock + received), closing balance
- Other logistics data, e.g., 0.05 ml syringes for comparison with BCG doses used
- Vaccine wastage rate

Potential outputs:

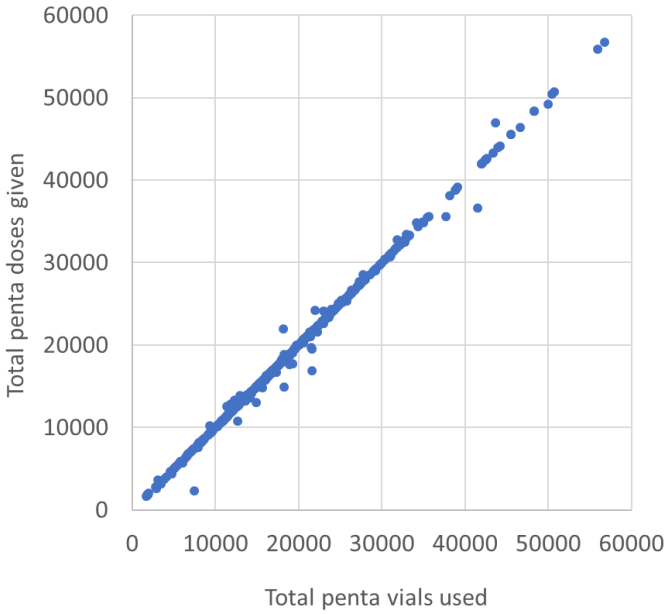
- A bar or line graph depicting trends in number of doses administered, number of vials used, number of doses received and/or available at the national level by year/month for different vaccines.
- Scatter plot of bar graph comparing the number of doses administered and doses used or doses received by sub-district or health facilities for different vaccines.
- Ranked list or heat map of doses administered, doses used and vaccine wastage by district/facility (example 14).[6]
- Similar comparisons of doses used with population targets by district/facility.
- For areas with anomalies, review monthly trends in reporting of dose administered and doses used or doses received by line graph.

Notes:

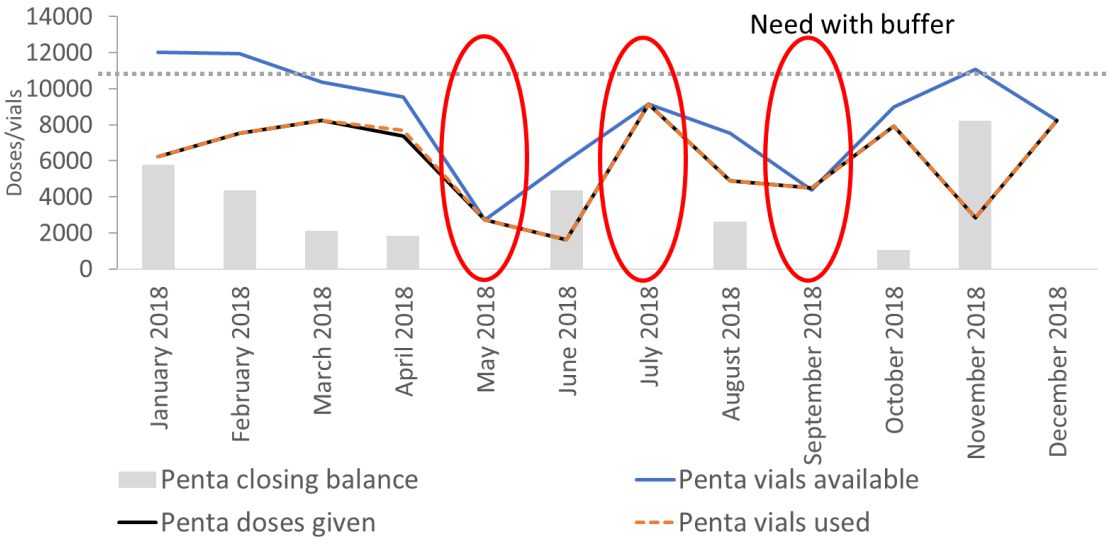
- Interpret results with care depending on quality of data in the administrative reporting and stock management system. When anomalies in reporting are identified, drill down in terms of the area (e.g.,

sub-district to health facility) and/or time period (e.g., yearly to monthly) to see if obvious data entry errors or gaps in reporting can be identified.

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



Example 12. Scatter plot correlation between Penta doses given to children versus Penta vials used by the health facility, 2018. The Penta vaccine used is a single dose vial, so direct comparison can be made. Most of the discrepancies observed were related to missing monthly stock reports, or apparent data recording/entry errors in the health management information system.



Example 13. Combination graph comparison of total Penta doses administered vs. vials used (stock), needed, and closing balance in a select sub-district, 2018. The Penta vaccine used is a single dose vial, so direct comparison can be made. Good data agreement is observed between Penta doses given and vials used. However, there are

several months when the total number available is below the need (with buffer) and all of the doses available are given, resulting in zero closing balance (red circles). A supervisory visit to this area confirmed that stockouts and hoarding of vaccine were occurring, negatively impacting coverage.

2018			Jan-June 2019		
Total Pentavalent Given	Total Pentavalent used	Pentavalent open vial wastage (%)	Total Pentavalent Given	Total Pentavalent used	Pentavalent open vial wastage (%)
2318	7480	69.4	1055	1055	0
16906	21565	21.6	9020	9020	0
14954	18280	18.2	9173	11366	19.3
10771	12669	15	5752	6086	5.5
2589	2910	12.2	1269	1465	13.4
13074	14867	12.1	7721	9184	15.9
36574	41565	12	17246	19291	10.6
3148	3424	9.5	1425	1586	10.2
32513	32807	0.92	14612	16692	12.5
34806	35032	0.66	20560	17778	-15.6
25568	25616	0.19	12940	10996	-17.7
28555	27765	0.15	12403	14517	14.6
8277	8287	0.12	4335	3719	-16.6
28955	28986	0.11	15026	10309	-45.8
24273	23969	0.01	12247	10273	-19.2
22645	22645	0	12422	14084	11.8
30393	30393	0	17527	15527	-12.9
35453	35452	0	17871	15707	-13.8
22857	22857	0	11630	10105	-15.1
20103	20102	0	10676	9115	-17.1
10338	10338	0	5478	4675	-17.2
13641	13641	0	7259	6195	-17.2
41969	41969	0	22742	19003	-19.6
5315	5295	-0.19	3544	2881	-23
3665	3057	-3.1	1814	1313	-18.5
9186	8602	-6.8	4865	4735	-2.7
46931	43643	-7.5	28140	26448	-6.4
13280	12317	-7.8	6710	6710	0
13909	12905	-7.8	7298	6223	-17.3
12859	11822	-8.8	6808	6664	0
14685	13484	-8.8	7340	7340	0
10168	9313	-9.1	5449	5449	0
24227	22008	-10.1	12801	12801	0
12605	11369	-10.9	6689	6690	0.01
21977	17194	-20.8	11038	9163	-20.5

Example 14. Heatmap of negative or excessive pentavalent wastage rates at the district level, 2018. The Penta vaccine used is a single dose vial, so direct comparison can be made. Some districts had high wastage rates (>10%, yellow and green), and some had negative wastage rates (red). Based on this analysis, the country decided to include this check in dashboards and supervisor guidance for doing monthly data quality checks.

I. Comparison of vaccination coverage and programme management data

Data available for this type of analysis will vary by country and can be prioritized for investigation based on known issues in country. Quality of some of these data sources may be poor and any issues with data quality should be considered (completeness, large variations in reported values) and acknowledged as a limitation. Because of the variation in data available, please be as clear as possible about what is being analyzed.

Potential data: Possible indicators for the subnational level include proportion of vaccination sessions held (vs planned); density of health facilities (number per 100,000 population; density of health workers (number by type per 1,000 population); stock-outs / full stock availability of specific vaccines; availability/functionality of cold chain equipment; reasons for non-vaccination from coverage surveys; geospatially modeled data may also be relevant.

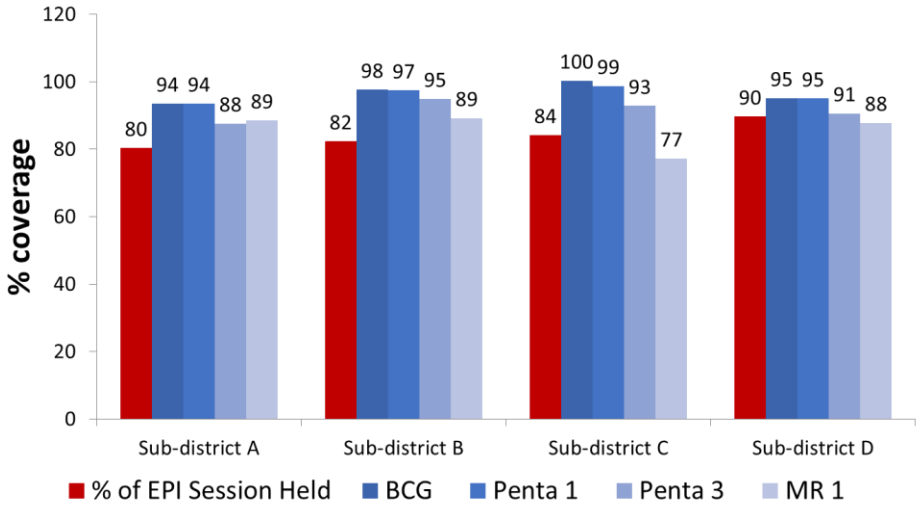
Potential outputs:

- Subnational maps comparing the availability of health facilities, health workers, cold chain with vaccination coverage.
- Bar graphs comparing coverage with the proportion of vaccination sessions planned that are held.
- Comparison of stock outs with vaccination coverage for specific antigens with annual coverage.
- For exploring trends across subnational areas, heat maps can be created by sorting variables and using conditional formatting to facilitate easy interpretation (see example 14 of a heat map).[9]

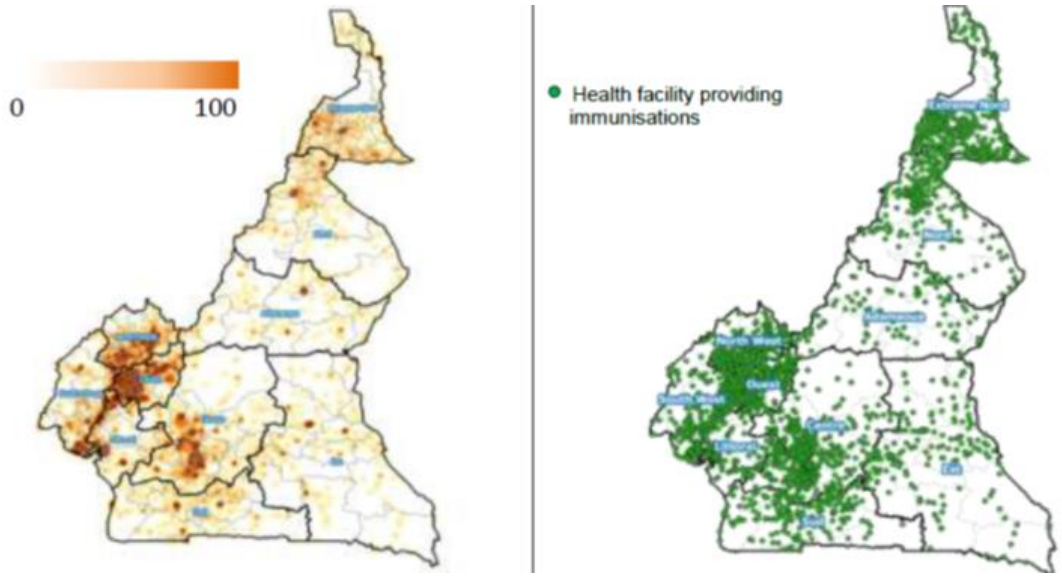
- Bar charts showing reasons for non-vaccination.

Notes:

- The proportion of vaccination sessions held may vary seasonally, so it may be helpful to examine quarterly and over longer time periods (e.g., one year)
- The definition of a stock-out could vary in terms of duration by reporting level (e.g., running out of vaccine before the end of the month, a whole month or more without vaccine). There may not be "stockout" variables that are ready to analyze, making analysis challenging. One potential data source is the national and subnational stockouts reported through the JRF.[13]

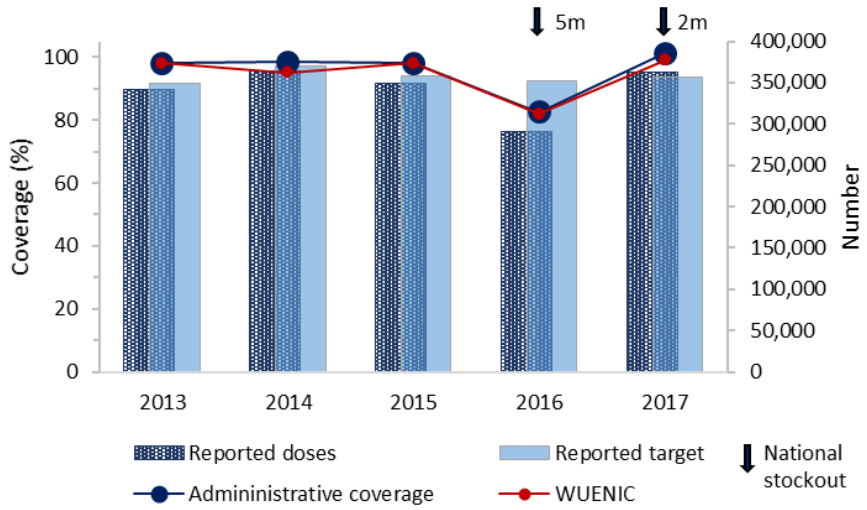


Example 15. Bar chart comparison of vaccination coverage of different antigens vs % of EPI sessions held in sub-districts reporting ≤90% of sessions held, County X, 2018. Vaccine coverage in some of the sub-districts may be over-reported when % of EPI sessions held is considered.



Example 16. Maps of population density (left) and health facilities providing vaccination (right). Health facilities are largely concentrated in areas with greater population. (Source: Cameroon Joint Appraisal, 2018)

[13] Stockouts reported in the JRF can be found in the *5. Immunization system indicators* section of the WHO IVB Data, Statistics and Graphics site: https://www.who.int/immunization/monitoring_surveillance/data/en/



Example 17. Bar chart comparing administrative coverage, doses administered, target, and national stockouts. Lower coverage reported in 2016 was linked to a 5-month national stockout (Source: WHO/UNICEF Joint Reporting Form).

Disease outbreaks reveals programme performance gaps

Measles outbreaks are sentinel events because the disease is very infectious, and outbreaks occur in places not achieving high coverage (93%-95%) with two doses of vaccine. Outbreaks of rubella, diphtheria, and poliovirus, including vaccine derived poliovirus (VPDVs), occur at much lower coverage levels (less than 80%-85%).

Many countries have the experience of detecting frequent outbreaks of different VPDs in the same high-risk groups that are missed by routine immunization. Conducting enhanced surveillance after an outbreak of one VPD can result in finding other VPDs that were previously undetected. In this way, surveillance can help find gaps in immunization coverage. For more information, see the Guidance Annex 2 on Immunity Gaps.

J. Suspected cases reported through case-based and aggregate surveillance

Case-based surveillance has disease-specific performance indicators and associated targets, e.g., for polio, measles-rubella, neonatal tetanus, diphtheria (see D).[5] However, it is still possible to achieve these targets and still have challenges with not capturing the full number of suspected disease cases being detected either at the national level, or in specific subnational areas (i.e., challenges with representativeness). For the subnational level, geographic differences may be explained by variation in access to laboratory testing. This is because case-based surveillance is mistaken as being laboratory-based surveillance in some countries, so case investigations are not completed for cases where specimens cannot be collected.

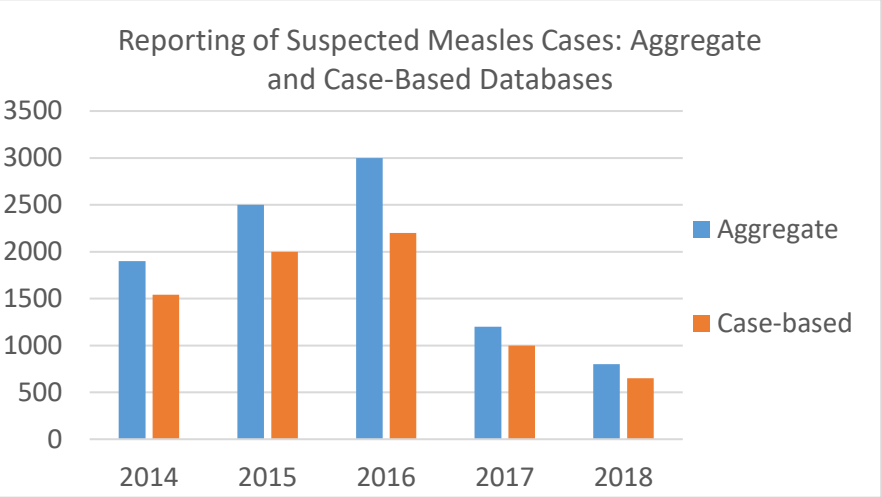
Data required: For diseases with case-based surveillance (e.g., polio, measles, neonatal tetanus, diphtheria), the number of suspected cases reporting through case-based surveillance by year; number of suspected cases reported through aggregate surveillance (e.g., weekly report); Health Management Information System (HMIS) reporting of diagnoses from health facilities (e.g., monthly report) may also be relevant. Surveillance performance indicators (see D), such as districts silent for reporting or under-reporting.

Potential outputs:

- Bar charts comparing suspected cases reporting through aggregate and case-based surveillance by year
- Side-by-side subnational maps comparing the number of suspected cases reporting through aggregate and case-based surveillance, and/or surveillance performance indicators or silent districts
- Ranked list/heat map of % of suspected cases reported through case-based surveillance as proportion of those in aggregate reports (no. cases case-based surveillance / no. cases in aggregate reports x 100)[9]

Notes:

- Note whether there are differences in case definitions or reporting practices for the systems that could explain the differences in reporting. For example, case-based surveillance may include additional measles cases identified in the field during outbreak investigations.



Example 18. Reporting of suspected measles cases through aggregate and case-based surveillance, Country Y. The aggregate surveillance system has had higher numbers of suspected cases every year, indicating incomplete case investigation. The difference between the cases reported in aggregate vs. case-based surveillance decreased in 2017-2018. This may be due to a lower number of cases reported overall making it more feasible to investigate every suspect case.

K. Comparison of vaccination coverage to VPD Surveillance

High disease incidence and large and repeated outbreaks occurring in areas with high reported coverage, merit detailed epidemiologic investigation. Interpretation requires careful attention to age and vaccination status of cases and eligibility for different doses, including the history of vaccine introduction, age of vaccination in schedule, historic coverage for birth cohorts, and SIA history (year, targeted age group). When comparing across areas, disease incidence (e.g., cases per 100,000 or million annual population, or by age-group) is a truer reflection of gaps in population immunity than number of cases. Looking specifically at incidence in vaccine eligible children under 5 years (e.g., 9 months to 4 years for measles) reflects more recent deficiencies in the vaccination program. More detailed comparison of confirmed cases and coverage data by age or birth year, i.e., by the year the children should have been vaccinated, is also relevant (i.e., age cohort analysis).

Data required: Cases of measles, rubella, diphtheria, neonatal tetanus, non-neonatal tetanus, polio and vaccine derived poliovirus, if relevant. Cases by reporting area, age, and vaccination status. Annual vaccination coverage in the general population for corresponding disease antigens. History and coverage vaccination campaigns and coverage, if relevant. Key surveillance performance indicators.

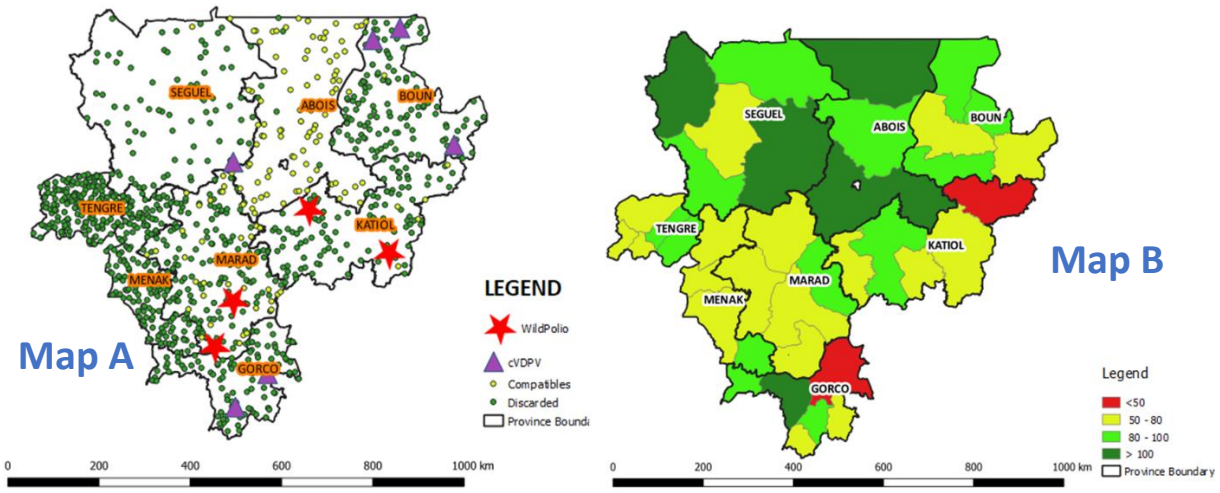
Potential outputs:

- Overlay or side-by-side color-coded maps of subnational coverage and disease spot maps comparing:
  - Confirmed measles and rubella cases with MCV (M or MR or MMR) coverage
  - Diphtheria or tetanus (neonatal and non-neonatal) cases with Penta3 and DTP4 coverage
  - Polio and vaccine derived poliovirus with polio vaccine coverage, if relevant
- Maps of disease outbreaks, disease incidence, age-specific disease incidence
- Bar graphs of cases by age and vaccination status for areas of interest
- Age cohort analysis of coverage, exposure to different vaccination campaigns, and confirmed cases within the corresponding birth year when relevant (example 21; see also Immunity Gap Annex 2)
- Subnational maps of VPD surveillance performance indicators, as relevant

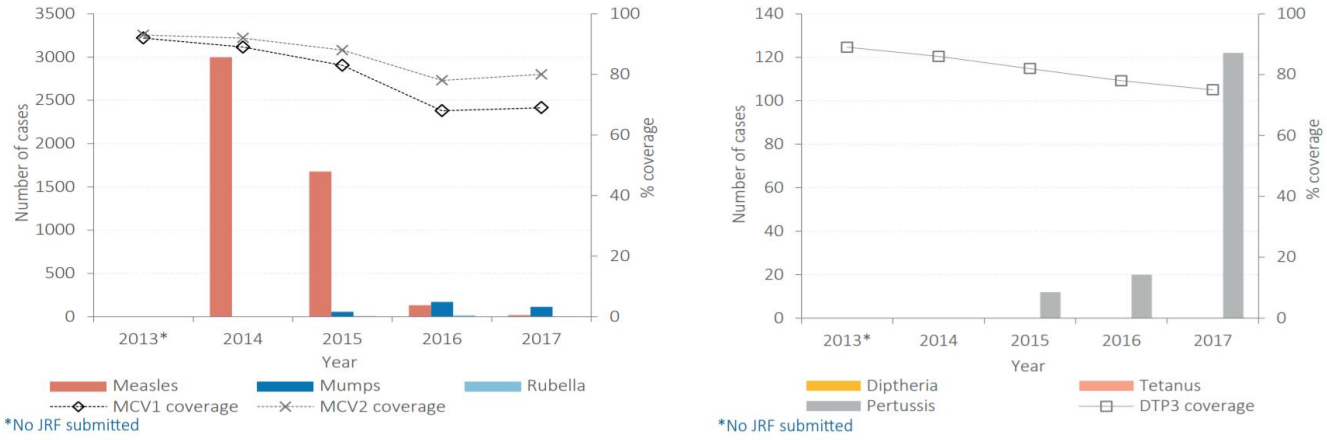
Notes:

- Where possible, use only the number of cases for ages under five years in comparisons with coverage. This is particularly relevant for diphtheria and tetanus vaccines that have waning immunity, without provision of vaccine booster doses in many countries.

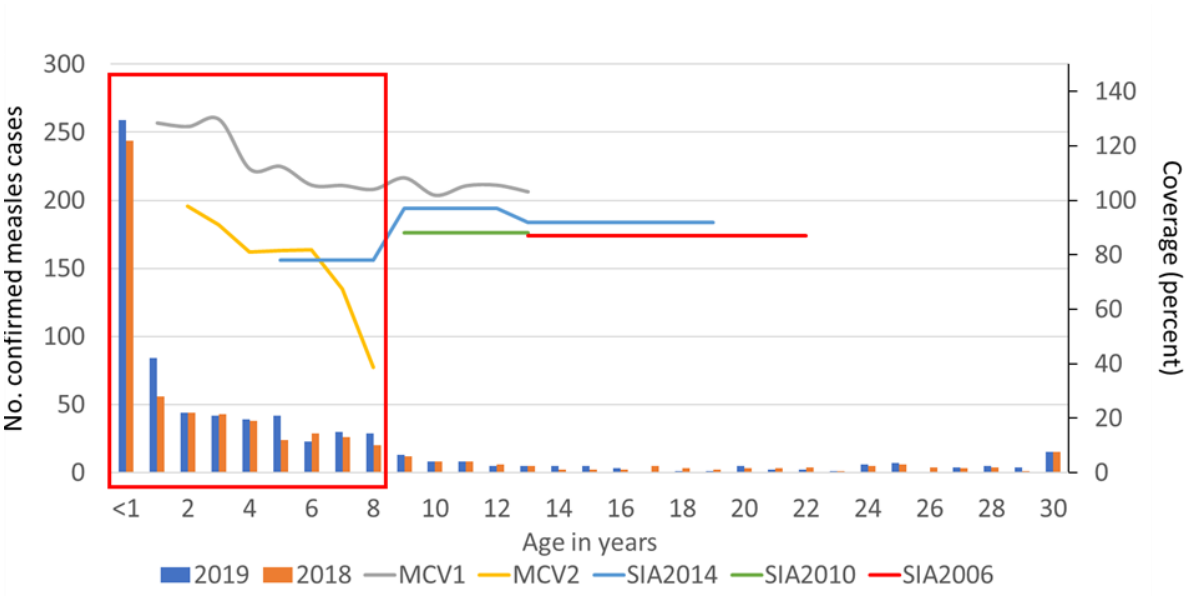
- Note the occurrence of recent SIAs with regard to year, antigen type, and target population where relevant, as this should be incorporated in the interpretation.
- Note: In areas of high coverage, surveillance data should detect fewer cases relatively speaking, but there will be a higher proportion of vaccinated cases.
- Surveillance performance indicators should be considered when interpreting the data (see D and J).



Example 19. Comparison of a dot map of acute flaccid paralysis (AFP) case final classification (A) and third dose coverage with oral poliovirus vaccine (OPV3) by district, 2016 (B). Wild poliovirus cases (stars) and circulating vaccine-derived poliovirus (cVDPV) cases (triangles) were detected in areas reporting varying levels of coverage, while districts reporting coverage <50% reported confirmed no polio cases. This result raises questions about the quality of subnational vaccination coverage data. A high number of compatible cases was reported in one state with higher coverage (Abios), raising concerns about surveillance data quality there.



Example 20. Combination graph of (left) measles, mumps and rubella (MMR) cases vs MMR vaccine (MCV) coverage estimates and (right) diphtheria, tetanus, and pertussis cases vs third dose of diphtheria-tetanus-pertussis (DTP3) vaccine coverage estimates in Country Z. WUENIC for both MMR1/2 and DTP3 vaccination have decreased starting in 2015, and mumps and pertussis cases have since increased. By contrast, measles cases have declined, raising the question of whether supplementary immunization has occurred or whether there are potential issues with surveillance reporting (Source: WHO-EURO Routine immunization country profiles. http://www.euro.who.int/en/health-topics/disease-prevention/vaccines-and-immunization/data-and-statistics).



Example 21. Age-cohort analysis of confirmed measles cases by age and historic coverage of different measles vaccination opportunities in district X, 2018–2019. MCV=measles containing vaccine; SIA=supplementary immunization activity. In a highly populated district with a relatively poorly performing program, most confirmed measles cases are among birth cohorts not targeted by SIA or recently missed by routine immunization services.

Consider explanatory causes

It is important to consider local knowledge and context during the synthesis of your data triangulation analyses. Performing a root cause analysis is also relevant (i.e., asking "why does this happen?" multiple times until the root cause is determined), as described elsewhere.[14] This will allow you to more accurately interpret the data, including explanatory causes and develop more targeted program improvement efforts.

Key considerations
Areas with large or repeated VPD outbreaks or known performance gaps (areas silent for VPD reporting may reflect poor surveillance, not lack of VPD occurrence).
Issues with public awareness of the importance of vaccination, unreliable stock or other service delivery challenges.
Data recording and entry issues, as well as missing reports in the health information system.
Changes in methodology, information system or data collection practices.
Areas with small populations, which may be unstable, or having unreliable population data.
Local practices regarding processes for data monitoring, supervision, and remediation of poor performance.

[14] World Health Organization (WHO). Handbook on the use, collection, and improvement of immunization data (2018 draft): https://www.dropbox.com/s/8ivdiu0g5xvnlbc/handbook.pdf?dl=1

Act

Develop a plan for action

After discussing the results with key players, develop a plan of action to address the identified gaps in data quality and immunization programme performance. The plan could include actions for any administrative level. Actions should be prioritized for what is feasible for the short- and long-term, based on potential impact and feasibility, i.e., what will take more time to address. Think creatively about solutions to the issues identified, especially if resources are limited.

Depending on the findings from the data triangulation analyses, some specific potential actions could be included in the following areas:

- Identifying subnational areas in need of:
    - Field assessment for root-cause analysis
    - Supportive supervision and targeted assistance
- Revising programme policy, guidance and processes
    - Monitoring indicators and process for data validation
    - Supportive supervision guidance & tools including more effective data use
- Implementing targeted interventions for data quality improvement or RI strengthening
- Raising issues to other decision-makers

Country X Example: Recommendations & Action Plan

Period	Recommendations
Short-term	• Improved/standardized approach to dashboards • Increase routine monitoring and corrections of errors in DHIS2 • Triangulation of 2018-2019 DHS, MICS and EPI coverage surveys • Targeted data quality self-assessment to evaluate numerator error
Medium-term	• Revise supportive supervision tools & manager training on data use • Conduct training and implement WHO Data Quality Tool in DHIS2 • Change tally sheets to be less complex for aggregation
Long-term	• Include supportive supervision and data quality self-assessment data in DHIS2 • Include annual microplan data in DHIS2 • Evaluate & consider pilots of electronic immunization registries

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