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Gavi Digital Health Information Strategy

Technical Brief Series

Timely detection of vaccine-preventable diseases for targeted vaccination and outbreak response

Gavi The Vaccine Alliance

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Executive summary

Digital Health Information (DHI) applications can help facilitate data capture, sharing, analysis and visualisation of information related to the surveillance and outbreaks of Vaccine Preventable Diseases (VPDs). The digitisation of VPD data can be used to trigger rapid outbreak response, enhanced immunisation activities and identify priority pathogens targeted for action. Gavi, the Vaccine Alliance, has identified digital health information systems that enable timely VPD data capture, sharing, analysis, and visualisation linked to decentralised testing and electronic case reporting as a priority area for country support in the coming 5 years. Building on progress and advances in aggregate electronic Integrated Disease Surveillance and Response (eIDSR) and VPD case-based surveillance systems, Gavi will support countries to more efficiently and rapidly target vaccination efforts in response to detected VPD outbreaks through VPD data exchange applications. Drawing from the literature, key informants, Gavi's DHI prioritisation exercise and Gavi board priorities, the following priority steps are recommended for Gavi and Alliance Members.

RECOMMENDATIONS

- Prioritise partnership engagements to increase national governments' capacity for data triangulation and decentralised testing and electronic case reporting of VPDs.
- Prioritise improving the computer literacy of frontline health, laboratory workers, and others to support decentralised testing and electronic case reporting of VPDs.
- Prioritise evaluation of current decentralised testing and electronic reporting initiatives in other disease areas to help catalyse better diagnostic testing and reporting for a range of VPD including, typhoid, cholera, meningococcus, measles, rubella, and yellow fever.
- Prioritise support for digital systems and tools to facilitate reporting of results from decentralised testing to national disease surveillance systems
- Prioritise appropriate use of technology as needed, such as SMS instead of internet-based data transfer, aggregate instead of case-based for test reporting and interpretation for the range of diseases.
- Prioritise information systems that enable linkage and visualisation of aggregate data from multiple sources including surveillance, laboratory, population, and geospatial data.

This Technical Brief provides a review of the state of evidence and experiences with DHI-enabled VPD surveillance, identifies gaps and makes recommendations to inform the development of Gavi's Digital Health Information Strategy.

Background

Digital technologies provide many opportunities for disease surveillance, prevention, and control by improving the timeliness of data capture, analysis, and visualisation to increase people's ease of data use and inform decision-making at all phases of a disease outbreak and management. Many countries supported by Gavi struggle with routine vaccine-preventable disease (VPD) reporting. COVID-19 has demonstrated how rapidly pathogens can spread worldwide if unchecked and without reliable reporting and data. The Covid-19 pandemic has also led to increased vigilance and contributed to better data capture and more real-time disease monitoring. Public health disease surveillance may be conducted on the entire patient population – *population-based surveillance* – or at designated sites on representative samples of the population – *sentinel surveillance*. Countries use both active and passive surveillance, depending on the VPD.

The International Health Regulations 2005 (IHR 2005) is the mechanism by which the WHO receives country reports on public health events of international concern. Countries, including those supported by Gavi, see advances in digitised surveillance as an opportunity to meet IHR reporting requirements as well as other reporting needs. Infectious disease surveillance is intended to detect, monitor, and identify outbreaks of known vaccine-preventable diseases (VPDs), priority pathogens, and events related to vaccination (Murray and Cohen 2017) and remains crucial for the following strategies:

a. *Preventive campaigns* - identify areas sufficiently affected by disease outbreaks to warrant increased attention for routine vaccination

b. *Trigger outbreak response* - generate early warning signs and an alert system for the likelihood of potential outbreaks

c. *Quality control of immunisation programmes* - ensure equitable vaccine coverage, and monitor effectiveness

d. *Schedule management* - identify the need to change vaccine formulation and protection against new strains or variants

Information on the seasonality, demographics, location, and symptoms of infectious disease cases in the population can provide actionable feedback on vaccine effectiveness, areas of low coverage, problems in the cold chain or vaccine handling, and early detection of disease outbreaks that can trigger mitigation and emergency measures. None of this information is useful unless it is communicated quickly, accurately, and in a coordinated way to mobilise action and response promptly. Improved timeliness and completeness of reporting can provide a platform for coordination, investigation, and response to under-immunised populations.

Disease surveillance for VPD helps countries efficiently target immunisation efforts and respond to disease outbreaks while meeting reporting obligations. This **Technology Assessment Briefing Document** is the output of a systematic search of published literature augmented by targeted key informant interviews with disease surveillance experts.

In alignment with the Gavi 5.0 Strategy, the Digital Health Information development process identified "timely detection of vaccine-preventable disease for targeted vaccination and outbreak response" as one of six interrelated digital health information areas that can facilitate achievement of its strategic goals through the following pathways:

Goal 1: Introduce and scale-up vaccines

Better surveillance activities by national governments will ensure efficient, effective, and equitable introduction and targeting of vaccination using multi-sourced triangulated information to identify areas of low coverage for rapid corrective action to reach pockets of zero-dose and under-immunised children.

Goal 2: Strengthen health systems to increase equity in immunisation

A strengthened health system will use contextual and appropriately generated disease surveillance data, triangulated with decentralised testing and laboratory data alongside vaccination and other programme data for efficient, effective, and equitable use of scarce vaccines where they are needed most. Surveillance data, when accessible and used, remain important to detect gaps in initial vaccination and prompt compensatory action.

Goals 3: Improve sustainability of immunisation programmes

Improved country capacity to budget for and provide domestic financing alternatives for surveillance will sustain the monitoring of EPI programme performance through phases of transition from Gavi support. Subnational surveillance costing analysis will help inform resource needs for sustained surveillance systems used to improve routine immunisation coordinate responses to VPD outbreaks.

Goals 4: Ensure healthy markets for vaccines and related products

Greater visibility into disease patterns through integrated tools for surveillance and targeted response will help identify market needs at a granular level.

Disease surveillance systems that rely on paper reports often do not provide an up-to-date picture of disease incidence and potential outbreaks in a country. Paper reports are often delayed, incomplete or missing and do not easily facilitate rapid information exchange and coordination (MSH 2018; Ngaujah and Clemens 2019). In addition, paper reporting does not normally include geo-location (coordinates), which can provide accurate case locations and help identify spatial clustering of cases. Digital reporting can help collate, analyse standardised data, send automatic feedback and reminders, provide quality checks, and trigger automated alerts to investigate and take action on suspected outbreaks, events or symptoms related to priority diseases (MSH 2018; WHO 2010). Integrated reporting systems can incorporate mobile phone-enabled data transfers that are especially important during field investigations and responding to outbreaks in remote areas. Digital reporting can also incorporate periphery health centres and communities in disease reporting (WHO 2010; Adokiya et al. 2015).

Gavi investment in electronic surveillance to date

During Gavi 4.0, in 2019, following the request by WHO responding to numerous country requests, Gavi invested in the development of the DHIS2 modules for IDSR and case-based surveillance (CBS).

- **Integrated Disease Surveillance & Response (IDSR) package:** weekly aggregated reporting and analysis of vaccine-preventable and other notifiable diseases for surveillance. Standard dashboard following WHO and content expert guidance support the routine analysis and use of these data.

- **Vaccine-preventable diseases (VPD) case-based surveillance:** case-based, longitudinal data capture and analysis for VPDs; designed as an integrated program covering 9 priority diseases. This package is intended for implementation alongside aggregate IDSR reporting. The module integrates case-based clinical and laboratory data to capture, analyse and use robust epidemiological data for disease surveillance and response and data triangulation to identify immunity gaps. Fifteen countries have already requested support for implementing this package in their 2021 Targeted Country Assistance (TCA) work plans.

While the DHIS2 VPD case-based surveillance package was being developed with WHO, US CDC, and other content experts support, the COVID-19 outbreak started. In March 2020, University of Oslo (UiO) released a DHIS2 toolkit for COVID-19 surveillance & response including modular components for case-based surveillance, Points of Entry screening, contact tracing, aggregate situation reports, and outbreak line listing aligned to WHO technical guidance. The rapid global adoption of the toolkit with technical support from the regional HISP network and global training materials by 36 countries demonstrate the high feasibility of adoption by other countries as well. Johns Hopkins University (JHU) Global mHealth Initiative Digital Solutions for COVID-19 Response assess DHIS2 as one of *"two platforms that stand out for their maturity, flexibility, and large-scale deployment...turn-key ready applications for COVID-19 and a history of proven success with large-scale deployments. Globally, there is much experience and capacity in adapting and deploying DHIS2 with minimal involvement of the steward organisation. With CommCare, adaptation and deployment support can be provided (at a cost) by the steward organisation."* (JHU Global mHealth Initiative 2020).

Over the past 3 years Gavi has also invested in improved testing and local capacity for yellow fever diagnostics (Hampton, Johnson, and Berkley 2022). These efforts demonstrate that diagnostic challenges for other diseases with low or erratic testing volumes can be overcome with dedicated support and response. Leveraging this progress with yellow fever, the Board approved the expansion of Gavi's efforts to improve the availability of fit-for-purpose diagnostic tests to include cholera, typhoid, meningococcal, measles, rubella, and yellow fever tests. Improved diagnostic capacity, particularly for measles, is also expected to facilitate identification of zero-dose and under-immunised children. In December 2021 the Gavi Board's Policy and Programs Committee proposed the need for better diagnostic testing capacity as an effective disease surveillance strategy to support more effective, efficient, and equitable use of targeted vaccines, i.e. vaccines used in routine immunisation in some but not all areas, in outbreak response vaccination, or both. For many of these diseases, diagnostic tests procured with Gavi funding support will likely involve more decentralised testing, and digital disease surveillance systems could be extremely useful for ensuring that the results of these tests are systematically reported to regional and national health authorities in a timely manner.

Review of frameworks, literature and experiences

The findings from both the systematic literature review and the key informant interviews are grouped by disease surveillance strategy including the surveillance type, tool used, geographic location, and specific surveillance use.

Integrated disease surveillance reporting systems (ISDR)

Integrated disease surveillance reporting (IDSR) systems have great potential to improve timely reporting, rapid response, and coordinated actions to contain outbreaks of VPDs and to identify inequities in immunisation programme service delivery. Based on key informant interviews and study findings, one way to classify integrated disease surveillance is by the type of tool used, which reflects on the format of data collected by the tool. According to a key informant, the leading electronic tool for disease surveillance in countries where Gavi works is DHIS2.

> *"When people talk about surveillance tools, the main tool is still DHIS2. If you consider tracking the number of cases of a disease, the DHIS2 aggregate data collection platform is what people tend to refer to as their surveillance system." – Key Informant*

The WHO African Regional Office (AFRO) technical guidance for Integrated Disease Surveillance and Response (IDSR) identified data sources that include outpatient registers, inpatient registers, health facility reporting forms, case-based and/or line listing reporting forms, outbreak investigation reports, log of suspected outbreaks and rumours, and laboratory reports from subnational levels (WHO AFRO 2019). This section will discuss integrated surveillance according to the format of data – aggregate vs. case-based.

Aggregate-based disease surveillance systems

As part of an aggregate-based disease surveillance system, digital formats facilitate data collection of diagnosed cases on the aggregate, or total, number of disease cases for a specific period to improve monitoring of infectious disease events, identify trends and locate possible outbreaks to mobilise resources as soon as possible (Murray and Cohen 2017). According to an informant,

> *"… the IDSR tool is running very effectively in Uganda where we have very quick reporting of the 23 notifiable diseases, same in Kenya… it's at community level as well…" – Key Informant*

A key informant noted that WHO AFRO had used the EpiInfoTM based-surveillance system for multi-disease surveillance since

the early 2000's. However, due to compatibility issues of that version of EpiInfoTM with Windows 10, that EpiInfoTM-based system is being replaced by DHIS2. The DHIS2 platform supported by multiple development donors has capabilities for capturing and reporting weekly aggregates for disease notification and is being used in several African countries (DHIS2 n.d.).

According to a key informant, the eSURV system is used in over 30 countries in coordination with WHO Afro for active polio surveillance. eSURV is an ODK-based tool developed with support from the Bill and Melinda Gates Foundation that runs on surveillance officers' mobile phones (or a mobile phone provided by the programme) as they visit up to 20 priority sites on a monthly basis (Clarke et al. 2019). The application includes a standardised form that is used to collect geolocation information and document evidence of facility surveillance visits to capture missed polio cases from the health facility registers. In the PAHO region, an informant noted they also have a web-based system for "new" vaccines including meningitis, pneumonia, bacterial meningitis, bacterial pneumonia, and rotavirus surveillance. The EWARS is another aggregate emergency information system deployed in emergencies. The EWARS is primarily supported by WHO and used in conflict or disaster zones.

Case-based surveillance systems

Case-based reporting includes information on patient demographics, symptoms, location, time, vaccination status, and laboratory results to facilitate follow-up investigation of every incident reported in the surveillance system (Blazes and Lewis 2016). Individualised case-based reports are especially useful for tracking diseases targeted for elimination, such as polio and measles, where every report of possible infection must be carefully tracked and investigated to reach the elimination goal (Murray and Cohen 2017; Blazes and Lewis 2016). Case-based reporting requires a significantly more advanced enabling environment and greater financial and human resource investments compared to aggregate reporting systems. Often case-based systems can be initiated in countries that have established successes in digital aggregate reporting systems, strong ownership from the health system leadership and training programmes for all levels of users and data managers to ensure optimised use of data for action and decision-making (Reynolds, Dialio, and Macdonald 2019). A key informant shared that a case-based system is preferable, but not always feasible for many reasons related to the required DHI enabling environment.

In Brazil, data from their electronic immunisation registry (EIR) used at health facility level has been used for surveillance of adverse events following immunisation (AEFI) (Sato et al. 2018).

Also, the VPD case-based surveillance package implemented as part of DHIS2 allows for the capture of individual longitudinal information linking clinical, laboratory and case outcomes (DHIS2 n.d.). According to an informant, this package has entry options for HIV and a separate one for TB, and more recently COVID-19. Based on the DHIS2 website, the package includes support for nine of the priority childhood VPDs standardised to the WHO definitions (DHIS2 n.d.).

For polio, Audio-Visual AFP Detection and Response (AVADAR), a community-based acute flaccid paralysis (AFP) identification system, has been extensively used in Nigeria (Ticha et al. 2020), Liberia (Shuaib et al. 2018) and other countries. The AVADAR app allows for community-level capture of pictures or video of suspected polio cases that are sent to higher levels of the health system for evaluation and further action, though not without challenges:

> *"The problem with the AVADAR is it bypasses the national system. The cases that are reported within IDSR for a country may not align with what's going to AFRO … so they have a high AFP case until they can investigate." – Key Informant*

Another tool used for disease surveillance is the SORMAS system. A key informant highlighted that SORMAS had been used for IDSR in Nigeria, Ghana, Fiji Islands, and Germany. On the website, SORMAS is based on international standards, supporting case-based surveillance, and interoperable with DHIS2, EpiInfoTM and many other systems (na 2020).

Role of the laboratory in VPD surveillance

Historically, laboratory testing has been complicated, requiring sophisticated training with test confirmation only happening at reference laboratories often situated in large cities. Advances in HIV, Malaria, and other disease testing with more point-of-care tests are changing the narrative and present opportunities for decentralised testing models (Kpokiri et al. 2020). The WHO is responsible for coordinating a network of laboratories for timely and accurate laboratory confirmation of infections, critical for surveillance in a health system (Mulders et al. 2017). A key informant said the Association of Public Health Laboratories (APHL) (APHL n.d.) is working on a global repository of digital laboratory information systems and tools. The repository will help document and establish a maturity framework to evaluate laboratory DHI software tools.

The COVID-19 pandemic has exposed the inadequacies of health system testing capabilities. Many developed countries are responding to testing bottlenecks with decentralised testing, including home-based self-testing. Improvements in DHI tools for sharing and storing laboratory testing information is essential.

> *"But if you look at the functionalities needed for lab information system, you'll see the DHIS2 doesn't meet those functionalities, it doesn't meet the functionalities of an electronic medical record either." – Key Informant*

Self-testing, self-sampling, and institutional-based testing outside conventional clinical settings are promising options to bridge the gap in the availability of health facility **diagnostic testing** (Kpokiri et al. 2020). Decentralised testing options have been shown to increase uptake without significant adverse outcomes while empowering individuals (Kpokiri et al. 2020). Another **advantage of decentralised testing** is that results can be stored in a decentralised database for shared data access at multiple levels. In self-testing, an individual collects their own sample and interprets the result (WHO 2016); self-sampling occurs when an individual collects their own sample, sends it to a laboratory for processing and receives the result from the laboratory (Harding-Esch et al. 2017). Non-traditional institutions like schools, pharmacies, correctional settings, churches and others can also conduct point-of- care testing similar to traditional laboratories and issue standardised results (Hector et al. 2018). Key informants also consider this an area of importance.

"There's been an increasing trend towards being able to test for specific diseases using much simpler tasks, rapid diagnostic tests which usually aren't quite as accurate, but they are a lot easier to use and a lot easier to ship…" – Key Informant

Widespread availability of diagnostic testing for VPDs would mean increased reporting of confirmed cases, particularly in the event of an outbreak. As part of the many innovations heralded by the COVID-19 pandemic, decentralised point-of-care diagnostic testing is helping to address inequities. Decentralised diagnostic testing of COVID-19 with confirmed results has been successfully tried (Hengel et al. 2021).

Periodic population-based survey surveillance

Population-based surveys like the Demographic and Health Survey (DHS) —conducted every four to five years— have been used for estimation-based disease surveillance and planning in many Gavi-supported countries like Senegal (Salam et al. 2017) and India (Hasan et al. 2021). Estimation-based surveillance uses data from population estimates derived from surveys triangulated with routine service delivery data. Some Gavi countries still base their international immunisation coverage reporting on population estimates from surveys (Burton 2009; WHO and UNICEF 2020).

Sentinel surveillance

Often, only a small fraction of suspected cases of a disease under surveillance are laboratory confirmed. Reference laboratories or select health facilities called sentinel surveillance sites, test a random sample of suspected cases of a disease. In India, for instance, a study found that only 21.3% of suspected rubella cases are laboratory confirmed (Murhekar et al. 2020). Based on key informant discussions, DHI-enabled laboratory integration of sentinel surveillance testing and results remains a large gap in VPD surveillance.

Surveillance information systems integration and Interoperability

Information systems integration has been identified as critical to effective immunisation targeting and outbreak response based on DHI facilitated surveillance. Based on responses from key informants, several efforts are ongoing for integration at multiple levels. Some focus on data sharing agreements, some on the format of data to be exported and shared in Excel format, others on triangulation and automated integration of multiple aggregate data sources and platforms, including DHIS2. There is promise in integrating case-based surveillance systems with related data sources and leveraging existing or new DHI registries.

Guinea's integrated case-based reporting system automatically links data on individual cases with test results stored in the laboratory information system (Reynolds, Dialio, and Macdonald 2019). This integrated approach can improve the immunisation programme and the health system's ability to more rapidly verify, investigate and respond to reports of VPDs based on the most accurate and timely information available. Issues such as the functionality of these systems when demands increase, as is the case with Covid-19, or multiple outbreaks, emergencies and other natural disasters remain gap areas.

A form of integration occurs in countries leveraging data from survey, sentinel, immunisation and surveillance for triangulation and visualisation as exemplified in Pakistan (Imran et al. 2018) and Liberia (Clarke et al. 2019). Implementing an integrated disease surveillance system can be supported with global and regional Global Goods and resources to guide the effective adoption, adaptation and use of technologies, including starting with the WHO AFRO Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) in the African Region (WHO Afro 2019). The guideline lists attributes for assessing quality of a surveillance system to include usefulness, simplicity, acceptability, representativeness and quality of generated data.

Key Considerations & Recommendations

Evidence from implementation experiences in LMICs shows that improvements in the quality and use of disease surveillance data depend on key DHI enabling environments such as partnerships and collaboration, standards, supervision, and infrastructure. As one key informant notes, if disease surveillance depends on case-based systems , then DHI registries (like master facility list, provider registry, national ID) and CRVS become key enablers. The gaps and corresponding enablers are grouped into governance, funding, standards, partnerships/collaboration, capacity and infrastructure.

Governance

The general approach to governance in many Gavi-supported countries is considered to be limited, including the organisational structure and processes available to support a DHI-enabled surveillance system. Leaders in LMICs are faced with the constant push for different DHI systems, Global Goods, new technologies, and other established proprietary systems. There have been efforts to support these governments in arriving at informed decisions through working groups and decision support tools. There are also limited incentives and capacity to invest in and support data sharing.

One key informant highlighted the importance of *a seat at the table* for DHI professionals (like informaticians and IT stakeholders) in health ministries and departments responsible for key activities like surveillance to overcome some DHI governance challenges. Other layers of governance to consider may be data-specific governance or data sharing (interoperability) governance.

Funding

Funding was highlighted as a major gap related to the scale and sustainability of surveillance interventions. Surveillance was noted to often be tied to external project objectives with limited country ownership. When funding ends, the surveillance programme stops. An informant shared that there are several multi-donor engagement initiatives, but there is little output and more needs to be done to improve inter-donor collaboration. Development partners still fund some core country staff

members' salaries in some countries. Funding was also flagged as one reason why a pilot-tested system showed the system was great and widely used, but there were insufficient resources to expand beyond the pilot.

Standards and DHI Registries

The WHO provides technical guidance in general, and specifically for disease thresholds for the identification of outbreaks. Specific thresholds are stipulated by the International Health Regulations (IHR). This is often then domesticated based on local country policy. In addition, the WHO in collaboration with partners, sets standards for DHI and has passed several resolutions at the World Health Assembly (WHA) (World Health Organization 2005; WHO 2013). As countries find the path of "least resistance" in their data collection efforts, standards should be discussed and implemented at the onset. Informants consider standardised population denominators a major challenge in calculating surveillance quality indicators.. They also noted that the lack of linkage to national data reporting systems limits the value of data and eventual scale as they often represent a snapshot of events. Other relevant areas where standardisation is needed include laboratory test nomenclature and health facility naming. Cross-border information sharing can also benefit from better standardisation of data that is collected and shared.

An informant suggests that in the short term, for example over the course of one year, one system may need to be mandated as an easy way for some countries to achieve standardisation. In the long term, systems can then be criteria-based rather than there being an emphasis on a particular system.

Partnerships and Collaboration

Aggregate and case-based disease reporting requires coordination and cooperation among sub-national/district managers to receive and enter standardised reports from all health facilities in their area. Poor collaboration among stakeholders in the surveillance and immunisation value chain (the series of activities to achieve immunisation or surveillance goals) was identified as a major gap. There is a consensus among informants that most activities regarding disease surveillance centre around case identification, case-reporting, case investigation, sample collection and testing, and data analysis. One key informant suggests that partners should pressure each other so that any outlier partner attempting to develop or use a siloed system will not achieve sustainability. Intra- and inter-institution collaboration was highlighted as important, with an example of limited country staff collaboration with international/HQ staff of the same organisation. Most countries have yet to properly manage the multiplicity of partners coming with support, which is an area where greater collaboration among partners can show improvement.

Most Informants identify with Gavi's support of DHIS2 towards a multi-disease approach and believe countries need to go in that direction. They also acknowledged some limitations when some programmes have a greater focus and resources on specific diseases such as polio, HIV, TB, and malaria. Informants described examples of less-than optimal collaboration where two agencies responsible for surveillance and immunisation were unable to share information in at least two Gavi Priority countries.

Disparities in data and their quality impedes collaboration and data sharing, for instance, while a country may be reporting 95-99% coverage in immunisation, outbreaks of specific diseases in specific geographic areas are often an indication of low vaccination coverage. This may be further exacerbated by the differences in population denominators and different numerators for the same diseases being reported.

Capacity

Training, capacity building, mentorship, and supportive supervision programmes are essential to the successful use of DHI-enabled disease surveillance systems at all levels, including procedures and protocols for making use of the data, identifying and investigating cases and coordinating responses across sectors and administrative or national borders (Masiira et al. 2019). Dedicated training programmes can help improve end users' knowledge, comfort, and understanding of a reporting system, not just the deployment of new technology and tools (Randriamiarana et al. 2018). Lack of training and supervision are cited as the reasons for low rates of on-time reporting to the digital disease surveillance system in Malawi (Joseph Wu et al. 2018). In Kenya, special training on the integrated disease reporting system for sub-national disease surveillance focal points improved completeness (proportion of units reporting) and timeliness (proportion of reports sent on time) compared to countries that did not receive the training but were expected to use the same system (Njeru et al. 2020).

Insights from key informants show that DHI human resource needs remain a bottleneck to achieving the immunisation and surveillance programme agenda. When they are not adequate, there is increased turnover and staff attrition, often fuelling the need for refresher trainings. Several informants highlighted the need for computer literate graduates from African Universities to support such activities. DHI capacity is somewhat universal, meaning that if a health provider is trained on using an aggregate tool for surveillance, then they have enhanced capacity to learn and use other aggregate DHI tools. Local DHI capacity within the Ministry of Health, the community, or service points varies across countries and within countries.

> *"…like the Rwandans from my understanding, basically built most of their surveillance system on their own or it's largely a custom system. In other countries, there's not much capacity so it's going to vary dramatically." – Key Informant*

In contrast, another country's eIDSR system stopped working the moment donor funding ended despite building off a Global Good. The informants believe this was because there was limited local capacity to galvanise country ownership of this highly successful and effective eIDSR system. Ghana and Rwanda were cited as good examples of countries with strong IT departments whose capacity are considered adequate for country ownership of supported DHI systems with the knowledge that there will be other systems in the future. Other countries use external experts, like the HISP network, to provide the needed support. Overall, informants want to see local ability to modify and provide general support for deployed DHI Global Goods. Technical capacity to understand, utilise and interpret data trends also remain inadequate.

Infrastructure

Digital Health Information (DHI) of any kind requires basic infrastructure defined in the WHO/ITU eHealth strategy toolkit as electricity, internet connectivity, and hardware devices (WHO and ITU 2012). This infrastructure is foundational for any level where DHI is to be used depending on the architecture of the surveillance system. If it is community, facility, or district-based,

adequate devices and arrangement for electricity to charge/ recharge them, and an application and internet connectivity for transmitting the collected data are needed. Informants noted that most support for DHI tools do not consider the relevant infrastructure carefully, including what happens when hardware needs replacement. An informant shared an incident where a partner purchased thousands of smartphone hardware for internet-based surveillance work in many countries without adequate internet connectivity. This fundamental infrastructure mismatch limited the success of the intervention.

Recommendations for Prioritised Gavi DHI Strategy Investment

Global

- A robust evaluation of VPD e-surveillance data systems, including how they are interfacing with existing case-based surveillance and lab confirmation.
- Development of a readiness assessment tool for countries interested in expanding their electronic data systems to be in line with the global comprehensive VPD surveillance guidelines from WHO-Geneva.
- Promotion of interoperability of laboratory with epi data for VPD electronic information systems including template for data sharing agreement. This would encompass various current platforms and tools or those in development, development of the work on unique identifiers and CBS.
- Develop a framework (or tool) for countries to use to determine the appropriate level of integration/ triangulation/ visualisation, given the country's DHI enabling environment maturity: 1)aggregate data triangulation & visualisation 2)case-based integration leveraging real-time linkage to DHI registries and CRVS 3)standalone system-to-system interface (aggregate or case-based) 4)design and implementation of interoperability-layer 5) decentralised information sharing
- Catalytic support for the tools most requested by countries supported by Gavi.

Country

- Community based surveillance: development of a framework to roll out the many existing tools in an integrated way.
- Facilitate capacity building for different roles focused on decentralised testing systems and data triangulation – system users, system maintainers, data users for decision-makers.
- Scale aggregate electronic integrated surveillance and response systems, taking lessons from polio and other disease areas in support of decentralised testing.
- In countries with more advanced systems for disease surveillance already in place, priority investments may support the integration of laboratory information systems to link test results with case-based reports and improve the coordinated investigation of suspected disease events.
- Incorporate geospatial data into an integrated disease surveillance and decentralised reporting system for better visualisation and decision making.

Conclusion

The current state of DHI surveillance strategies and systems in LMICs (particularly Gavi-supported countries) and enablers were identified, including a few countries with successful aggregate IDSR systems and some transitioning to case-based systems. DHIS2 is the most widely used aggregate-based integrated disease surveillance information system. There are various pilots of case-based surveillance, but no evidence in the published literature of scale (even district/state-wide scale). Population-based surveys are also still being used particularly to meet reporting obligations, especially in the face of population denominator/numerator discrepancies. Laboratory and sentinel-based surveillance are also used. In locations with multiple systems, interoperability is limited for both aggregate and case-based surveillance systems. There is at least one aggregate system-to-systems integration. There are significant gaps in the necessary enablers to support DHI surveillance—especially in the areas of data sharing, data standards, capacity, and infrastructure. Similarly, Gavi's disease surveillance focus should prioritise multi-sourced data surveillance and triangulation and enhancement in decentralised testing.

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Appendix A: Literature Review methodology details

A rapid review of published studies, research, project guidance and grey literature was conducted to better understand the context, current approaches and experiences with digital health and data applications for surveillance of any one of the major vaccine-preventable diseases (measles, rubella, polio, DPT).

Documents were identified for review from a broad semi-systematic database search using standard key words (see boxed text). From an initial 413 unique citations identified, 27 documents were identified for full-text review and included in the review. The documents selected for full-text review are a combination of evaluations and experiences with digital tools in laboratory surveillance, sentinel surveillance, aggregate, case-based and sentinel surveillance, population-based surveys and data triangulation. Other documents, project reports and articles suggested by key informants contributed to the review and overall background.

Literature Review Methodology

PubMed database searched for relevant literature using a selection of standardised key words with the names of 142 low- and middle-income countries:

Electronic
Digital
Data
Surveillance
Monitor
Measles
Rubella
AFP
DPT

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