USE OF SURVEILLANCE AND/OR OUTBREAK RESPONSE DATA TO IDENTIFY ZERO-DOSE CHILDREN OR MISSED COMMUNITIES

Evidence on pro-equity interventions to improve immunization coverage for zero-dose children and missed communities

EVIDENCE BRIEF

Gavi
The Vaccine Alliance

Part of a series, this evidence brief presents results from a **rapid review** of the literature to understand the effectiveness and implementation considerations for select interventions, including use of surveillance and/or outbreak data, which could help achieve more equitable immunization coverage, specifically helping to increase coverage and reach zero-dose children and missed communities.

Evidence summary

What is surveillance and outbreak response data?	Vaccine preventable disease (VPD) surveillance involves continuous and systematic data collection, analysis, and interpretation to inform the planning, implementation, and evaluation of public health programming and policy related to VPDs. Identifying cases and case characteristics is a major objective of this type of surveillance. Another goal is the detection of outbreaks and conducting outbreak investigations to inform an appropriate response. The purpose of this review was to understand how surveillance/outbreak response data are being used to identify un/under-immunized individuals, whether such use is "effective" in identifying individuals in need of vaccination, and to identify key implementation characteristics.	
How effective is surveillance and outbreak response data in identifying zero-dose children and missed communities?	**There is promising evidence that using surveillance/outbreak response data is effective in identifying un/under-immunized populations.** Two main use cases were identified: identifying immunity gaps through incorporating surveillance data into mapping, modeling, risk assessment tools, and comparing surveillance data to coverage data; and using surveillance data to inform decision-making and build support. However, evidence is lacking related to the use of surveillance data in the context of routine immunization to identify zero-dose children and missed communities. Most evidence involved the use of surveillance data to inform introduction of new vaccines, decisions on non-routine vaccine targeting, outbreak response and decisions on supplemental immunization activity (SIA)/campaigns. Most studies and reports were not context specific; tools and data were gathered and applied across urban, rural, conflict-affected settings.	**PROMISING INTERVENTION**
What are the main barriers and facilitators to implementation?	• **Major facilitators** include using surveillance data for **triangulation/ complementary** purposes, **community involvement** in interpretation of surveillance data to identify areas at higher risk, engaging **decision-makers** in analyses and dissemination, using **effective risk communication** to convey results, and **being open to innovation and collaboration** for data use, particularly in outbreak settings and across administrative boundaries. • **Major challenges** include **limited data availability, data quality, time-constraints** for analyses conducted in real-time, **and lack of support and/or coordination among key stakeholders** for using results to inform action.	
What are the key gaps?	Most instances of data use informed district-level action and above; using surveillance data for identification at a **micro-level** were lacking. Few **implementation considerations** were described; most studies focused on analytic results versus processes involved in collecting, analyzing, and interpreting data. Few examples specific to identification of zero-dose children were found; most studies relied on surveillance data to identify high-risk or priority populations; use of **surveillance data for identification purposes in the context of routine immunization** was lacking.	

Introduction

What is vaccine preventable disease (VPD) surveillance?

Vaccine preventable disease (VPD) surveillance involves continuous and systematic data collection, analysis, and interpretation to inform the planning, implementation, and evaluation of public health programming and policy related to VPDs (1).

There are different types of and approaches to surveillance. For example, coverage for surveillance can either be universal (i.e., monitoring of an entire population or representative sample) or sentinel (i.e., monitoring of specific locations, such as sites, events, animals/vectors that are of key interest). Surveillance activities can be passive or active. In passive surveillance, health providers report cases on their own initiative. In active surveillance, case reports are actively solicited from health facilities or other sources, which can be time and labor-intensive. Surveillance requires certain standardization, such as developing a case definition and collecting data. Once data are collected, analyses are conducted to better understand disease spread and correlates of disease, and results are used to mitigate or prevent future disease outbreaks (2).

Data collection can involve diverse activities such as collecting case reports from active and passive surveillance systems, and conducting routine or cross-sectional surveys to understand disease prevalence (such as seroprevalence studies) and risk. Data collection can also involve environmental means, such as monitoring for pathogens in wastewater, or monitoring for disease in animals/vectors of disease, such as livestock or mosquitos.

What are outbreak responses?

An outbreak response is a series of activities that occurs once a disease outbreak (more cases of disease than expected in a given area or among a specific group of people over a particular period of time) has been identified, most likely through use of one of the surveillance activities listed above. A critical part of outbreak response is to collect data to better understand the outbreak, develop case definitions, identify possible causes, and test hypotheses. Outbreak responses also involve conducting descriptive epidemiology, and may also involve developing mathematical models to help identify those at heightened risk of disease, including those who are unimmunized or under-immunized (3).

How are surveillance and outbreak response data relevant to achieving equity?

One main purpose of VPD surveillance and outbreak response is to identify unreached and under-immunized populations so that these populations can be targeted for immunization. Often this identification involves triangulating surveillance data with other information, such as vaccine coverage, population data, and clinical/administrative records to identify immunity gaps (4). Heterogeneous vaccination coverage across and within districts can often drive outbreaks; a major advantage of using surveillance data for identification could be to identify at-risk places and/or groups of people so these groups can be targeted for vaccination to help achieve equity.

This review focused on diseases included in the World Health Organization's routine immunization schedule (5), as well as diseases that could serve as a proxy for poverty and other vulnerabilities/inequities often faced by zero-dose children and missed communities, including yellow fever, cholera, typhoid fever, and diarrheal disease. Efforts to identify individuals at-risk for these diseases could point to novel solutions for how surveillance could be utilized for identification of zero-dose children or missed communities. Other diseases, including Ebola and dengue fever, were excluded as these were considered less relevant, zoonotic, and not widely circulating.

Why was this evidence synthesis on surveillance and outbreak response undertaken?

The overall goal was to synthesize existing evidence on the effectiveness and implementation of using data from surveillance programs and outbreak responses to identify zero-dose children and missed communities so these groups can be targeted for immunization, thereby reducing gaps in vaccination coverage. Through a rapid review of peer-reviewed and gray literature, this work aimed to address the following questions:

1. What types of surveillance data and analyses are being used to inform identification of zero-dose children and missed communities?
2. Are interventions involving the use of surveillance data and/or data gathered as part of an outbreak response effective in identifying zero-dose children and/or missed communities?
3. What are the implementation considerations for carrying out a review/analysis of surveillance and/or outbreak response data with the purpose of identifying zero-dose children or missed communities?

This rapid review involved searching electronic databases of published literature, searching websites for unpublished literature, soliciting potentially relevant articles from experts, and secondary reference searching of some included articles. To be included, studies/reports had to be conducted in a low- or middle-income country, published (or posted) from 2010-2022, and report on using surveillance or outbreak response data to identify un/under-immunized people. More information on the review methods is presented in Appendix A. Notably, literature relating to VDP surveillance and outbreak response is vast. To make the search more manageable and relevant, additional steps were taken, including:

- Focusing on studies that provided evidence of "effectiveness" or "implementation" of using surveillance and/or outbreak response data. "Effectiveness" studies were defined as studies or reports that either compared identification using surveillance to identification using other data sources, a pre/post comparison of identification efforts before and after utilizing surveillance, or a multi-arm comparison.
- Including modeling studies if methods compared surveillance to non-surveillance means of identifying un/under-immunized populations.
- Excluding studies that simply described use of surveillance data without any implicit or explicit comparison given the vast literature that reports descriptively on surveillance data.
- Defining "implementation" studies as studies reporting on implementation of efforts to use surveillance and/or outbreak response data to actively identify susceptible populations.

Results

What is known about surveillance programs and outbreak responses regarding identification of zero-dose children and missed communities?

Two main uses cases were identified, and overall results demonstrated that incorporating surveillance data into efforts to identify un/under-immunized populations was effective. Of approximately 2,000 articles and reports screened, 35 were included. The following disease areas were represented: measles (18 studies)(6-22), cholera (7 studies)(23-29), poliovirus (4 studies)(22, 30-32), yellow fever (2 studies)(33, 34), and one study each pertaining to pertussis (35), typhoid fever (36), and rotavirus and pneumococcal disease (37). Two studies were non-disease specific (38, 39). Studies took place across countries in Asia, Africa, and the Americas. Studies were mostly not specific to zero-dose but discussed identification of populations susceptible to disease, including individual correlates of vaccination status/disease susceptibility or physical locations of "high risk" areas. These studies were included because they are relevant for understanding how surveillance data could be used to identify zero-dose children and missed communities.

Use case typology: How are surveillance data being used to inform identification of zero-dose children and missed communities?

We identified two major use cases and several sub-categories that describe how surveillance data is being used to identify priority populations or un/under-immunized groups.

1. Identify immunity gaps for planning, prioritization, and response.
    a. Identification of characteristics associated with immunization status and/or VPD
    b. Risk assessments tools (for prioritization of key administrative areas)
    c. Modeling/mapping exercises
    d. Use of other types of surveillance (environmental, zoonotic) to enhance identification
    e. Comparison of surveillance data with other data sources, such as administrative immunization coverage rates, to identify discrepancies and weaknesses in existing data that mask the existence of populations with immunity gaps
2. Use surveillance data to build political will and/or contribute to immunization program decision-making to enhance the potential for identification.

Below we more fully describe these use cases and present examples:

1. **Identify immunity gaps**: This use case serves as the primary mechanism through which surveillance and outbreak response data are used to identify un/under-immunized populations. Commonly, surveillance data are analyzed descriptively to assess population characteristics associated with either vaccination or VPD status. Reports from outbreak responses also typically provide descriptive information on case characteristics and can also point to behavioral factors contributing to under-immunization. For example, a report of a measles outbreak in Vietnam identified a confluence of factors that led to the outbreak, including under-immunization among certain ethnic groups living in remote areas and rising mistrust in vaccines (40). While outbreak response reports and descriptive correlation analyses provide clear evidence of how surveillance data are being used to identify un/under-immunized groups, given their abundance in the literature, examples mentioned above are merely illustrative. More examples of outbreak reports can be found through WHO's Disease Outbreak News (DONs) repository as well as in the published and gray literature. This review also identified other ways that surveillance and outbreak response data are used to identify un/under-immunized populations, including through using risk assessment tools, modeling/mapping exercises, and layering additional surveillance mechanisms into local areas, including zoonotic and environmental surveillance.

a. Regarding **risk assessment tools**, several studies described the development and use of the WHO programmatic risk assessment tool for measles (6, 8-11). This district-level tool uses data on population immunity, surveillance quality, program performance, and threat assessment to indicate districts more susceptible to potential outbreaks (11). The tool was piloted in the Philippines (6), Namibia (10), India (9), and Senegal (8). Another risk assessment tool was developed in Brazil that utilized surveillance data to identify vulnerable areas susceptible to measles re-introduction following local elimination (12).

b. For **modeling and mapping exercises**, a wide range of strategies were employed. Notably, many studies were specific to cholera. Studies ranged from manual, human-centered approaches to developing sophisticated statistical models. Two studies from Malawi and Pakistan used surveillance data during participatory workshops and consultative meetings to leverage data interpretation by local experts to identify and map priority areas (27, 39). Conversely, other studies incorporated surveillance data with other data sources, such as coverage data, spatial-temporal positioning, mobility data, and other population characteristics, to develop sophisticated models to predict locations and/or populations susceptible to outbreaks (13, 22, 24, 28, 29, 32). Two studies used modeling to make predictions in real-time. One study estimated susceptible populations for an ongoing measles outbreak in Guinea (7), and another identified districts at high-risk for cholera outbreaks following a cyclone in Mozambique (26). Although this method might be useful to identify populations facing vulnerabilities in general, these vulnerabilities may correlate with routine immunization and zero-dose children, which makes it potentially adaptable to the zero-dose context. Additionally, one study used surveillance data to understand correlates of cholera transmission specific to identified cases, thus suggesting specific vaccination strategies needed to reach populations facing vulnerabilities (25).

Several studies described the use of **additional, non-case-based surveillance** mechanisms to identify susceptible populations. One study in Brazil used epizootic data and surveillance data to predict areas at heightened risk of human yellow fever outbreaks (33). Again, while this method is specific to identifying potential vulnerabilities, similar triangulation methods might be useful for identifying gaps in routine immunization coverage. Another study in Mexico used environmental surveillance (monitoring poliovirus strains in wastewater) to identify municipalities susceptible to the emergence of vaccine-derived poliovirus due to inadequate coverage of IPV/OPV vaccination (31).

c. **Comparison of surveillance data to other data sources:** Another common use case was comparing surveillance data to other data sources, typically administrative coverage data, reviewed as part of an outbreak investigation. Often these comparisons were further augmented by survey data and other sources, such as reviewing facility records and conducting interviews with facility staff. Of seven studies conducted within outbreak investigations (14, 17, 20, 21, 34, 35, 41), most found that administrative coverage estimates were inaccurate and overly inflated. Other studies found inaccuracies were due to factors such as vaccine failure, often due to sub-optimal cold chain management. These comparisons yielded critical information on understanding how outbreaks occurred, who to target for future intervention, and why coverage estimates were discrepant, which often led to corrective action.

Two other comparative analyses were identified. One study compared measles surveillance data, administrative coverage data, and "gold standard" coverage data from DHS reports across 19 countries in Africa (18). The study found that surveillance data (aggregated information of suspected measles cases) better predicted subnational measles coverage than administrative data (18). Another study modeled the utility of "triggered" measles vaccination campaigns, comparing potential triggers derived from either the presence of disease outbreaks or from seroprevalence studies. The study found that campaigns triggered by serological evidence could help prevent outbreaks and outlined potential benefits of carrying out serology studies to identify areas for targeted vaccination campaigns (19). The study did not describe how this strategy could be used for routine immunization.

2. **Use surveillance data to build political will and inform decision-making**: Several studies described efforts to build political will and/or contribute to immunization program decision-making to enhance the potential for identification. Three regional initiatives used surveillance data to identify high-risk populations (23, 30, 36). The Cross Border Health Initiative facilitated inter-country communication and intersectoral collaboration in Kenya and Somalia to improve poliovirus surveillance and immunization coverage (30). The Africhol initiative aimed to improve cholera surveillance and inform interventions. The included examples report on Africhol activities in Mozambique (23) and Uganda (24). The Typhoid Fever Surveillance in Africa Program (TSAP) set-up 13 sentinel sites across sub-Saharan Africa to assess incidence of typhoid fever in a standardized manner, which authors highlight will inform targeted prevention programs (36). Another study from China described building a surveillance reporting system to align with the country's political system to facilitate action and build political will. The system successfully identified high-risk areas, developed targeted intervention approaches, and built capacity (16). Finally, case studies from Bangladesh, Gambia, and Armenia highlight how use of pneumococcal and rotavirus surveillance data have informed vaccination decision-making within these countries, such as by demonstrating the impact of a vaccine on disease burden (37); however, notably these case studies were not specific to understanding how these methods could help inform decision-making and identification regarding zero-dose children and missed communities.

Effectiveness: What is known about whether surveillance systems and outbreak responses "work" to identify zero-dose children and missed communities?

Overall categorization of effectiveness

To help program planners assess whether an intervention, such as using surveillance and/or outbreak response data to identify zero-dose children and missed communities, should be considered, a categorization scheme is used to rate interventions as potentially ineffective, inconclusive, promising, or proven. A more detailed description of this categorization can be found in the general methodology for reviews in this series [linked on the evidence map website].

CATEGORIZATION	RATIONALE
PROMISING	There is promising evidence that using surveillance/outbreak response data is effective in identifying un/under-immunized populations. Two main use cases were identified: identifying immunity gaps through incorporating surveillance data into mapping, modeling, risk assessment tools; and comparing surveillance data to coverage data and using surveillance data to build political will and inform decision-making. There is evidence across use cases that use of surveillance data improves the ability to identify un/under-immunized individuals or groups. However, evidence is lacking related to use of surveillance data in the context of routine immunization to identify zero-dose children and missed communities. Most evidence identified involved the use of surveillance data to inform introduction of new vaccines, decisions on non-routine vaccine targeting, outbreak response, and decisions on SIA/campaigns. Most studies and reports were not context specific; tools and data were gathered and applied across urban, rural, and conflict-affected settings. Overall, these studies demonstrate that use of the surveillance and/or outbreak response data can help identify existing weakness in the system, inform models, draw conclusions about correlates of un/under-immunized status, and identify priority areas, but more research is needed regarding how these methods can be adapted for use in the context of routine immunization to identify zero-dose children and missed communities.

What evidence exists on the effectiveness of using surveillance systems and outbreak responses to identify zero-dose children and missed communities?

Effectiveness of using surveillance data to identify immunity gaps

Results from risk assessment tools and modeling/mapping studies show mostly promising results regarding effectiveness. Results from studies that incorporated surveillance data into completing a risk assessment tool were validated in that districts identified as high-risk were locations where outbreaks occurred; action was taken to guide a subsequent supplementary immunization campaign (6). For studies using surveillance in modeling and mapping exercises, several studies used historical outbreak data to validate models constructed using surveillance data. In general, these validation efforts showed mixed results (6, 9-13). In one case, real-time modeling output was validated using data from the existing outbreak, demonstrating some inaccuracies (e.g., the model generally predicted more cases than occurred). Study authors mention that changing case definitions and suboptimal data quality likely impacted results (7). In some cases, particularly studies using modeling and mapping, it was unclear whether results from the activities that used surveillance data were linked to actual identification of priority groups/areas with action undertaken to reach these groups with immunization activities (23, 24, 26, 27, 33). This finding suggests an evidence gap showing how results from such studies are used to inform immunization activities. There were many studies that suggested their methods or results could be used to identify un/under-immunized groups in the future, but no studies were found that reported on implementation of immunization activities as a direct result of these analyses outside of the studies mentioned above. Notably, studies on routine immunization were lacking within this category.

Data from studies conducting comparative analyses to identify immunity gaps provided the strongest evidence demonstrating the effectiveness of using surveillance to identify un/under-immunized populations. The study by Bhatia et al., described above, directly compared measles surveillance data and administrative data across 19 countries in the WHO Africa region and found surveillance data provided superior predictors of coverage at the subnational level (18). Similarly the analysis by Lessler et al. found that using measles surveillance data, specifically seroprevalence data, as a trigger for targeted vaccination campaigns versus waiting for an outbreak to occur could avert a significant number of cases and help prevent outbreaks (19). In reports from outbreak responses that compared surveillance data and administrative coverage data, almost all found discrepancies in surveillance and administrative data, suggesting surveillance data was more accurate and revealed immunity gaps that had been masked by administrative coverage data (14, 17, 20, 21, 34, 35, 41). These investigations often led to an understanding of how the discrepancies occurred, which enabled corrective action to be taken. Outbreak data was also often used to inform supplemental immunization activities to ensure missed populations were reached with vaccination.

Effectiveness of using surveillance data to build political will and inform decision-making

Few studies within this use case provided evidence on “effectiveness,” although some narratively describe successes from initiatives using surveillance data, as described below in the “implementation” section.

Implementation: What is known about “how” efforts to use surveillance systems and outbreak responses work to identify zero-dose children and missed communities?

Most included studies focused on analytic results, not processes involved in obtaining and analyzing data and disseminating results and subsequent actions, especially for reports and articles describing results of outbreak investigations. Thus, it is challenging to understand implementation considerations for using surveillance/outbreak response data for identification purposes. However, there were notable exceptions. Studies focused on real-time modeling that used surveillance data elaborated on the processes involved with obtaining and using data. Additionally, studies focused on systems strengthening referenced key implementation considerations. One review was identified that discusses the cost of VPD surveillance in low- and middle-income countries (38). Notably, few studies were implemented in specific Equity Reference Group (ERG) priority areas (i.e., remote rural, urban poor, and conflict settings); often reports were relevant to various settings within a certain country or region.

Summary of barriers and facilitators to implementation

Below is a summary of major facilitators and barriers to implementation, as well as benefits and drawbacks, identified within include studies.

USE CASE	MAJOR FACILITATORS/ BENEFITS	MAJOR BARRIERS/ DRAWBACKS
Identify immunity gaps: Risk assessments	• Use of programmatic indicators that are recent and reasonably accessible (i.e., historical data is not needed) • Helpful in identifying programmatic weaknesses	• Dependence on data quality • Not a predictive tool but useful in identifying priority areas
Identify immunity gaps: Modeling/ mapping	• Bring together those with complementary skills (e.g., those skilled in modeling and those with access to data) • Involve those with community expertise in data interpretation and decision-making • Decision-maker recognition of potential benefits of adding novel methods (e.g., modeling) to outbreak responses • Timely dissemination to decision-makers • Involvement of decision-makers in analyses	• Lack of flexible funding • Data quality • Data availability • Lack of coordination with and/ or support from decision-makers to implement recommendations • Lack of openness for innovation • In some instances, unclear whether results were actionable given time lags and lack of engagement with decision-makers
Identify immunity gaps: Novel surveillance mechanisms	• Can provide early warnings of risk, which increases time for preparations/early response • Can provide data/feedback in real-time	• Investment in laboratory resources • Can be labor intensive • Only implementable under certain conditions and only relevant to certain VPDs

USE CASE	MAJOR FACILITATORS/ BENEFITS	MAJOR BARRIERS/ DRAWBACKS
Identify immunity gaps: Comparative analyses (through outbreak investigations)	• Having sensitive surveillance systems • Effective leadership and communication • Governments and health systems that are responsive to corrective action recommendations	• Inaccurate coverage estimates can mask immunity gaps • Outbreaks are lagged indicators • Time and effort
Using data to build political will and influence decision-making	• Cohesive system for cross-country community engagement and involvement of community health volunteers • Providing forums for sharing learnings across countries and building cohesion • Efficient risk communication • Seeking personal commitment and engagement from local stakeholders • Using surveillance data as an advocacy tool to garner support for immunization program needs	• General lack of communication and coordination across country borders • Disconnect between those collecting/analyzing data and consumers of data reports • Lack of consequences for local officials for poorly performing areas

Below we elaborate on implementation considerations mentioned within specific studies.

Using surveillance data to identify immunity gaps

Overall studies found that use of surveillance data was acceptable, feasible, and appropriate in contexts in which activities were implemented.

Regarding risk assessment, several studies that pilot tested the WHO programmatic risk assessment tool for measles found the tool acceptable and feasible to implement (6, 8-10, 12).

Regarding modeling, three studies described implementation of activities that used data from surveillance/outbreaks to make predictions in real-time. Graham et al., used surveillance data being generated from an ongoing measles outbreak (e.g., number of cases, case locations) in Guinea to estimate susceptible populations and predict future case numbers using stochastic modeling (7). Authors noted several important considerations for feasibility including logistical challenges of rapidly obtaining data from the field to feed into the model, uncertainties with data quality, quick turn-around times necessary to produce timely model estimates, and the "ad hoc" nature of the collaboration, which was essentially established out of necessity once the outbreak was underway. Investigators note that for future endeavors, establishing partnerships in periods of non-outbreak response would be beneficial. Despite these challenges, the study concludes that modeling is an acceptable use of surveillance data and can be critical to inform and target vaccination campaigns during an outbreak (7). No mention is provided as to whether this model would be acceptable and/or informative for use in routine immunization.

Kahn et al., used modeling involving multiple data sources, including surveillance data, to predict areas at highest risk of experiencing a cholera outbreak following an extreme weather event (26). Investigators highlighted feasibility challenges in connecting model output to on-the-ground decision-making. Investigators conclude that although the model provided accurate estimations, it is unclear how much the model-generated risk maps fed into a vaccination campaign. Like Graham et al., investigators noted challenges in obtaining the necessary data from health authorities within the time needed to inform decisions. Additionally, investigators note a critical mismatch in incentives to incorporate modeling into outbreak responses among relevant actors that likely impacts appropriateness (perceived fit of the intervention). Investigators explained that often groups tasked with responding to outbreaks might be less inclined to involve new techniques, like modeling, into the response, and those most skilled to help with the modeling itself, such as academic researchers, are not well poised to do so due to the relative infrequent occurrence of outbreaks and limited flexible funding options (26). Although not mentioned in the article, it is possible such systems could be adapted in the context of routine immunization.

Almeida et al., used epizootic surveillance data (deaths of non-human primates), coupled with data on population density, mobility, and population susceptibility, to identify areas at high-risk for yellow fever outbreaks across 46 municipalities in Brazil. Based on epizootic reports, vaccination was recommended in 23 municipalities. Investigators note significant variations in timing of vaccination campaigns following recommendations, which impacted the feasibility of using results to inform immunization activities. Investigators highlight the critical importance of risk communication, and that variations in municipality preparedness and familiarity with outbreaks led to uneven responses to recommendations. Notably, in this example, disease surveillance was critical to deciding when and where to vaccinate as vaccination would not occur without imminent risk. This clearly differs from the context of routine immunization; therefore, it is less clear how this method could be used in the context of routine immunization, unless the epizootic surveillance was relevant to one or more routine immunizations as it could then be used to help with risk assessment and targeting.

Conversely, several other reports focused specifically on using surveillance data during mapping exercises to meaningfully engage local officials in data interpretation and development of targeted approaches (27, 39). One activity involved hosting a community workshop in Pakistan where participants helped review and interpret various data sources, including surveillance data, to identify missed communities. This report highlighted that local knowledge was critical for data interpretation as community experts could draw upon their understanding of the local context, and also noting the critical fact that such groups often cross administrative boundaries, making them more likely to be missed without such local input (39). In Malawi, bringing together a diverse set of local stakeholders that worked across fields including water, sanitation, and hygiene, and providing this group with relevant surveillance data proved to be a feasible, acceptable, and appropriate way to identify priority districts for intervention, resulting in the administration of over one million cholera vaccines within high priority districts (27).

Few studies that compared surveillance and coverage data during an outbreak response discussed implementation considerations. Notably most analyses were conducted as part of outbreak investigations, and the focus was on analytic results and not implementation of the investigation itself. Studies mostly provided important insights into the implementation of processes and procedural challenges related to vaccine administration and reporting, which led to inaccuracies in coverage data and hid missed communities (14, 20, 21, 34, 35, 41). For example, one study from Ethiopia highlighted potential vaccine failure due to sub-optimal maintenance of the vaccine cold chain (41). Other studies highlighted issues with overly inflated administrative coverage data and issues with data quality (20, 35).

Implementation considerations for systems strengthening to improve use of surveillance data and use of data to build political will and support

An article included on the Cross-Border Health Initiative (CBHI) describes a concerted series of efforts and funding to fill gaps in poliovirus surveillance and outbreak responses along the Somalia-Kenya border, an area home to nomadic, mobile populations that faces security concerns. Activities of the CBHI have resulted in development of an early warning system and enhanced surveillance. The article notes that activities have resulted in the identification of under-immunized and "missed" children for vaccination by tracking nomadic populations, but no further details are provided. Implementation of CBHI involves a series of activities involving developing cross-border forums and dialogues, funding and support for community health volunteers (CHVs), and facilitating partnerships with affected populations. The article notes that CBHI is now an integral part of the operational health plans in the region, suggesting significant penetration (30).

The study from Guangxi, China provided concrete examples of how a surveillance reporting system was developed that aligned with the country's political system (16), such as by alerting government officials with "warnings" for counties not showing improvement, which fed into performance evaluations for local government officials. Investigators describe the system in this way: "… it moves one step further into the realm of influencing policy and decision making, translating 'information' into 'messages' and further into actions" (16). Investigators highlight the need to engage in effective risk communication with local government and to seek personal commitment and local engagement. The case study report from Bangladesh, Gambia, and Armenia demonstrated how surveillance data can be used as an advocacy tool to generate support for investments in immunization and in surveillance systems—efforts that will most likely aid in the identification and reach of un/under-immunized populations (37).

Cost

One identified review discussed costs of VPD surveillance in low- and middle-income countries (38). The review included 11 studies from 6 countries. Studies mostly reported on incremental costs of adding surveillance components; the review was not specific to activities using surveillance for identification purposes. The study noted that personnel time was the largest driver of costs (21% to 61% of total VPD surveillance costs across nine studies). Synthesized findings from five studies included in the review found that cost per capita ranged from USD 0.03 to 0.16 for VPD surveillance activities (38).

Existing evidence gaps and areas for future research

This review identified several important gaps regarding the evidence base for using surveillance and outbreak response data to identify zero-dose children and missed communities.

- **There is a lack of focus on zero-dose children and missed communities**. Most studies focused more generally on high-risk areas and correlates of vaccination status, often without mentioning actionable ways to target populations identified. More understanding is needed on how surveillance data can be used to specifically identify zero-dose children and missed communities.
- **There is a lack of focus on routine immunization.** Most included articles described use of surveillance data during the introduction of new vaccines, decisions on non-routine vaccine targeting (i.e., cholera), outbreak response, and decisions on SIA/campaigns. Few studies described use of surveillance data for routine immunization. While many methods described in this review could potentially be adapted for use in the context of routine immunization, actual examples of use in this context are lacking.
- **Many studies focused on analytic results and did not discuss implementation considerations** involved with obtaining data, using data, or disseminating results. More understanding of specific steps taken to carry out activities and descriptions of successful (and unsuccessful) uses of incorporating surveillance and outbreak response data into identification efforts are needed.
- **Few studies describe efforts to use surveillance to identify un/under-immunized groups at the micro-level (i.e., sub-district).** Given the importance of finding these groups and that such groups could be missed when viewing district or subnational coverage rates, understanding how surveillance can be used at the micro-level for identification purposes is needed.
- **Studies reported various uses of surveillance and outbreak response data, but it was infeasible to ascertain which uses worked better than others and in what contexts.**

- **The types of partnerships necessary** to effectively analyze surveillance data and disseminate results for identification purposes **are unclear** and were not discussed across most studies, although there were notable exceptions (7, 16, 27).
- **Implementation of ERG-specific uses of surveillance and outbreak response data were mostly lacking**. Most studies describe use of surveillance data over large geographic areas encompassing both urban and rural areas. The Cross Border Health Initiative between Kenya and Somalia is a notable exception (30).

Limitations

Despite undertaking a comprehensive search strategy, this synthesis involved a rapid literature review and involved a topic that is both vast (surveillance) and conceptually new (using surveillance data to identify zero-dose children and missed communities); it is likely that relevant citations were missed. This topic merits further conceptual clarity and would benefit from more in-depth, focused reviews, such as conducting reviews specific to certain disease/vaccination areas. Additionally, this review included only relevant peer-reviewed publications and publicly available gray literature sources. Existing repositories of outbreak response reports, such as WHO's DONS system, were not searched due to time and resource constraints. It is likely that more evidence exists, especially programmatic data that might not be available through the sources searched. Also, despite the use of standardized forms and trained staff members, data interpretation is somewhat subjective, especially given that formal, quantitative synthesis of outcomes was infeasible. Few studies presented outcomes specific to zero-dose children and missed communities, thus limiting our ability to understand effectiveness and implementation considerations. Finally, concepts such as "effectiveness" are typically used to describe whether an intervention demonstrates change within specific outcomes of interest. Applying "effectiveness" to a data collection method (surveillance) and/or analyses that use surveillance data is not ideal, yet the term was used both for consistency with other topics assessed in this series and to help answer the research question of whether using surveillance data to identify zero-dose children and missed communities is "effective." Similar challenges were found using the term "implementation," yet the term was used for similar reasons. Despite these limitations, this review provides an initial understanding of how surveillance data has been used to identify at-risk populations and the extent of existing evidence demonstrating these methods are effective and implementable.

Conclusions

Despite the lack of identified studies that used surveillance data and/or outbreak response data to specifically identify zero-dose children and missed communities within the context of routine immunization, evidence is clearly promising that surveillance data can play a meaningful role in identifying un/under-immunized populations. Two main uses cases were identified, including: 1) using surveillance data to identify immunity gaps through identifying correlates of vaccination/VPD status, conducting risk assessments, integrating data into modeling/mapping exercises, layering on novel surveillance methods, and comparing surveillance data with other data sources; and 2) using surveillance data to inform decisions and build political will/consensus. While these applications provide an understanding of how these strategies could be adapted to identify zero-dose children, more research is needed to understand the implementation and effectiveness of such efforts, including understanding how these methods could be adapted for use in routine immunization. Review findings suggest that successful use of surveillance and outbreak response data for identification purposes involves close collaboration between those collecting data, those analyzing data, and decision-makers tasked with acting upon results.

How should pro-equity programming shift based on findings?

Using surveillance and outbreak response data to identify populations in need of vaccination serves as one of the main functions of surveillance systems. To further shift surveillance efforts towards identification of zero-dose children and missed communities, the following steps could be taken:

- Use surveillance data, particularly in areas reporting high coverage, as a check on coverage data for identifying gaps in immunization coverage that might otherwise be missed, especially in the context of routine immunization.
- Pair analytic efforts with meaningful engagement of local officials to create support to ensure results will be used to inform targeted programs to reach populations in need.
- Find novel and innovative ways of using existing surveillance data to better understand factors associated with zero-dose children and missed communities.
- Move beyond focusing on geography to identify “high risk” areas and focus more efforts at the micro-level. Leveraging local expertise in data interpretation could help identify pockets of individuals/groups who are un/under-immunized.
- Consider using surveillance data for generating political will to address gaps in immunization coverage that are previously known but not addressed.

Based on the findings, should supportive supervision interventions with an equity perspective be brought to scale?

Based on review findings, scaling-up use of surveillance data to identify un/under-immunized populations is a promising pro-equity approach. However, as few identified studies were specific to zero-dose children and missed communities, and that various use cases were identified, critical questions related to scale-up remain unanswered. Careful thought and additional research are needed to understand how and when surveillance data can be used to complement existing data sources and identification activities. Some overarching recommendations relevant to scale-up include:

- Strengthen surveillance systems, and health systems overall, and increase investments to ensure data quality.
- Make data and analyses more user-friendly for policymakers, decision-makers, and program implementers to increase the likelihood that results will be acted upon.
- Identify and report on replicable ways to use surveillance and outbreak response data to identify zero-dose children and missed communities and influence decisions in routine immunization.

Developing rigorous learning agendas would help in determining how and when use of surveillance data should be integrated into identification efforts.

Appendix A.

How was this evidence synthesis conducted?

SEARCHING, DATA EXTRACTION, AND ANALYSIS: The review followed a general methodology for all topics in this series. In brief, the methodology involved comprehensively searching electronic databases from January 2010 through November 2022, conducting a gray literature search, screening through all citations, and developing topic-specific inclusion criteria. Data were extracted into standardized forms, and results were synthesized narratively.

INCLUSION CRITERIA: We included studies that took place in low- or middle-income countries, evaluated or described the use of surveillance data or outbreak response data to identify zero-dose children and/or missed communities. Studies needed to present data relevant to the identification of zero-dose, missed communities, or otherwise un/under-immunized populations or describe processes for using surveillance data for identification purposes. We included both effectiveness studies (defined as using a multi-arm design or using pre/post or time series data that evaluates the identification of these populations using surveillance data as compared to some alternative) and implementation studies (defined as any study containing descriptive or comparative data relevant to implementation outcomes).

SEARCH RESULTS:

- 2,060 articles were identified in the published literature search.
  - 1,970 articles were excluded during the title and abstract screening (90 citations were retained and included in the full text review).
  - 65 articles were excluded during the full-text review, leaving 25 citations for inclusion.
- Ten additional articles were identified through other means (contacting experts in the field, secondary screening of references from included studies).
- In total, 35 articles and reports were included:
  - 1 review related to cost
  - 34 related to effectiveness and/or implementation

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