Public Health Data Triangulation for Immunization and Vaccine-preventable Disease Surveillance Programs:

Draft Framework Document

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Disclaimers

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Executive Summary

Robust methods for data triangulation have been developed and used successfully by health programs (e.g., HIV, reproductive health), as well as in other domains (e.g., education). The Expanded Program on Immunization (EPI) has an abundance of data sources (e.g., routine administrative data, coverage surveys, vaccine supply, program management, surveillance, serosurveys), but general guidance on triangulation methods for EPI program use has previously been lacking. With help from a Gavi Data Strategic Focus Area grant, the World Health Organization (WHO), United Nations Children's Fund (UNICEF) and the U.S. Centers for Disease Control (CDC) have been collaborating to develop an EPI data triangulation framework for the global immunization community, with a plan for county guidance to follow.

This framework document provides background on public health data triangulation, describes use of data triangulation by EPI programs, and outlines a rationale for developing more specific operational guidance on data triangulation for immunization and vaccine-preventable disease surveillance programs. The process used to develop this document included reviewing existing data triangulation methods and examples, gathering expert consensus through a technical consultation, and conducting an online survey of national and subnational EPI staff on potential user needs. The Strategic Advisory Group of Experts (SAGE) Working Group (WG) on the Quality and Use of Immunization and Surveillance Data reviewed the document and provided input. Finally, the framework was presented for broader feedback during the EPI Partners' Meeting on Improving the Availability, Quality and Use of the Data in Budapest, Hungary (October 2018).

Data triangulation is defined herein as an approach for critical synthesis of two or more existing data sources to address relevant questions for program planning and decision-making. The data triangulation process identifies and aims to address limitations of any one data source and/or data collection methodology. Data triangulation also encourages deeper insight into the phenomena of interest through making sense of complementary information and integrating knowledge of the broader context and underlying processes.

To date, EPI guidance data triangulation as described in the WHO Data Quality Review (DQR) toolkit, has focused exclusively on assessing data quality by checking consistency of similar indicators in different data sources (e.g., vaccination coverage from administrative data vs. survey data). Beyond this important purpose, there is also a potential role for data triangulation to guide policy and strategy, from vaccine introduction to verification of disease elimination, despite the existing data quality limitations of individual sources.

The proposal is for the triangulation process articulated in the DQR to be: (1) generalized and expanded to address data analysis topics of broader relevance to the EPI program, (2) driven by important program questions articulated by immunization and surveillance programs, e.g., identification of immunity gaps, and assessment of program impact, and (3) incorporating use of disparate data sources (e.g., VPD surveillance, vaccine supply/use) that add richness to the analysis and interpretation. The approach would emphasize better use of available data to inform decision-making for program planning and changes in policy and strategy.

The proposed audience for the data triangulation guidance will include national and subnational EPI, surveillance, and health information staff. Guiding principles and a 10-step process for conducting EPI data triangulation are proposed, as adapted from a standardized public health triangulation approach developed by the HIV program. The guidance document will be formatted as basic and advanced chapters that are tailored to the capacity and relevant data triangulation questions at different program levels. Both levels will have annexes with cases studies structured around several key triangulation questions.

As follow-up, triangulation guidance and training is being developed and piloted in two countries during 2019 to early 2020. After refinement based on country experiences, the final WHO guidance is intended for the second half of 2020. It is hoped that building capacity for Data Triangulation within the EPI program could contribute to a strengthened health system and fewer unimmunized or under-immunized children through increased use of data for program planning and decision-making.

Background on this Document

WHO, UNICEF and CDC are collaborating, with help from a Gavi Data Strategic Focus Area grant, to develop an EPI data triangulation framework and accompanying country guidance through review of existing methods and examples, gathering expert consensus, and piloting use of the methods in two countries before finalizing as a WHO guidance document.

This framework document, written for the global immunization community, is the first output from the collaboration. The framework aims to provide background on public health data triangulation and outline the potential application of specific operational guidance on data triangulation for immunization and vaccine-preventable disease surveillance programs. The Strategic Advisory Group of Experts (SAGE) Working Group (WG) on the Quality and Use of Immunization and Surveillance Data, convened between August 2017 and April 2019, has recognized the importance of EPI data triangulation and agreed to review this Framework document and publish a related manuscript as a joint-product of the SAGE Data WG.

During 31 May–1 June 2018, a technical consultation group was convened to develop consensus on inputs for a draft framework on EPI data triangulation and develop a list of project deliverables and timelines. Representatives from WHO, CDC, and Gavi Secretariat attended, as well as two members of the SAGE Data WG. Representatives from UNICEF and Bill and Melinda Gates Foundation were unable to attend, but their input was included through conference calls and review of meeting outputs.

Prior to the meeting, CDC participants conducted a landscape analysis of general methodologies for data triangulation, examples from other health programs (HIV, TB, malaria, reproductive health, and clinical care), and examples from EPI. Published and grey literature references were obtained from PubMed and Google searches; consultation with immunization experts at CDC, WHO, UNICEF, BMGF and Gavi and HIV experts at CDC and UNAIDS; and snowballing of cited references. References were abstracted in an excel spreadsheet including the purpose, methods (data sources, indicators, analysis), and findings. Members of the technical consultation reviewed an initial draft of the landscape analysis and contributed more references, mostly to fill noted gaps in country examples and triangulation of vaccine use, vaccine supply, and program management indicators. In the end, the review included 44 references on general triangulation methodology and examples from other health programs, including 16 HIV references. Also included were 122 references consisting of EPI examples. Key references were used as a basis for developing this document, and prominent examples are summarized in subsequent sections.

In addition, questionnaires on EPI data triangulation were developed using SurveyMonkey® and deployed as online convenience surveys through emails of professional networks and the Better Immunization Data (BID) Initiative listserv. The first survey targeted global immunization partners (n=32 responses), and the second survey targeted national and subnational staff in the areas of immunization, surveillance, vaccine supply/logistics, and health information (n=36 responses). Questions included opinions on relevant triangulation objectives and data sources, as well as preferences for what the guidance could include and how it could be implemented. Survey responses were used to gauge what the EPI data triangulation guidance should address.

The review process for this Framework document included review by the member of the original technical consultation and SAGE Data WG, as well as presentation for broader feedback at the “EPI Partners’ Meeting on Improving the Availability, Quality and Use of the Data” in Budapest, Hungary during 9–11 October 2018. During the meeting, input was received by attendees in the context of the plenary session with interactive feedback from the audience by Mentimeter, a working group discussion session, and a small group process to prioritize activities for the next 2 years.

Based on feedback from participants, draft data triangulation guidance for the national and subnational program levels are being developed and piloted in two countries (one completed during 2019, and the second continuing into early 2020). The guidance will be revised based on the country experiences and published as WHO guidance in the second half of 2020.

History of Data Triangulation Use

The term triangulation originated in the fields of maritime navigation and land surveying as a method to determine the position of a given point using the angles and distance between two landmarks (7, 8). The quantitative psychologists Campbell and Fiske (1959) were the first to describe a triangulation process using multiple data sources and tests to evaluate the same phenomenon and look for "convergent validity" (9). The underlying assumption was that confidence in conclusions could be increased if different data sources and methodological approaches yielded consistent results to the same question.

Denzin (1978) further developed triangulation as a research strategy including four general categories: (a) data triangulation including time, space, and person; (b) investigator triangulation, (c) methodological triangulation, and (d) theory triangulation (10). However, it has been noted that only the first three are feasible in practice, and the fourth acknowledges the importance of considering theoretical context(s) as part of the analysis (10-12).

Since the 1970s, triangulation has been employed in a broad range of research in the social and health sciences, including political science, geography, social work, education, and nursing (7, 8, 11, 12). Over time, the focus of triangulation has shifted from using triangulation to "validate," or correctly ascertain an objective truth, to enrichment of knowledge and deepening of understanding (8, 11-13). There has also been greater acknowledgement that triangulation outcomes may not always *converge*, but that making sense of inconsistencies provides an opportunity to gain deeper insight about the phenomena of interest (8, 11-13).

Since the early 2000s, there has been a surge in the use of data triangulation for public health. In this context, data triangulation can be used to address important questions around assessment of disease burden and risk, program monitoring and impact, and the quality and reliability of information sources. A standardized approach to "public health triangulation" has been developed and used by HIV programs (14-16). The published and grey literature also provide examples of use of triangulation for tuberculosis, malaria, and reproductive health (17-19). While specific examples of data triangulation use by immunization and surveillance programs exist (see Landscape section), guidance for general program use is lacking.

What is Data Triangulation?

Within the last 5 years, the term "data triangulation" has been used with increasing frequency in the EPI field, without a common functional definition. In common parlance, data triangulation can be used to describe everything from pen-and-paper comparisons of coverage figures (e.g., administrative reporting vs. survey) to complex modeling of disease burden (Figure 1). Based on the landscape analysis conducted, triangulation can be used by the EPI program for five types of analytic objectives: 1) check of consistency across data sources (e.g., coverage monitoring); 2) diagnostic for targeting program interventions (e.g., risk assessments, surveillance performance monitoring); 3) estimation of coverage, target populations, or disease burden; 4) observational evaluation of the impact of interventions (e.g., vaccine introduction, campaigns), and 5) holistic assessment of program adequacy (e.g., outbreak investigation, disease elimination verification).

Similar to other definitions used in public health fields (16), we have defined data triangulation as an **approach for critical synthesis of data from two or more sources to address relevant questions for program planning and decision-making**. The data triangulation process identifies and aims to address limitations of any one data source or data collection methodology. Data triangulation also encourages deeper insight into the phenomena of interest through making sense of complementary information and integrating knowledge of the broader context and underlying process.

For our purposes, it may help to clarify that data triangulation is ***not***: 1) meta-analysis or other well-defined research methodologies; 2) assessments of data quality that evaluate consistency of data originating from the same source (e.g., tally sheets and summary reports of this data); or 3) presenting two different graphs, without synthesis and interpretation of the data.

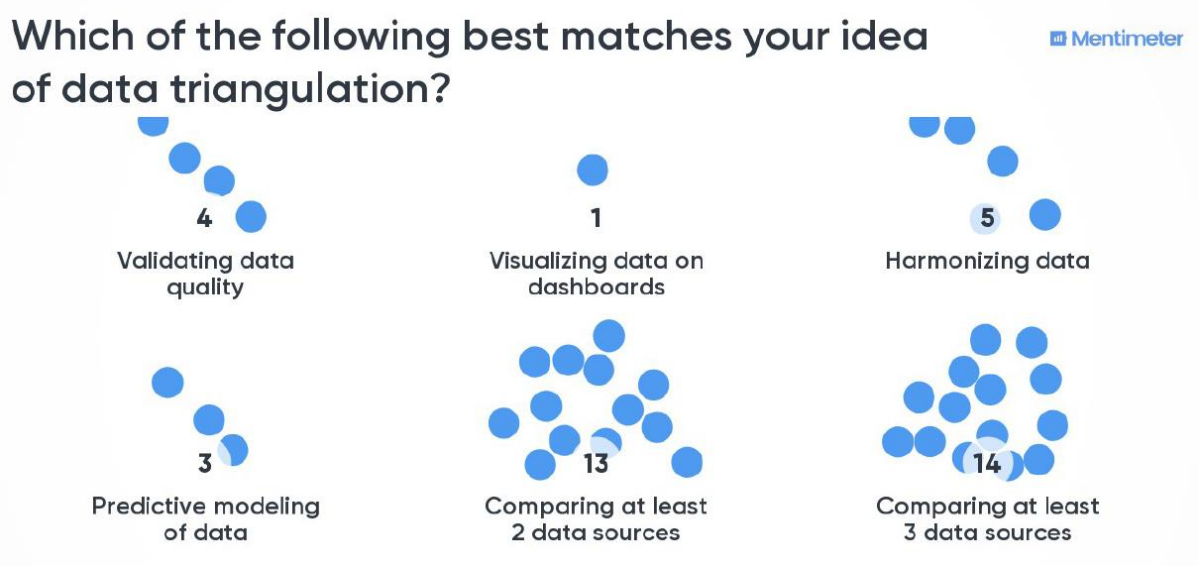


Figure 1. Interactive survey (Mentimeter) responses (n=40) for the definition of data triangulation during the EPI Partners' Meeting on Improving the Availability, Quality and Use of the Data in Budapest, Hungary, 9–11 October 2018.

Example of Data Triangulation Use by the HIV Program

Examples of data triangulation use by HIV programs have been documented going back at least 20 years (16). Within the past 10 years, robust technical guidance has been developed by WHO (2009), UNAIDS (2010) and FHI (2010), and includes a 12-step process (Table 1) (14, 15, 20). This 12-step data triangulation process from the HIV field has been proposed for general public health use in Rutherford *et al* 2010 (16).

Table 1. Public health data triangulation process from Rutherford et al. 2010 (16)

Which part of the process?	What steps are involved?
Planning	**Step 1**: Identify key questions
	Step 2: Ensure question is important, actionable, answerable & appropriate for triangulation
	Step 3: Identify data sources & gather background information
	Step 4: Refine research question
Conducting	**Step 5**: Gather data/reports
	Step 6: Assess data reliability & make observations from each data set
	Step 7: Note trends across data sets & hypothesize
	Step 8: Check (corroborate, refute, modify) hypotheses
	Step 9: If necessary, identify additional data & return to step 5
	Step 10: Summarize findings & draw conclusions
Communicating	**Step 11**: Communicate results & recommendations
	Step 12: Outline next steps for public health action

Early use of data triangulation for HIV usually occurred in the form of country-specific capacity building workshops including relevant stakeholders and using the 12 steps described above. Early HIV data triangulation examples included process (e.g., are there disparities in the reach of and access to HIV treatment) and outcome questions (e.g., what is the overall trend in HIV prevalence nationally and what is the impact of treatment on HIV transmission). Data sources included antenatal clinic surveillance, population-based surveys, national census data, prevention and treatment delivery reports, data from other health programs, and special studies.

Recently, a more robust array of HIV data sources has become available, including health facility program data (national and sub-national), surveillance data (e.g., Population-based HIV Impact Assessments, integrated bio-behavioral surveys), and modeled data. HIV data triangulation use has shifted towards routine monitoring of program targets associated with the HIV Cascade, or the stages of HIV care from initial

diagnosis, to receiving treatment, and achieving viral suppression (with targets of 90% each, respectively). HIV triangulation now primarily focuses on locating the undiagnosed, untreated, and unsuppressed populations in order to geographically target testing and treatment programs.

HIV data triangulation continues to play an important role in on-going monitoring and evaluation, as well as capacity building for more effective data analysis. Although triangulation workshops are not as frequently conducted, some countries (e.g., India, Tanzania) have continued using the triangulation tools at trainings at the state and local levels. In recent years, the global HIV program has been successful in creating a culture of monitoring by using triangulation methods to review and synthesize data on a monthly or quarterly basis using program, surveillance, financial, and quality improvement data.

Lessons learned from the HIV data triangulation experience

- Focus on key triangulation questions related to identified program information gaps and priority interventions (not research)
- Intentional effort may be needed at first to build triangulation capacity, but then methodology should be incorporated into routine monitoring and evaluation processes and tools

Landscape of Data Triangulation Use by the EPI Program

Data triangulation has been used for a long time in the EPI field, without necessarily using the term "data triangulation." The lack of unifying terminology made it challenging to systematically review EPI use of these methods within the literature. However, examples were identified through targeted literature searches and soliciting key examples from EPI colleagues. Key examples of triangulation use are described below (Table 2).

Table 2. Examples of EPI data triangulation use by program area

Program area	Examples of data triangulation use
Global Polio Eradication, Measles & Rubella Elimination	• Monitoring quality and impact of immunization activities • Outbreak investigations • Risk assessments • National and Regional Certification/Verification Committees
Maternal & Neonatal Tetanus Elimination	• Risk assessments
New & Underutilized Vaccine Introduction	• Vaccine introduction impact assessments
Coverage & Equity Monitoring, Data Quality & Use	• WHO and UNICEF Estimates of National Immunization Coverage (WUENIC) • Health Equity Assessment Toolkit (HEAT) • Data Quality Review (DQR) • Population denominator guide
Vaccine Supply Chain & Logistics	• Dashboards of Immunization Supply Chain (DISC)
Surveillance	• Monitoring quality of surveillance performance

Some of the earliest EPI data triangulation examples identified come from the polio eradication, and measles and rubella elimination programs. Figures 2 and 3 are examples of triangulation between disease incidence, vaccine coverage, and estimated disease susceptibility, visually displayed in a way that will be familiar to most readers of this document. The first graph helps with interpreting whether increases in routine immunization coverage or periodic supplementary immunization activities (SIAs) yielded the anticipated impact on measles cases (1). The second analysis performed during an outbreak investigation provides a visual assessment of whether any age cohorts have high susceptibility as a result of low coverage or vaccine failure and should be targeted by SIAs (5). The Measles Strategic Planning Tool facilitates similar analysis in Excel of age-specific susceptibility due to vaccine effectiveness, annual fluctuations in coverage, and exposure to campaigns, as well as modeling the impact of different vaccination strategies (21).

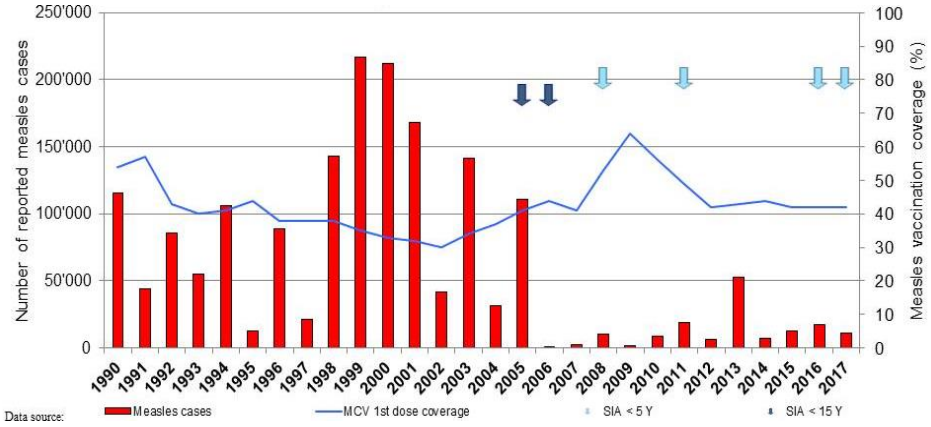


Figure 2. Measles cases, coverage with the first dose of measles-containing vaccine (MCV1) and supplementary immunization activities (SIAs) by year— Nigeria, 1990–2017 (1). Measles incidence declined in 2006 after SIAs targeting ages <15 years. Since then, MCV1 coverage has stagnated and incidence has fluctuated with SIA implementation.

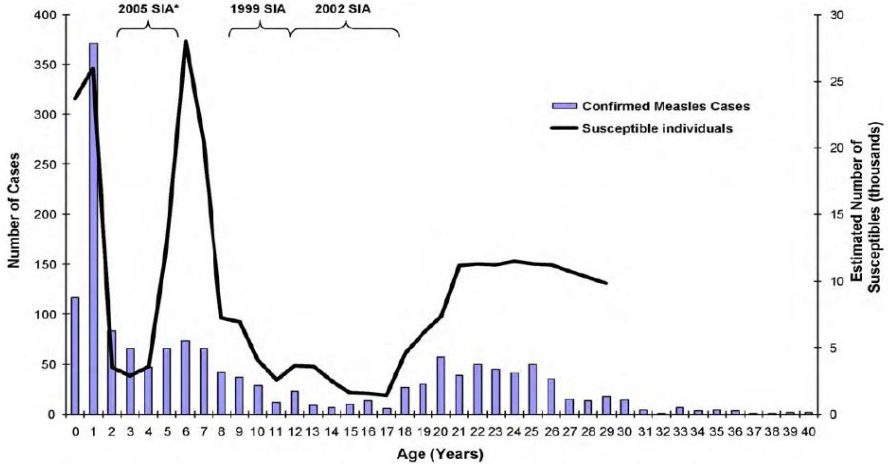
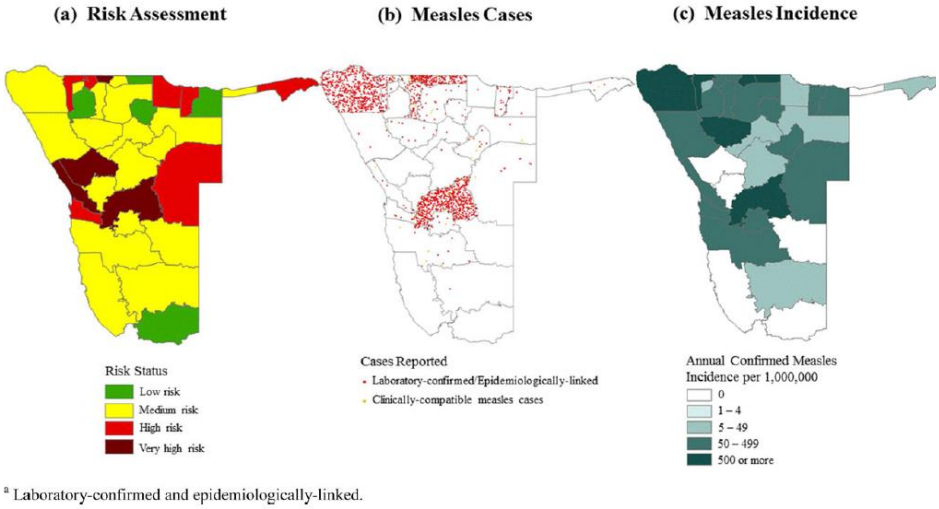


Figure 3. Measles cases and susceptibility by one-year age cohort based on vaccine effectiveness, annual fluctuations in coverage, and exposures to SIAs — Tanzania, 2007 (5). Confirmed measles cases generally occurred among age cohorts with greater susceptibility that were not targeted by SIAs.



[a] Laboratory-confirmed and epidemiologically-linked.

Figure 4. Maps visualizing measles data, Namibia. (A) Measles risk assessment, 2006–2008, (B) measles surveillance cases, 2009, (C) measles incidence, 2009. This analysis showed that areas assessed as very high risk using the measles risk assessment tool predicted measles outbreaks and disease risk, although this has not always been the experience in documented examples from other countries (6).

Polio and measles risk assessment tools were developed to identify subnational areas for targeted program improvement (22, 23). The tools weight more than 20 indicators in the areas of population immunity, surveillance quality, program performance, and threat assessment, and output risk categories that can be mapped by color to facilitate visual interpretation of risk by geography (Figure 4). The risk assessment tool for Maternal and Neonatal Tetanus Elimination (MNTE) uses an algorithm (i.e., decision tree) to assess tetanus risk at the district level through triangulation of vaccination coverage and surveillance data with maternal-child health indicators (e.g. clean deliveries) (24). High-risk districts are flagged for targeted SIAs of women of reproductive age.

The annual processes associated with National and Regional Certification Committees for Polio Eradication and Verification Committees for Measles, Rubella, and Congenital Rubella Syndrome Elimination are also good examples of data triangulation (4, 25). These committees pose the central question: "Is the evidence sufficient to certify/validate the absence of polio/measles/rubella transmission?" The process focuses on synthesizing analyses of surveillance data, including performance indicators for "elimination-standard" surveillance, as well as population immunity and other indicators of program performance (Figure 5).

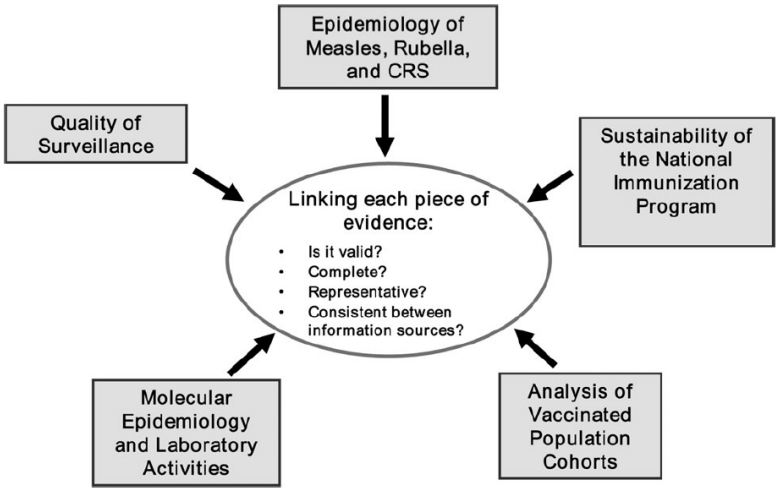


Figure 5. Schematic of the process of verifying Measles, Rubella, and Congenital Rubella Syndrome Elimination in the Region of the Americas (4). Various lines of evidence are linked and evaluated with regard to validity, completeness and representativeness. Consistency of information between sources is also assessed.

Disease eradication and elimination programs have also provided examples of data triangulation to monitor the quality of immunization activities and identification of immunity gaps, including comparisons of coverage with seroprevalence, or the proportion of cases detected by surveillance that were vaccinated (26, 27). For introduction of new and underutilized vaccines, widespread impact assessments have been conducted that triangulate coverage, program management data, and lab-based sentinel surveillance, in the context of the timing of vaccine introduction (28, 29).

Since 2000, WHO and UNICEF have provided Estimates of National Immunization Coverage (WUENIC) using a methodology to triangulate coverage survey, administrative reporting (coverage, numerator, denominator), and other program data (e.g., stock-outs) to provide a best estimate of coverage each year (30, 31). A method of subnational coverage estimation is currently under development and has been piloted in India, Pakistan and Ethiopia (Figure 6) (3). More commonly, analyses that check the consistency of coverage from administrative reporting against coverage survey results are performed (32, 33). Spatially modeled surfaces of coverage from Demographic Health Surveys (DHS) are now regularly available online and represent a potential source of coverage data for use in triangulation (34, 35). Similarly, predictive modeling of subnational coverage by the Institute for Health Metrics and Evaluation (IHME) based on DHS coverage, a variety of geospatial covariates, and administrative coverage data is an example of advanced triangulation (36). With further validation, these type of methods show promise for routinely producing more reliable estimates of subnational coverage at the global level.

The Health Equity Assessment Toolkit (HEAT) is a software package that allows analysis and visualization of vaccination coverage by different dimensions of inequality, such as age, education, economic status, place of residence and subnational region; comparisons with other program indicators and across settings are also possible (37). The software is available as an online or standalone version, and either comes preloaded with many years of data from the Demographic Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS), or with the ability to upload and analyze other data sources. Interactive country profiles with these data also exist in the WHO Health Equity Monitor website (38). Triangulation of quantitative and qualitative data to validate or contextualize information, e.g., surveys of caretakers or healthcare workers to identify reasons for non-vaccination, is also relevant for addressing coverage and equity issues (39).

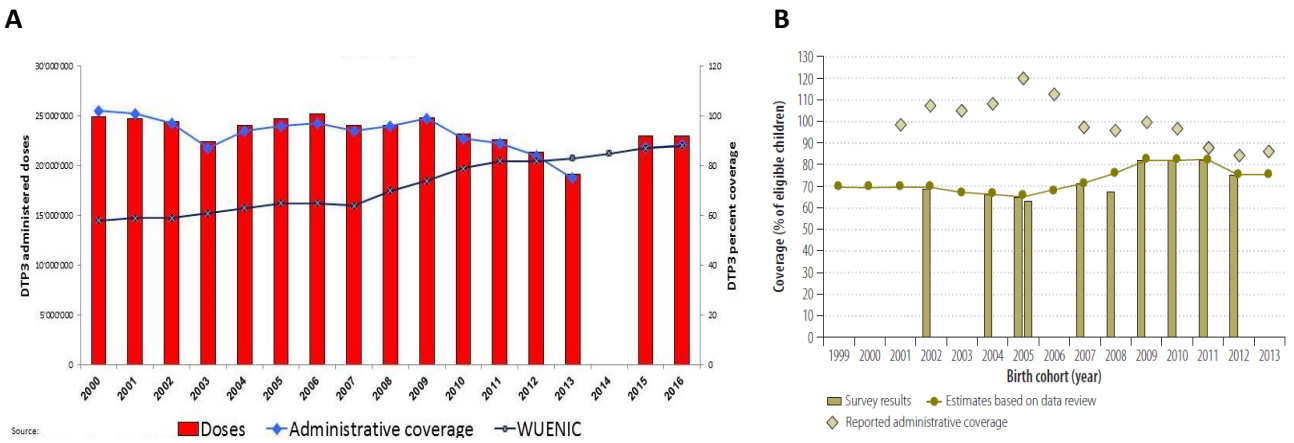


Figure 6. (A) Third dose of diphtheria-tetanus-pertussis vaccine (DTP3) in India during 2000–2016, including doses administered, administrative coverage, and WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) (1). Through 2011 when a national census occurred, trends in administrative coverage and reported doses were consistent and generally higher than WUNEIC. During 2015–2016, the three sources were consistent. (B) Estimates of DTP3 vaccination coverage in Chhattisgarh state, India during 1999–2013 as part of a subnational coverage estimation exercise (3). Administrative coverage was more consistent with estimated coverage and survey results after 2011.

Various data quality assessment tools have been developed for use by immunization programs, including the Data Quality Audit (DQA, 2003) and Data Quality Self-Assessment (DQS, 2005) (40, 41). The DQA was the first example of a data quality assessment methodology, which has been replicated by other programs (42). The DQS is a simplified method that is easier to implement by immunization programs. Both tools are field-based approaches to assess the fidelity of recording vaccine doses across various forms and the integrity of the reporting process, i.e., doses reported at various levels. While independent validation of reported figures by re-tallying primary source data in the field may represent a form of investigator triangulation, these processes did not meet our definition of data triangulation because the data compared are aggregate data originating from the same source.

The Data Quality Report Card (DQRC, 2015) and Data Quality Review (DQR, 2018) are integrated assessment tools that include EPI and other programs (antenatal care, HIV, tuberculosis, malaria) as part of a health systems approach (43, 44). These methods include desk reviews of different data sources and specific analysis steps analogous to the public health data triangulation process (Table 3) (16). For example, the DQR assesses reporting completeness and timeliness; separate trends in reported coverage, numerators and denominators; consistency between related indictors (e.g., doses given at the same opportunity); external comparisons with other data sources (e.g., survey coverage, UNPD population); and a root cause analysis performed after a field assessment. This process has carried forward to the Immunization Information Systems Assessment (2017, draft) and WHO Data Monitoring Handbook (2018, draft), which include a systems assessment and an emphasis on data quality improvement planning (37, 45). A data monitoring module for the District Health Information System 2 (DHIS2) with the same triangulation steps has also been developed by WHO, with accompanying guidance (38).

Draft WHO guidance on Improving the Quality and Accuracy of Population Denominators (2015) provides methods for triangulating different sources of population data for the purpose of assessing consistency and improving immunization target estimates (46). Analyses that assess the potential impact of using program denominators versus estimates from the United Nations Population Division (UNPD) on vaccination coverage have been published (30, 47). Use of spatially modeled population estimates from satellite images as an additional data source for triangulation is an area of ongoing research (48).

Table 3. EPI triangulation guidance in Data Quality Review (44)

Key Triangulation Process Steps	Data Quality Review	Immunization indicators/comparisons
Assess reliability and trends in each data set (completeness, plausible variation)	• Completeness of reporting • Internal consistency (outliers)	• Coverage, doses, and population • DTP1-3 vs. PCV1-3/ OPV1-3, MCV1 • National vs. subnational • HMIS vs. survey • DTP1 vs. DTP3 • DTP1 vs. ANC1 • Official births vs. UNPD • Official births vs. health program
Compare across data sources and over time (agreement, disagreement, silence)	• Consistency between indicators • External comparison with other data sources	
Consider underlying explanatory causes (limitations, sources of error)	• Root cause analysis (after field assessment)	

Triangulation of vaccine supply and other immunization program management data is also a growing area of interest. A routine immunization monitoring dashboard has been implemented in multiple countries in the African region that includes indicators for vaccination coverage, data quality (reporting completeness, negative dropout rates, coverage >100%), and various process indicators (immunization sessions, outreach, vaccine stock-outs, microplans, supervision) (49). Comparisons of wastage and various stock level indicators could help increase program efficiency by reducing wastage and preventing stock-outs and loss of vaccine potency. As more countries introduce Logistics Management Information Systems (LMIS), supply data may be of increasing availability and quality. Guidance on Dashboards of Immunization Supply Chain (DISC) within LMIS has been developed to support easier visualization and use of these data, including triangulation (50). Comparisons of vaccine doses used or shipped to vaccine doses administered and wasted may be a helpful validation check for coverage numerator data (51). More research in this general area is needed.

In the area of vaccine-preventable disease (VPD) surveillance, various disease-specific performance indicators exist (e.g., reporting completeness, surveillance sensitivity, adequacy of case investigation and laboratory confirmation) that are calculated from several different information sources (aggregate facility reports, case investigations, and laboratory data). Monitoring these indicators in combination with incidence data is helpful for determining surveillance reliability and for identifying areas needing improvement (52). Within a country, comparisons of the numbers of suspected cases reported through aggregate surveillance or a Health Management Information System (HMIS) with case-based surveillance (e.g., for polio, measles, neonatal tetanus) may be helpful to identify a need to improve case investigations (53). Detection of VPD cases through surveillance often highlights immunity gaps not previously appreciated due to issues with the quality of subnational vaccination coverage data. In general, increased integration and use of current and historical vaccination coverage and surveillance data together by EPI programs is needed.

In the last 3 years, data triangulation has been discussed by the SAGE Measles-Rubella WG as having a role in identifying immunity gaps. Data triangulation projects have been commissioned by the SAGE for deliberations around changing the diphtheria vaccination schedule and by the SAGE Data WG to assess the quality of tetanus surveillance data as a potential monitoring tool for the life-course of vaccination approach (54, 55). The urgent need for guidance and capacity building on EPI data triangulation was articulated at the Gavi Data Partners Meetings in Geneva during 25–28 June 2017 and in Cascais during 23–25 October 2017. One guidance document that explicitly addressed this need was entitled “Data Triangulation: Use of Health Facility Immunization Reporting Tools” from John Snow Inc. (2017) (Figure 7). The document outlines an approach to harmonizing EPI data on tally sheets, registers, vaccination cards, monitoring charts, stock ledgers and monthly reports towards improving the quality of the data recorded at health facilities (2).

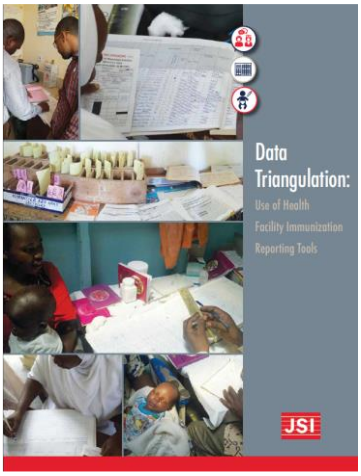


Figure 7. John Snow Inc. guidance on data triangulation of health facility data (2)

Rationale for Developing Guidance on EPI Data Triangulation

An increasing amount of data are being collected by the EPI program, but data use and synthesis are still limited. To date, guidance from EPI on data triangulation, i.e., DQR and JSI guide, has focused exclusively on assessing data quality by checking consistency of like indicators in different data sources (e.g., administrative coverage vs. survey). Beyond this important purpose, there is also a potential role for data triangulation to guide policy and strategy, from vaccine introduction to verification of disease elimination, despite the existing data quality limitations of individual sources.

We propose that the triangulation process articulated in the WHO Data Quality Review be: (1) generalized and expanded to address data analysis topics of broader relevance to the EPI program, (2) driven by important program questions articulated by immunization and surveillance programs, e.g., identification of immunity gaps, and assessment of program impact, and (3) include use of disparate data sources (e.g., VPD surveillance, vaccine supply/use, program management, serosurveys, etc.) that add richness to the analysis and interpretation.

The approach would emphasize better use of available data to inform decision-making for program planning and changes in policy and strategy. Even if not the primary objective, an assessment of data quality would be embedded in the analytic process and could continue to identify issues and inform the data improvement cycle (Figure 8). The use of data to answer relevant questions of program equity, efficiency and impact on disease burden has the potential to better highlight the importance of having high quality data relative to performing assessments of data quality in isolation.

The potential benefit of data triangulation for EPI programs is as follows. Data triangulation:

- Uses existing data and does not require additional data collection in the field;
- Encourages deeper understanding of data analysis and individual data, including synthesis with contextual information, framing within the epidemiologic and/or program process, and consideration of data limitations;
- Identifies areas for program improvement, including data quality, that might not be apparent from use of individual data sources;
- Improves confidence in conclusions and the quality of recommendations for planning and policy/strategy decision-making;
- Strengthens the health system and promotes a “data-use culture” by building capacity for critical thinking, data analysis and use within the context of an increasingly data-rich environment.

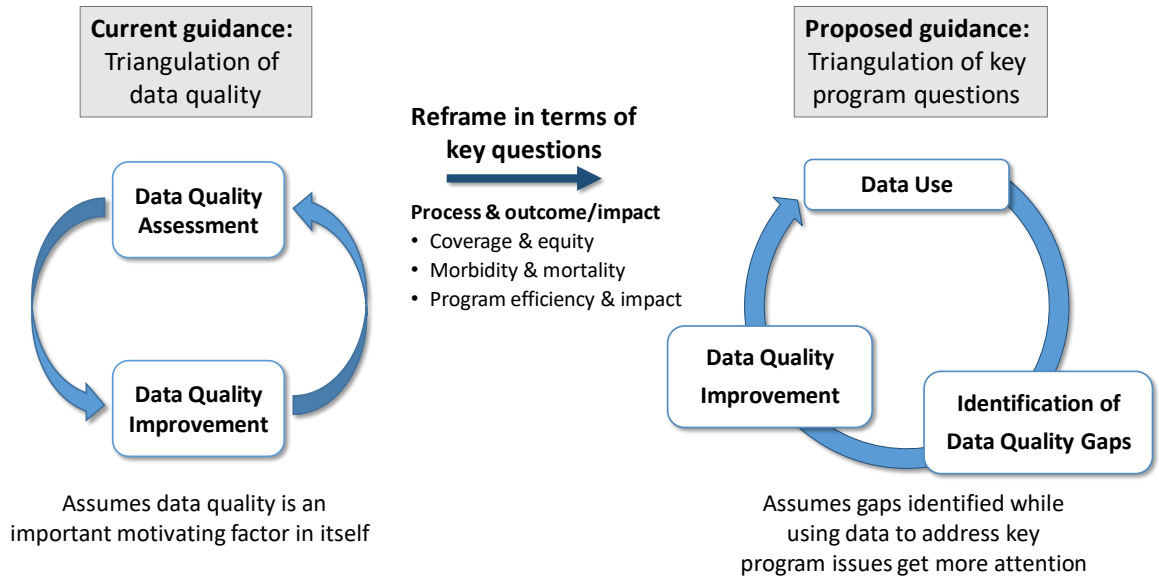


Figure 8. Reframing EPI Data Triangulation in terms of key program questions.

Guiding Principles for Data Triangulation

In terms of settings where conducting data triangulation may be feasible, the following guidance on *minimal criteria* are proposed*:* 1) existence of two or more different data sources that address the phenomena of interest (usually requiring shared dimensions of place and time), 2) data management/analysis capacity, and 3) willingness to take action on results. The format of implementation and persons involved in triangulation will vary based on the level (national vs. subnational) and frequency (routine vs. ad-hoc) of implementation. In general, the skills and job functions that a minimal team would possess include data analysis and program management (with decision-making authority, or with ability to effectively disseminate to such a person). Considerations for team composition and implementation are outlined in #4 below and in a later section. Below are six guiding principles of data triangulation for immunization and surveillance programs (adapted from Rutherford *et al* 2010) (16):

1. **Objective-driven process**: Questions that are programmatically important for the context should drive the data triangulation process. The scope should be limited based on what questions can be answered and acted upon, given the available time and resources.

2. **Use of existing data**: Generally, data triangulation is conducted as a desk review using the best existing data. Triangulation of existing sources could indicate a need for more data collection or field validation, but this piece is considered outside the scope of data triangulation guidance.

3. **Inclusion of diverse data sources**: Use of multiple, diverse datasets can help overcome the limitations of any one data source and deepen understanding. Data that include trends in process and outcome indicators that logically show a sequence of events may be particularly helpful. Explanatory studies and qualitative data may help provide contextual information and potential explanations for the results.

4. **Engaging a multidisciplinary team**: Triangulation benefits from broader collaboration across different government units and other organizations with varied expertise and access to data sources. It is important to engage key stakeholders for formulation of a question, identification of data sources, analysis of data, interpretation and dissemination of results.

5. **Basic analysis and interpretive synthesis of results:** Triangulation should focus on simple descriptive analyses and data visualizations, more than statistical analyses. The interpretation of results should preferably be integrated with contextual information and attempt to explain areas of agreement, disagreement and any limitations, similar to what is done in a narrative review.

6. **Using results for action**: Understanding the root causes that drive performance and data trends leads to better recommendations. All triangulation should inform improvement planning and/or decision-making on immunization program policy and strategy.

Data Triangulation Methodology

An overview of the draft methodology for the EPI triangulation process is shown in Table 4 and Figure 9. The process is flexible to accommodate questions most programmatically relevant for countries, including routine monitoring and ad-hoc evaluation needs. Triangulation can be outlined of as a 10-step process (adapted from the 12-step HIV data triangulation process[1]) that starts with identifying the key public health questions and ends with developing a plan for public health action (16). While each step is important, the triangulation process does not always need to be lengthy, particularly if the analysis builds on previous work, e.g., updating an analysis previously conducted on the same topic in a country, or an automated analysis for routine use.

[1] For simplicity's sake, steps 1 + 2 and 10 + 11 in Table 1 were combined.

Table 4. Proposed 10-Step Process for EPI Data Triangulation

Which part of the process?	What steps are involved?
Planning	**Step 1**: Identify key program problem or question
	Step 2: Identify data sources & gather background information
	Step 3: Refine analysis question to one that is answerable & actionable
Analysis	**Step 4**: Gather and prepare data in usable format
	Step 5: Assess reliability and trends in each data set
	Step 6: Compare consistency & trends across data sets
	Step 7: Consider different explanatory causes for trends, including sources of error
	Step 8: If necessary, identify additional data & go back to step 4
Results for Action	**Step 9**: Develop and disseminate a report summarizing the results & recommendations (include limitations and gaps in information)
	Step 10: Develop plan for taking action

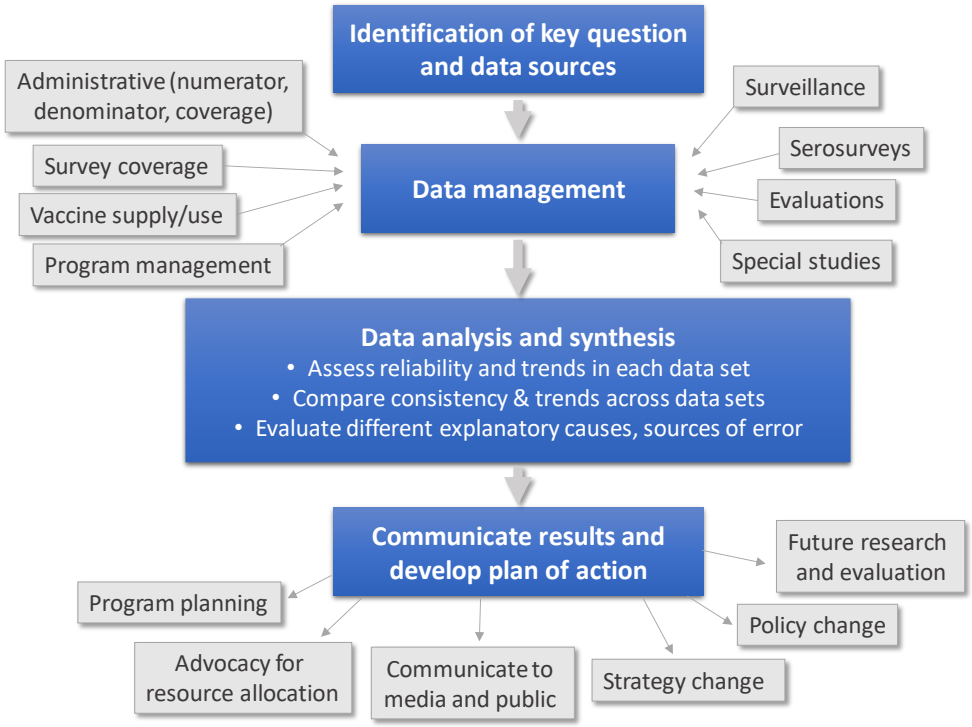


Figure 9. Schematic of Data Triangulation for Immunization and Surveillance Programs

Planning

A multidisciplinary team should be engaged from the beginning to articulate important program issues, aid in formulating the question for triangulation, and identify relevant data sources. Involving partners with diverse areas of expertise (e.g., demographers, refugee health officers) from different units of the government, non-governmental organizations, and national immunization technical advisory groups (NITAGs) has the potential to allow access to different data sources and a more informed interpretation of results. The following broad areas are relevant for use of EPI triangulation approaches:

1) Assess and improve data quality (e.g., coverage, vaccine supply/use, denominators, surveillance)
2) Identify immunity gaps and assess disease risk (e.g., age-groups, geographic areas, high-risk populations)
3) Monitor program performance (e.g., coverage, vaccine use/supply, surveillance)
4) Evaluate impact of interventions and program improvement (e.g. on disease burden, health system)
5) Verify and monitor progress towards disease elimination and control goals.

In terms of formulating a key question for the triangulation exercise, the criteria in Table 5 are suggested (16). Questions not meeting the criteria should be further refined to *limit the scope* to questions that can be answered and that have the potential to be acted upon.

Table 5. Criteria for a data triangulation questions (16)

Criteria	Description
Relevant	• Is the question important and timely based on country priorities?
Answerable	• Are data available to address question? • If trying to evaluate a recent change, has adequate time elapsed to allow measurement of the outcome?
Actionable	• Will the answer lead to initiation of public health action? • Will identified issues be modifiable and amendable to interventions?
Appropriate	• Is the question best addressed by triangulation vs. a research methodology, or analysis of a single data set?
Feasible	• Are sufficient time and resources available for completion?

For triangulation, the use of multiple, diverse data sets is recommended for deepening understanding and overcoming the limitations associated with any one data source. Data sources might include administrative coverage, coverage survey, vaccine supply, program management, and surveillance data, as well as special studies (e.g., publications, evaluation reports, student theses). Inclusion of explanatory research and qualitative data (e.g., EPI/VPD surveillance review, missed opportunities, hesitancy studies) is encouraged, especially to provide contextual information and potential explanatory factors for the results.

Data that describe trends over time in process and outcome indicators describing a logical sequence of events within an overall process may be particularly useful, such as vaccine coverage and incidence of vaccine-preventable disease, or program data (e.g., stock-outs) and coverage. The data sources in Figure 10 are arrayed within the context of an epidemiologic process that aids understanding of how the data relate to each other. Other processes are relevant and could be developed, e.g., immunization program management indicators could be visualized with coverage as an outcome.

Once the available data sources are determined, the key question may need to be refined based on feasibility. One of the most time-consuming and challenging aspects of data triangulation may be getting access to different data, analyses and reports that span multiple years, as well as the data management and cleaning required to put the data into a usable format. Qualitative data may often be in formats that require extra time to review and prepare.

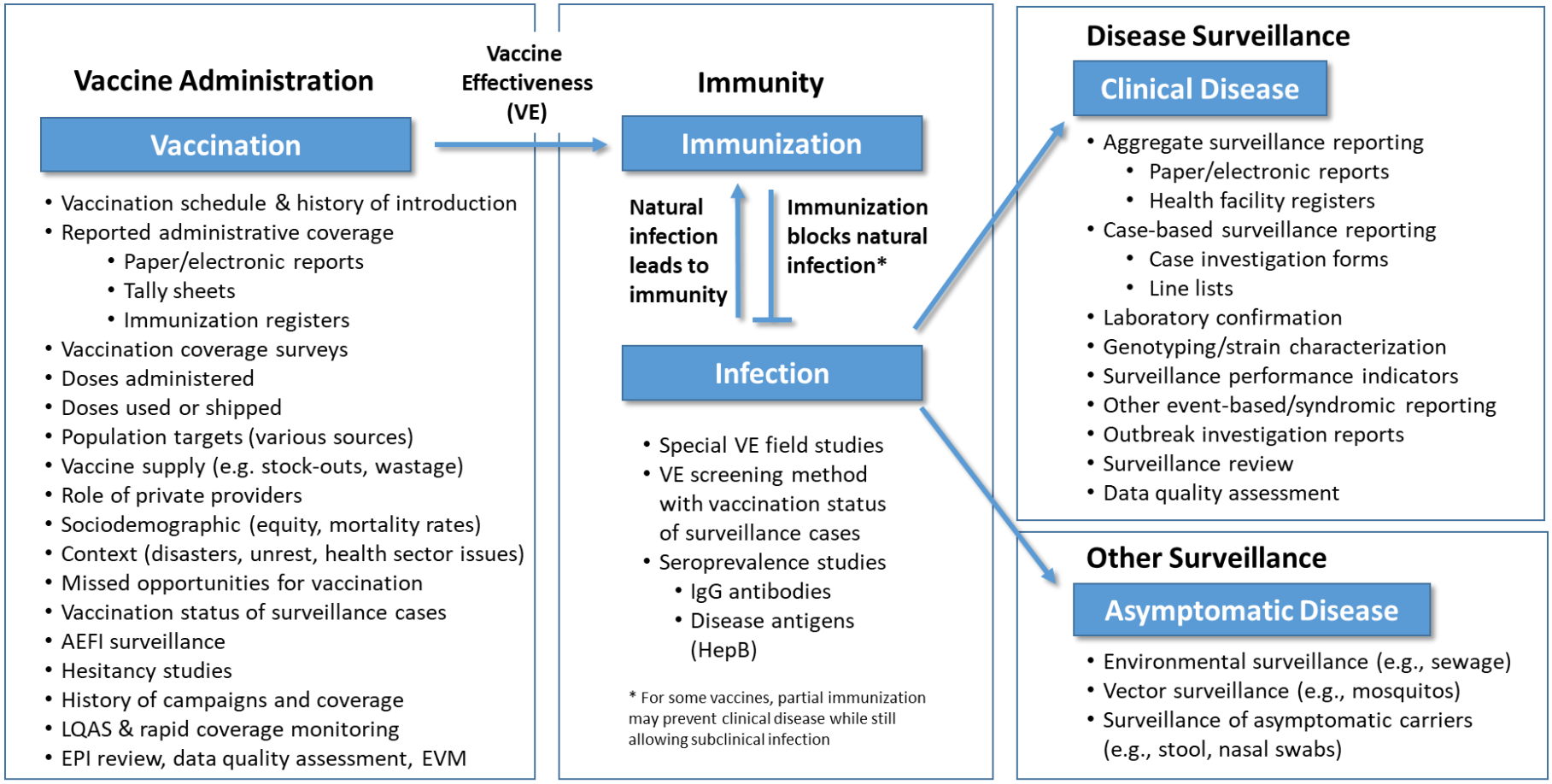


Figure 10. Relevant data sources for the Expanded Program on Immunization visualized within the epidemiologic process where administration of vaccine leads to immunization and prevention of infection, the outcome of which can be measured through disease surveillance or other types of surveillance to assess asymptomatic infection. Immunization program management indicators could be similarly visualized with coverage as the outcome.

Analysis

In terms of conducting the analysis, steps 5–7 in Table 4 build upon the core data triangulation process outlined in DQR (Table 3). The first task is to assess the reliability and trends of each data source. This includes the robustness of data collection methods (e.g., population-based surveillance, survey sampling), any changes in data collection over time, and sources of potential bias (e.g., non-response). In general, greater weight is given to data with collection methods designed to ensure representativeness of the population (e.g., surveys, surveillance, program data); however, lower quality studies should not be completely dismissed.

Data completeness at the district and facility level should be reviewed and generalizability considered (i.e., who's missing). Internal consistency should be evaluated by looking at the variation in values across geographic areas and over time. A critical view should be taken of silence (zero and non-reporting) and outliers, such as any deviations from expected program values (e.g., >100% coverage) or expected epidemiology. Examining consistency with related indicators (e.g., doses provided at same opportunity, dropout) is also helpful.

The second task is to compare the consistency and trends across data sets, or external consistency. Across geographic areas and population groups, note the consistency of trends over time. For a single time point, note areas of agreement, disagreement and silence across data sources, geographic areas and population groups. Is there a logical relationship across dimensions of person, place, and time? To interpret how different data sources relate to each other, deeper understanding is needed of the relationship between indicators, as well as the limitations of data sources. For example, to interpret the relationship between:

- Vaccine doses administered and vaccine doses used — consider wastage rates
- Vaccine doses administered and vaccine doses shipped — consider buffer stock practices and wastage
- Administrative coverage and survey coverage — consider population movement, role of private sector, and survey methods
- Coverage and seroprevalence — consider vaccine effectiveness, campaigns, role of natural infection and survey/laboratory methods
- Coverage and surveillance — consider surveillance performance, campaigns, and disease epidemiology

The third task is to consider different explanatory causes for observations, including sources of error. Formulate hypotheses to explain the data trends. For example, are changes in performance noted in areas that have been recently targeted for improvement, or with known issues? Did the intervention precede the change in performance? Evaluate alternative explanations for the data trends, including coincidence, and data limitations and errors that could lead to bias. Data that does not fit should not be discarded; closer consideration of these discrepancies can lead to new hypotheses and deeper understanding (Table 6). Finally, consider whether other data sources or further data collection are needed to evaluate new hypotheses. Triangulation is an iterative process, where explanations are refined until they best match the whole of the data.

Table 6. The dos and don'ts of performing data triangulation

DO	DON'T
1. Focus the analysis based on the key question identified and underlying hypothesis	Perform an unfocused, "everything but the kitchen sink" analysis
2. Be open minded and consider alternative explanations	Come to the process with preconceived answers and solutions
3. Be honest about data limitations, and consider performing sensitivity analyses to explore the impact of missing data	Fail to document the limitations of source data
4. Explore patterns and associations through descriptive and graphical methods	Over-interpret small effects, even if they may be statistically significant ("data dredging")
5. Embrace uncertainty and enable your audience to view the results through a clear lens/full picture	Discard results that do not fit your hypothesis

Limitations of Data Triangulation

Data triangulation efforts can be affected by multiple limitations. Examples include:

- The quantity and quality of the original data.
- The potential for interpretations of data to converge at a single conclusion that is not accurate (11).
- "Data dredging" in which analysis of large datasets can over-emphasize the importance of small differences. In statistical analyses, this can involve a focus on statistically significant (p-value >0.05) results that may not be programmatically relevant and the overlooking of corrections for the use of multiple statistical tests (16). This can be avoided by focusing on a key question and exploring patterns and differences of programmatic relevance through descriptive and graphical methods.
- The potential to draw incorrect conclusions about individual risk factors based on analyses performed at the population level (ecological fallacy). However, triangulation examines the consistency across data sources and methodologies, potentially reducing the risk of ecological fallacy compared to more limited analyses of single data sets (16).
- The inappropriate use of qualitative data (e.g., EPI/VPD surveillance review, hesitancy studies), i.e., through attempts to interpret qualitative data quantitatively (14).
- The potential for analyses to not be reproducible unless a careful appraisal of underlying data limitations is made and temptation is resisted to selectively ignore data not fitting a favored hypothesis (Table 6) (16).

A list of limitations by data source will be further developed for the guidance.

Results for Action

Triangulation performed as part of routine monitoring may not require dissemination beyond a supervisor who is in charge of program planning and empowered to make decisions on program priorities. Even results of routine data analyses should inform program action. Using evidence to tailor program activities will strengthen the quality improvement cycle.

For a more formal triangulation exercise, a succinct report (or presentation) should be developed to summarize the results, including graphs, likely explanations for trends, and recommendations. Limitations and gaps in information should be clearly documented, preferably in a table by data source. The report should be disseminated to key stakeholders, who should be engaged in developing a plan of action. A final version of the report or publication should include the intended actions based on the results, or better yet, how results of the triangulation were actually used, i.e., for change in policy or strategy, program planning or management. This will help document impact and provide a basis for allocating resources for future similar activities. If the analysis may be repeated (e.g., in subsequent years), documenting the analysis process and/or observations about datasets could make future efforts easier.

Considerations for Implementation

The team involved in triangulation may vary based on the level (national vs. district) and frequency (routine vs. ad-hoc) of implementation. At the subnational level (i.e., province or district), triangulation may be performed by the local biostatistician or data manager with input from the EPI, vaccine logistics, surveillance, and HMIS officers, and the national level may support the subnational level, depending on administrative organization. Involvement of other relevant local staff (e.g., statistics bureau, civil society organization) or assistance from national immunization or surveillance staff could improve the quality of the exercise.

At the national level, a triangulation exercise should include the EPI program manager, logistician, data manager/biostatistician; other relevant staff from the EPI, surveillance, and HMIS units; NITAGs; and immunization partners working in or familiar with the country context. For routine analysis, the team required may be considerably smaller than for larger, less frequent evaluations. For ad-hoc evaluations, a Special Task Force on Data Triangulation could be formed to raise the profile of the activity and allow greater coordination.

Special consultants could be involved for periodic evaluations to handle the demands of gathering and managing the data, as well as analysis tasks, in close consultation with program staff.

Formal data triangulation workshops will be conducted as part of the pilot exercises, but the sustainability of such an activity is questionable. It would be more sustainable to incorporate triangulation exercises as part of routine program activities, such as microplanning, EPI data review meetings (e.g., monthly, quarterly) and annual desk reviews of immunization data (e.g., before Gavi Joint Appraisal). Less frequent opportunities (e.g., every 5 years) include periodic in-depth assessment of routine immunization data, immunization data quality assessments, and EPI or VPD Surveillance Reviews. Other opportunities are National Committees for Polio Eradication or Measles and Rubella Elimination (annual), or outbreak investigations (ad-hoc).

For routine purposes, incorporation of automated analysis and visualization of triangulated data into monitoring dashboards would be ideal for assessing trends over time (Figure 11). Data management systems that are user-friendly and integrate various types of data would be good potential platforms for incorporating data triangulation dashboards.

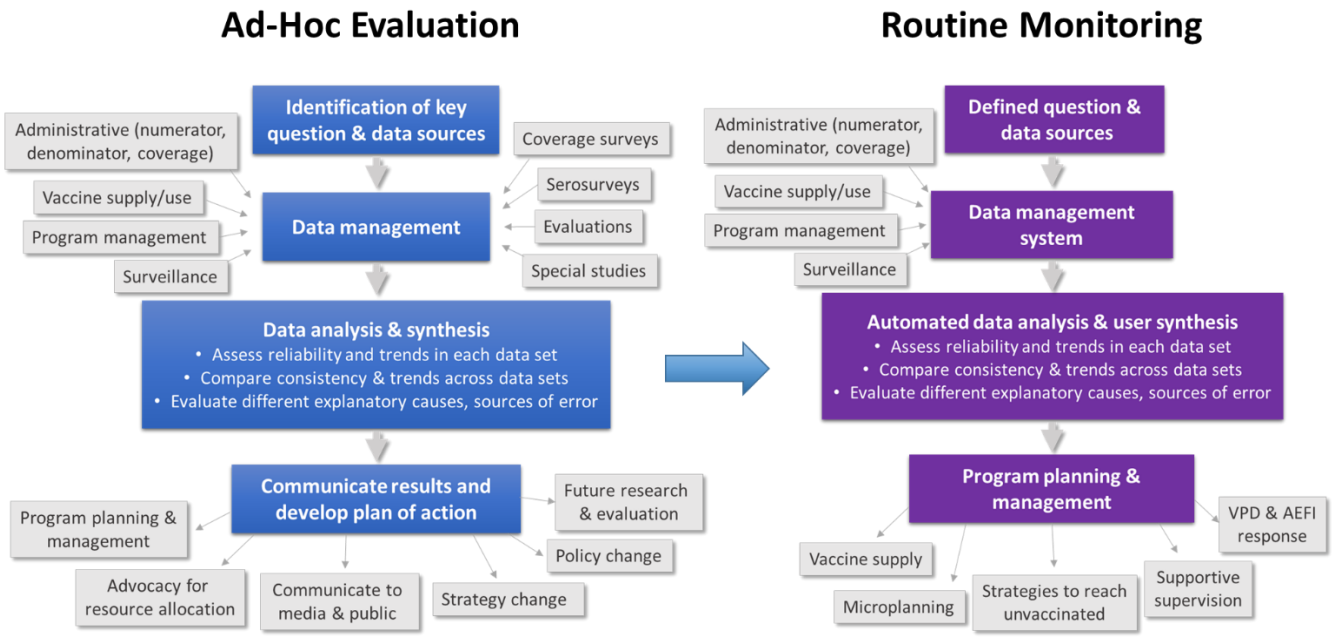


Figure 11. Data triangulation in ad-hoc evaluation vs. routine monitoring context. For routine monitoring, analysis of defined questions and data sources could be automated in data management systems with results used for routine program planning and management.

Next Steps: Developing Data Triangulation Guidance

The proposed audience for the data triangulation guidance will include *national and subnational* EPI, surveillance, and HMIS management staff. The guidance may also be relevant for regional and global EPI program staff and partners, as well as well as other key stakeholders working in global immunization.

We propose to develop a stand-alone guidance document(s) focusing on triangulation of existing data sources as part of a desk review to address various questions relevant to immunization and surveillance programs. Methods for prospective data collection in the field will not be included. The triangulation guidance should emphasize a process of critical thinking and be more pragmatic and shorter relative to HIV triangulation guidance documents (14, 15),. Pieces of the guidance may be abstracted for incorporation into revisions of other existing guidance documents, e.g., the Data Monitoring Handbook (51).

In terms of contents, the triangulation guidance is proposed to include generalized analytic methods and a stepwise protocol for implementation. Potential topic areas and relevant questions for triangulation will be included, along with guidance on how to choose the right question. Lists of potential data sources will be incorporated into tables with potential limitations and sources of error by data type. For help with interpretation, possible explanatory causes will be listed. Guidance will describe what specific indicators to compare and suggest potential visualizations of the data. Detailed case studies will feature various examples following the process of triangulation analysis. Where relevant, other existing guidance will be referenced.

The guidance document will be formatted to include chapters that are tailored to the capacity and relevant data triangulation questions at different program levels, a more basic chapter for subnational staff and an advanced level for national staff. Both chapters will have annexes with case studies structured around several key triangulation questions, e.g., data quality (including stock, surveillance), immunity gaps, denominators, coverage estimation, program effectiveness and impact. The basic chapter for subnational immunization and surveillance staff could be more like a job-aid and include one or two questions and a limited set of data sources and analyses. The advanced chapter for national immunization and surveillance staff could build off the basic level to include a broader set of questions and more complex data sources/analyses, and instruction on how to teach the basics to subnational staff.

The broad categories of data sources proposed for inclusion are as follows: administrative data (numerator, denominator, coverage), survey coverage, vaccine supply, program management (e.g., vaccination sessions), serosurveys, and VPD surveillance, including vaccination status of surveillance cases. Data from non-government sources (private sector, NGOs) and other sectors (e.g., socioeconomic) could also be employed effectively. Other robust EPI data sources (e.g., coverage from geospatial modeling) may be available in specific settings, or emerge in the future, so the methods should be permissive with regard to what data sources could be used.

The guidance will address practical issues like when to do triangulation and who to include in the process. Examples of simple data visualizations will be incorporated. The guidance will address how to communicate results and translate results into action. Considerations for data triangulation during crises or emergency situations will also be covered. Finally, tips for how to build triangulation into the data culture (e.g., regular review, sharing analysis) will be included, e.g., positive feedback to lower levels, distributing certificates.

The capacity-building aspect of the guidance is expected to emphasize skill development and be scenario-based. A training plan and materials for the different levels will be developed, and incorporating data triangulation content into other EPI training and supervision materials (e.g., eLearning modules, Mid-Level Managers) will be explored. Training opportunities that provide mentorship and practical exercises are predicted to be best suited for learning the material. Incorporation into the Immunization Monitoring Academy is planned, and developing content for field epidemiology programs (e.g., FETP, STOP) will be explored. Pre-built Excel-based (or similar pre-coded) tools are not considered to be flexible enough to be amenable for generalized triangulation methods, but training datasets and documented code for performing specific tasks in popular analytic software platforms may be relevant. EPI data triangulation guidance and field experiences have the potential to feed into recommendations for automated data triangulation analyses of defined indicators as part of information systems (e.g., dashboards).

Feedback from the Online Survey

Results from a small survey of national and subnational staff (n=36) on the perceived relevance of data triangulation objectives at the national and sub-national level are shown in Figure 12. Responses from a survey of global partners (n=32) generally agreed with those of national and subnational staff. On the question of what key program issues data triangulation guidance could help to address, themes from qualitative responses

included (roughly in order of frequency): data quality; denominators; immunity gaps & disease risk (measles outbreaks in areas of high coverage, population immunity profiles, predicting outbreak risk); effectiveness of immunization programs/activities; immunization program planning (services/activities, logistics, supervision); VPD surveillance quality; and coverage estimation.

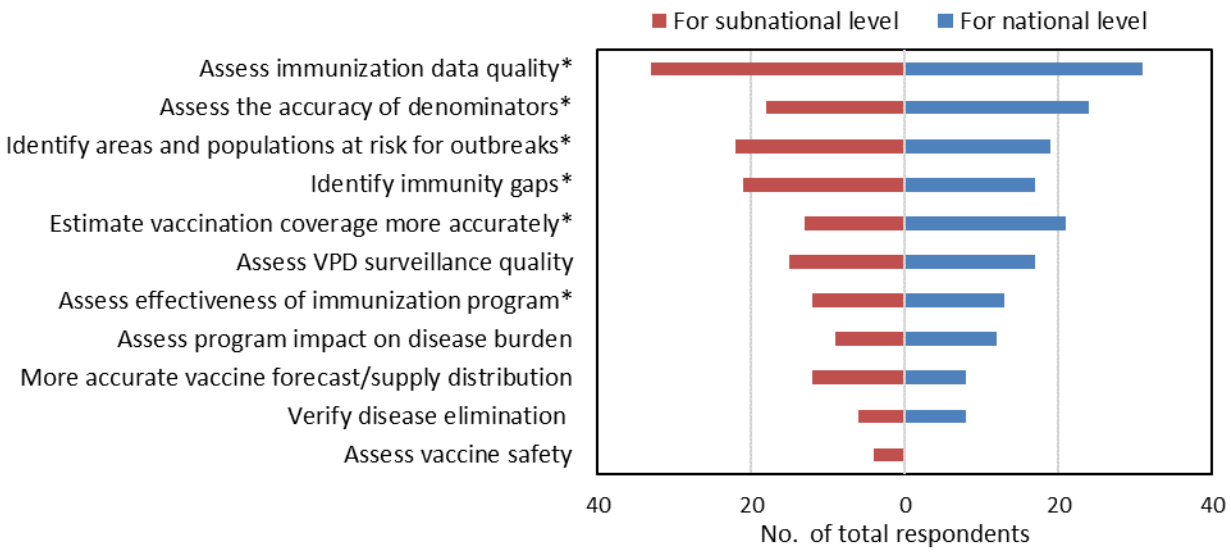


Figure 12. Perceived relevance of data triangulation objectives at the national and sub-national level from survey of 36 immunization, surveillance and health information staff at the national (n=22) and subnational level (n=14), 2018. Respondents were asked to select up to five objectives that were most relevant. Of note, 29 (81%) of responses were from the African Region. Asterisks indicate the top six ranked responses in a survey of 32 global immunization partners.

Comments from survey participants about use of data triangulation for EPI programs were informative. A selection of comments from global immunization partners and national and subnational staff is below:

Global immunization partners:

"… I'm not sure [data triangulation] should be presented as a new concept or tool... In my opinion this should be the norm for analysis, not a separate exercise called triangulation done in a corner somewhere."

"Tools are only one piece of the solution and it is unclear how much of a piece…"

"This needs to become a core component of EPI data use - worry if too complex it will be pushed out to consultants and not build EPI program capacity over time. Need to demystify and make 'possible' to do by 'ordinary' EPI program."

"The outcome of data triangulation should be concrete solutions to improving data and in the long term foster data use and verification/validation at all levels."

National and subnational immunization, surveillance and health information staff:

"It is high time to ensure data triangulation made annually in our country context. Different reports come up with different results, and this is a tool to take timely evidence based decisions… to improve the EPI program."

"Very good opportunity, as several recommendations have been made to ensure that programs triangulate different data sources, as denominator issues are key challenges."

"Sub-county staff need knowledge and skills on data management and especially DHIS2."

"It needs to be done in a way that it helps to build capacity of staff, rather than to be a burden, such as excel-based tool or web-based tool that has a user friendly interface to generate high quality useful data."

"It will improve data quality and impact on program performance supporting evidence based decision-making."

Feedback from the 2018 EPI Data Partners' Meeting in Budapest

This Framework document was presented in Budapest at the Data Partners Meeting during 9–11 October 2018. Input on the Framework was received from meeting participants (n=89, representing the following perspectives: 25% county, 25% regional, and 50% global) in the context of the plenary session, a working group discussion, and an interactive group prioritization exercise. Results from an interactive survey (Mentimeter) of meeting participants (n=55) on the perceived relevance of data triangulation objectives at the national and sub-national level are shown in Figure 13. Overall, feedback on the Data Triangulation Framework presented was positive with the meeting topic receiving the highest overall score for "relevancy" from a survey of all audience members at 79% (the next highest topic received a score of 67%).

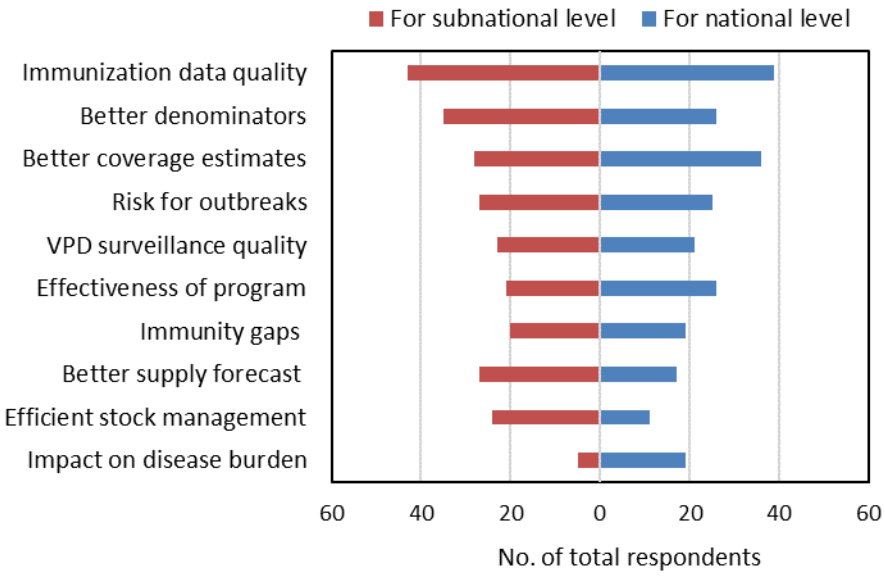


Figure 13. Perceived relevance of data triangulation objectives at the national and sub-national level from survey of 55 respondents at the 2018 EPI Data Partners' Meeting in Budapest. Meeting attendees represented the following perspectives: 25% county, 25% regional, and 50% global.

During the Data Triangulation working group (n=15 participants), the group discussed that EPI program staff were currently too focused on coverage, and not using all of their existing data to achieve more efficient program management and greater impact disease burden. The group acknowledged the need to clearly define "triangulation," outline key principles, and focus on key questions. The group emphasized an important need to developing critical thinking as a skillset, rather than just develop another tool, e.g., understanding the reasons for observations, interpreting discrepancies, and how to use data to inform planning and policy. The group advised to keep the guidance simple and intuitive to empower various administrative levels, and to avoid developing parallel activity (e.g., build into other tools and opportunities). The group suggested that the guidance be considered a "program refinement tool," rather than a new monitoring or assessment tool and expressed ambivalence about using the term "triangulation" (e.g., "This isn't new.").

During the meeting, helpful constructive feedback on the Framework was received, which was incorporated into the final version of the document. Input on contents and format of guidance documents and considerations for capacity-building have also been incorporated here and will be used to inform the development of the guidance and training tools. An interactive group prioritization exercise was conducted during the meeting to develop priority activities by topic; those for the Data Triangulation guidance work-stream are listed below (Box).

Box. Feedback from participants at 2018 EPI Data Partners' Meeting Participants on Triangulation Framework

- Align data handbook on triangulation topic (CDC/WHO) for end of December 2018.
- CDC, WHO, and UNICEF to develop simple guidelines built for operational level use at all levels (i.e. monthly review meetings at the district level).
- CDC to develop a case studies on data triangulation.
- CDC, WHO, and partners to pilot test the handbook in 2-3 countries by June 2019
- WHO, UNICEF, CDC, global partners, and key country partners to provide a forum to enable country experience sharing of lessons and best practices.
- Regional offices to select 2 or 3 countries over the next 5 years and deep dive with them.
- Provide technical assistance and training for EPI on data triangulation.
- Develop national capacity building on data triangulation and training.
- Have more on disease outcomes as a component to coverage, and triangulation for the two.
- Develop data quality exercises with focus on triangulation.
- Develop a data triangulation strategy on data management and statistical use.
- Establish routine use of data combining different sources.
- Think more as institutionalization use of data.

Conclusions

As next steps, triangulation guidance and training are being developed and piloted in two countries during 2019 to early 2020. After refinement based on country experiences, the final WHO guidance is intended to be ready in the second half of 2020. Incorporation of data triangulation principles into other existing guidance (e.g., WHO Data Monitoring Handbook, Gavi Joint Appraisal) is also ongoing.

It is hoped that building capacity for Data Triangulation within the EPI program will contribute to increased use of data for decision-making to improve immunization and surveillance programs, as well as evidence-based changes in policy and strategy to reduce the number of unimmunized children and the incidence of VPDs. Developing data triangulation capacity for immunization and surveillance programs has the potential to reinforce broader use by other priority public health programs in a country, and is anticipated to assist with strengthening capacity of the health system.

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