MOMENTUM

Routine Immunization Transformation and Equity

LANDSCAPE ANALYSIS OF HEALTH INFORMATION SYSTEMS AND DATA TOOLS FOR IDENTIFYING, REACHING, AND MONITORING ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN

Global-level Report of Findings

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ABBREVIATIONS

ANC	antenatal care
BID	Better Immunization Data
CBIS	community-based information system
CDC	Centers for Disease Control and Prevention
CHT	Community Health Toolkit
CHW	community health worker
COE	centers of excellence
CRVS	civil registration and vital statistics
DHIS2	District Health Information System 2
DHS	Demographic and Health Survey
DQA	data quality assessment
DQIP	data quality improvement plan
DQS	data quality survey
DQSA	Data Quality Self-Assessment
DRC	Democratic Republic of the Congo
EIR	electronic immunization registry
EPI	Expanded Programme on Immunization
GIS	geographic information system
GPEI	Global Polio Eradication Initiative
HBR	home-based record
HMIS	health management information system
IIS	immunization information system
IISA	Immunization Information System Assessment
IRMMA	identify, reach, monitor, measure, advocate
LGA	local government authority
LMIC	low- and middle-income country

LQAS	lot quality assurance sampling
MCH	mother and child health
MCSP	Maternal and Child Survival Program
MICS	Multiple Indicator Cluster Survey
MNO	mobile network operator
MOH	ministry of health
MOV	missed opportunities for vaccination
ODK-X	Open Data Kit Tool Suite X
PCCS	post-campaign coverage survey
RED	Reaching Every District
SIA	supplemental immunization activity
SMS	short messaging system
USAID	United States Agency for International Development
VPD	vaccine-preventable disease
WHO	World Health Organization

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1. INTRODUCTION

Despite the increase in coverage of new vaccines in low- and middle-income countries (LMICs) from 2000 to 2010, progress extending routine immunization services to all children slowed between 2010 and 2019. Immunization coverage in many countries remains below the goal of 90 percent established by the World Health Organization (WHO). (1) Drawing on lessons from the past decade, the Immunization Agenda 2030 lays out a strategic framework centered on achieving vaccine equity with the goal of "leaving no one behind." (2) In line with this strategic shift, Gavi and other funders have aligned their strategies to prioritize reaching zero-dose children and missed communities, with equity as the organizing principle. (3)

Most zero-dose children live in urban areas, remote communities, or conflict settings. (3) Reducing immunization inequities in these geographies requires more accurate, specific, and real-time data on how many under-immunized children and missed communities there are; who and where they are; and why they have not been reached. In addition, health care professionals need better information systems and tools to capture, analyze, and use these data to improve routine immunization.

Key concepts and definitions

Zero-dose children are those who have not received any routine vaccines. For operational purposes, they are defined as children who have not received the first dose of diphtheria, tetanus, and pertussis-containing vaccine.

Under-immunized children are those who have not received a full course of routine vaccines. For operational purposes, they are defined as children who have not received a third dose of diphtheria, tetanus, and pertussis-containing vaccine.

Missed communities are populations that face systematic constraints on their access to immunization and other essential health services.

2. LANDSCAPE OBJECTIVES AND HOW TO USE THE FINDINGS

Health systems face many important challenges to providing populations access to essential high-quality services in an equitable and inclusive manner. Essential public health programs, such as immunization, are of great importance in the prevention and control of diseases, as has been evidenced during different epidemics suffered in recent decades. Despite national efforts to expand vaccination coverage, there are important challenges to identifying, reaching, and monitoring all children. That is why the strengthening of health information systems in a holistic manner is an opportunity to improve decision-making based on data and in a timely manner, improving interventions and making them cost-effective, and optimizing resources.

The purpose of this landscape analysis is to describe information systems and tools to identify, reach, and monitor zero-dose and under-immunized children, with a focus on how they are being used in MOMENTUM Routine Immunization Transformation and Equity project ("the project" going forward) countries, such as the Democratic Republic of the Congo (DRC), Kenya, Mozambique, and Nigeria. These include information systems and tools that have been used for immunization or by other health programs and could be adapted for routine immunization. As a landscape, this report does not systematically review the effectiveness or cost of information systems and tools. However, where evidence exists, we provide actionable recommendations about their known or potential uses. Where possible, this report describes the challenges and opportunities related to implementing and scaling-up the systems and tools for the use cases of identifying, reaching, and monitoring zero-dose and under-immunized children. The primary intention of this landscape analysis' findings and recommendations is to inform project investments. They are also relevant for immunization funders and decision-makers who are considering how to invest in strengthening health information systems

to identify, reach, and monitor zero-dose and under-immunized children, and which gaps to prioritize for closing.

3. METHODS

3.1 FRAMEWORK AND SEARCH STRATEGY

This report answers the research questions through a non-systematic desk review of peer-reviewed and grey literature to identify relevant information systems and data tools. The search strategy and analysis approach were driven by Gavi's Identify, Reach, Monitor, Measure, Advocate (IRMMA) framework, which describes domains or steps needed to vaccinate zero-dose and under-immunized children and missed communities.

Key research questions

1. What information is needed to identify, reach, and monitor zero-dose and under-immunized children?

2. What data tools and information systems—including paper and digital—exist in selected countries for identifying, reaching, and monitoring zero-dose and under-immunized children, and what are the gaps?

3. For these tools and systems, what are the facilitators and functional requirements in place to identify, reach, and monitor zero-dose and under-immunized children?

4. What lessons can be drawn from tools and systems that have been introduced for COVID-19 vaccination?

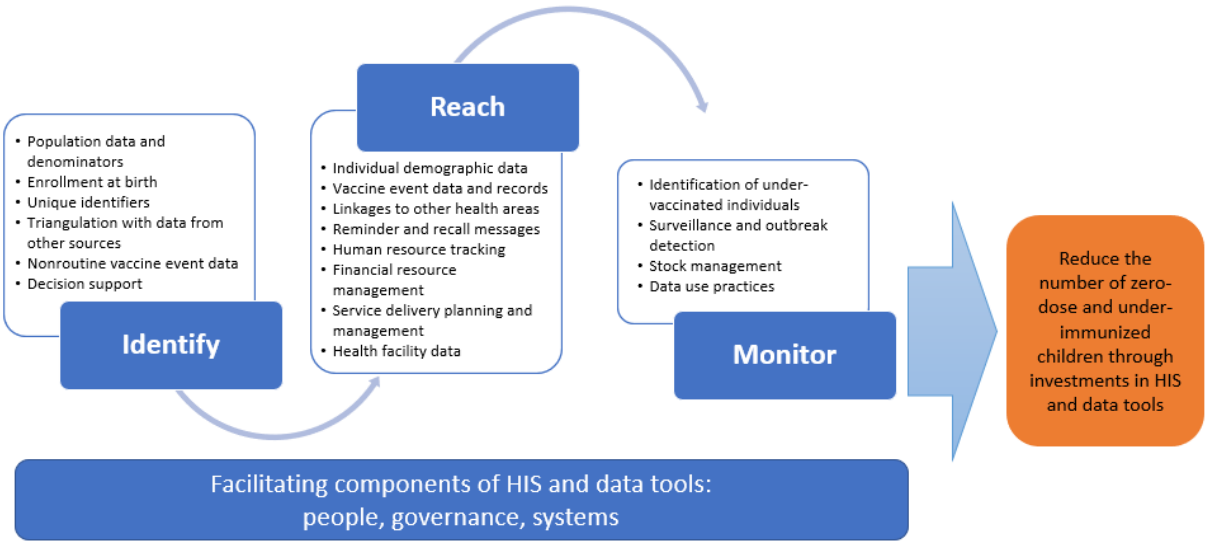
Intervention areas of the IRMMA framework

- **Identify:** Find and describe how many zero-dose children and missed communities there are, who and where they are, and why they have not been reached.
- **Reach:** Develop and implement tailored and sustainable strategies to overcome supply- and demand-side barriers to ensure missed children are reached with immunization in different settings (urban, remote rural, fragile, and others).
- **Monitor:** Ascertain if programmatic strategies are reaching zero-dose and under-immunized children and use data to decide on course correction measures.
- **Measure:** Evaluate the effectiveness and efficiency of immunization programs in reaching zero-dose children and missed communities.
- **Advocate:** Use evidence to make a case for political attention and resources to reach zero-dose children and missed communities with immunization services.

For the purposes of this landscape analysis, the research team adapted the Gavi framework to focus on the information system and data tool functional requirements that enable health workers, managers, and planners to identify, reach, and monitor zero-dose and under-immunized children (Figure 1). Functional

requirements are defined as what the system or tool can do and how end users interact it. A description of each functional requirement is provided in Annex 1. The framework includes functional requirements that support the specific information needs of immunization decision-makers—specifically health workers, managers, and planners—as illustrated by the questions in the box below. The resulting literature search strategy used terms to ensure that information systems and tools included would be able to meet the functional requirements for the target use cases.

FIGURE 1. FRAMEWORK FOR IDENTIFYING, REACHING, AND MONITORING ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN



Immunization decision-maker questions to identify, reach, and monitor zero-dose and under-immunized children

- How many children are eligible for vaccination?
- Where do unvaccinated children live?
- Why are children unvaccinated?
- What strategies can reach unvaccinated children?
- Are there enough vaccines for all eligible children?
- Are immunization strategies reducing the number of unvaccinated children?

We constrained the review to focus on systems and tools that have been or could be used by health workers, managers, and decision-makers (*who*) to identify, reach, and monitor zero-dose and under-immunized children (*what*). Use by clients, community members/civil society, researchers, and policymakers was beyond the scope of this review, although we describe insights related to these user groups when they are a significant aspect of the use of the system/tool, for example the role of clients in short messaging systems (SMS) to improve reach.

Considering the focus on health workers, managers, and decision-makers, the literature search focused on the identify, reach, and monitor steps. While information systems and tools can also support actions to

advocate for zero-dose and missed communities (e.g., by providing information to decision-makers), and to measure the effectiveness of interventions (e.g., by providing information to evaluators), this review focuses on the more direct-use cases for identifying, reaching, and monitoring zero-dose and under-immunized children as part of clinical and management decision-making.

The search included documents that described the use of systems and tools in LMICs. We performed targeted searches for DRC, Kenya, Mozambique, and Nigeria and reviewed examples from other LMICs, particularly when lessons could be applied to focus countries. Although our primary focus was immunization, we considered information systems and data tools that have been used by other health programs and could be adapted for routine immunization.

Since countries included in the landscape analysis vary across the spectrum of digital health maturity,[1] and because paper-based systems and data tools continue to dominate in most LMICs, the landscape includes both paper-based and digital systems and tools.

Consult these resources for more details:

- Digital Square Global Goods Guidebook
- Digital Square COVID-19 Map & Match
- UNICEF, Accelerating Results for Children with Technology and digital innovations
- Equity Reference Group (ERG) for Immunization Discussion Papers
- WHO, Reaching Every District (RED) – A guide to increasing coverage and equity in all communities in the African Region
- Gavi, Improving Immunisation Coverage and Equity through the Effective Use of Geospatial Technologies and Data – A Landscape Analysis and Theory of Change
- Digital Square, Electronic Immunization Registries in Low- and Middle-Income Countries
- VillageReach, Landscape Analysis of Electronic Immunization Registries
- Paper Based Health Information System in Comprehensive Care (PHISICC) project
- WHO Resource Library Resources for Improving Immunization Coverage and Equity

3.2 REVIEW AND ANALYSIS STRATEGY

From reviewed documents, we extracted information on the system or tool, including its functional requirements; its adoption, uptake, implementation, and sustained use; the context of its use, including users and use case; and challenges, facilitators, and lessons. The research team noted evidence on effectiveness or outcomes when it existed, although this was not the objective of the analysis. Findings related to each

[1]Digital Square developed a standardized 5-point scale for digital health maturity using data from the Global Digital Health Index, supplemented with World Economic Forum Networked Readiness Index indicators. Each country is categorized 1 to 5, with 1 the lowest level of maturity. (106) Among the focus countries included in this review, Mozambique is rated as having the lowest level of maturity (level 1), followed by DRC (level 2), and Kenya and Nigeria (level 3).

system/tool were summarized and are described in this report according to the IRMMA domains. When a given system/tool addressed multiple domains, the research team selected one for its presentation. Each section in this report includes information on lessons, use in focus countries, and initial recommendations for the project, funders, and global and national decision-makers.

4. DETAILED FINDINGS: WHAT INFORMATION SYSTEMS AND TOOLS EXIST TO IDENTIFY, REACH, AND MONITOR ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN AND WHAT ARE THE GAPS?

4.1 INFORMATION SYSTEMS AND TOOLS TO IDENTIFY ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN

OVERVIEW

Health workers cannot identify all children for vaccination if they have weak or incomplete data on the number of eligible children and where they live. Ideally, decision-makers would have current, accurate population census data to inform immunization planning, along with a well-functioning civil registration and vital statistics (CRVS) system that links to immunization registries, making it possible to check that all children registered at birth receive vaccines. In the Latin America region, for example, many countries have electronic immunization registries (EIRs) and CRVS systems that are linked or compared manually, enabling facilities to identify eligible children who miss their first vaccination. (4) However, only 4 percent of low-income and 34 percent of LMICs have complete birth registrations. (5) A review of Demographic and Health Survey (DHS) and Multiple Indicator Cluster Survey (MICS) data in 72 LMICs showed greater rates of Bacille Calmette-Guérin vaccine immunization coverage than birth registration records, suggesting that, given the currently deficient CRVS systems, immunization programs could be leveraged to increase birth registration rates. (6) Since immunization programs are unable to rely on population census data and because CRVS systems are incomplete or non-existent, alternative methods such as those described below are needed to calculate population denominators and identify unimmunized children and at-risk groups.

4.1.1 COMMUNITY-BASED INFORMATION SYSTEMS

Community health workers (CHWs) use community-based information systems (CBISs) to collect, manage, and analyze data on health and related-services provided to communities outside facilities. (7) CBISs enable CHWs to take a more proactive role in identifying and seeking people who need services in their catchment area by conducting household visits and using tools to track case management and cases lost to follow-up. Since they can be used to register births in the community and collect information on children soon-to-be born (e.g., in the case of maternal health registries), CBISs can help identify zero-dose children who may not be captured by the health system if they are never brought to a health facility. Since the success of CBISs requires contact with all persons and households within a catchment area, using them in combination with geospatial technology can increase assurance that critical geographies are not missed. Several well-

established CBIS digital global goods[2] have been deployed across health programs and geographies (Table 1). They have features such as offline-capable mobile data collection and can be customized to support community health systems and care delivery.

TABLE 1. DESCRIPTION OF CBIS GLOBAL GOODS AND SCALE

Description	Scale*
CommCare is a flexible application that allows for digitization of surveys and forms and includes decision support, notifications, and SMS. It is often used for case management and can be employed at all levels of the supply chain. More than 30 countries are using it for COVID-19 response, including community preparedness, contact tracing, facility readiness assessment, port of entry screening, and health worker education.	**Established.** Deployed in over 80 countries, including DRC, India, Kenya, Mozambique, and Nigeria.
Community Health Toolkit (CHT) is a collection of open-source technologies designed to support community health systems. It offers customizable applications for five areas of functionality: messaging, task and schedule management, decision support and care guides, longitudinal person profiles, and analytics. Solutions built on the CHT platform have been adapted to support reporting, verification, and escalation of potential COVID-19 cases.	**Established.** The largest CHW networks supported by the CHT are in Kenya, Nepal, and Uganda. It also supports community health networks and health systems in Burundi, DRC, Ghana, India, Indonesia, Malawi, Mali, Niger, South Africa, Tanzania, Togo, and Zimbabwe.
Open Data Kit Tool Suite X (ODK-X) suite lets you build custom apps to gather, manage, and visualize data on an Android device. It's been used by a variety of health programs, including malaria, HIV, and vaccination. Applications include cold chain management, longitudinal patient tracking, and geographic data collection.	**Emergent.** Implementation has taken place in over 100 countries, including DRC, India, and Kenya.
*The Global Goods Guidebook rates the scale of global goods. An emergent global good is a digital health tool that shows great promise for use in multiple countries but may require additional investments to adapt to a different context. An established global good has been deployed in multiple countries.	

FINDINGS

In Tanzania and Zambia, the Better Immunization Data (BID) initiative has tested mobile health apps, such as **RapidPro**, to register home births via SMS by a village representative or CHW. The SMS birth notifications create a placeholder patient record within the EIR that is validated and becomes official once the caregiver brings the child for immunizations. The placeholder record is useful for identifying zero-dose children because the CHW or health facility can use it to follow up with caregivers who never bring their child in for immunizations. (8) In Bangladesh, pregnant women are registered in the mobile health app, mTika, and are taught how to send an SMS birth notification after their child is born. In both examples, once eligible children

[2] Digital Square has cataloged the most prevalent digital health software tools in the Global Goods Guidebook. These include tools that can be used across different health programs and are tailored to the needs of different business domains within the health system. A digital health global good is considered mature if it is free and open source, supported by a strong community, funded by multiple sources, and interoperable. It must be deployed at significant scale, used across multiple countries over an extended period, and demonstrate effectiveness.

are captured in the immunization registry, caregivers can receive reminders about vaccination visits and the clinics have enough information to trace children who miss their first visit. (9) In South Africa, MomConnect is an mHealth initiative that uses SMS texts to register pregnancies, promote health, and provide pregnant women with a feedback mechanism on services received. (10)

Paper-based tools can provide similar information. In northern Nigeria, religious and traditional village leaders are responsible for recording the birth of all community members, which informs immunization planning. (11) A similar intervention in northern Nigeria enlisted barbers to identify and refer newborns for vaccination, helping ensure that births were detected and the data used directly to promote vaccination. (12) Integrating data systems across health programs is also important for minimizing missed children. For example, in Kenya, the Ministry of Health (MOH) developed the Mother and Child Health (MCH) booklet, which replaced the three separate medical records that existed for the mother-infant pair. If the booklet were given to the mother before or at birth, it could be used to record the initial vaccinations and subsequently monitor vaccination status and potentially increase reach (if used to counsel the family on when to return for next vaccinations). However, the booklet is usually given later if at all, so could be used for monitoring at best. The use of home-based records (HBRs) is discussed in greater detail in the next section.

USE IN LANDSCAPE FOCUS COUNTRIES

In DRC, there is no CBIS or mechanism for registering births in the community. DRC's community health system is weak and there is no overarching CHW program. Community care sites in 402 of DRC's 516 health zones are staffed by volunteer CHWs who have an important role in providing health services in hard-to-reach communities but are not integrated into the formal health workforce. CHW involvement in immunization includes reviewing children's health cards to verify they have received recommended immunizations and reporting any missed children to the health facility. CBIS digital global goods, such as CommCare, CHT, and ODK have been tested in pilot projects. CommCare was used for electronic payments and registration of staff and CHWs during the Ebola outbreak. The "Hang-up and Track" malaria project used ODK to collect information on socioeconomic status, malaria perception, and treatment. Except for these and a few other pilot projects, CHWs collect information on paper-based forms. CHW digital literacy is generally low given the lack of standardized training in use of mHealth tools. DRC is one of five UNICEF-supported countries for the implementation of a digital community information system that CHWs use to manage and that monitors their work. (13)

In Kenya, organizations like the Lwala Community Alliance are supporting CHW's use of CommCare to register pregnant women and children under five years of age. The app walks the CHW through the workflows for vaccination and other services and allows them to target areas with low coverage and households needing a reach out. This approach takes the national plan to link CRVS and national identifiers to a whole other level by already channeling children for vaccination services.

In Nigeria, community health extension workers in 20 primary health centers in Abuja and Nasarawa State are using CommCare applications to track and register pregnant women. (14) A next step could be expanding the tool to include birth registration and linkage with immunization registries to help health workers identify eligible children.

In Mozambique, we did not find any CBIS or tools used for immunization at the community level. upSCALE, a digital tool built on CommCare, is deployed at the community level for malaria case management. (15) The government plans to expand CHW use of digital tools but these efforts are hindered by the lack of a digital strategy and architecture, as well as relatively low internet availability.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

Since data collected in a CBIS are entered primarly by CHWs, the main challenge for scaling up CBIS is the need for CHWs, who may be lacking in rural areas. Even where coverage is strong, CHWs need access to tablets or mobile phones and the technical capacity to use them. The added workload of data collection and associated activities can also be a challenge for CHWs. Strong leadership and governance are also needed to develop a strategic vision and structures for community health and their information systems. This requires coordination of stakeholders operating at the community level, harmonization and standardization of tools, and creation of policies on the use of technology, including mobile applications, confidentiality, and security, at the community level. CBIS may also be challenged by limited internet connectivity, but features such as offline use and wireless synchronization can mitigate this challenge.

RECOMMENDATIONS:

- In the absence of comprehensive birth registration and CRVS, countries with functioning CHW systems may consider the feasibility of adopting community-based information systems and tools to identify and register children, particularly when it is possible to target these systems to the most underserved areas. Since barriers that impede birth registration systems can range from technical to more complex systemic challenges, stakeholder coordination across health programs and sectors is necessary to ensure that CBIS investments contribute to lasting improvements in alignment with national plans.
- Immunization and non-immunization programs may explore opportunities for greater integration and triangulation of information and service linkages across health programs and sectors such as civil registry and education. For example, antenatal care (ANC) can be leveraged to identify eligible children before they are born and link mothers to future immunization services. At the facility level, health care workers can be trained to triangulate between maternal health and immunization registries to identify and follow-up with children who have missed immunizations.
- Countries may consider opportunities to continue investing in digitizing data collection and use at the community level by targeting investments in key digital health building blocks (e.g., human capacity, investments and funding, data capture and use, infrastructure, standards and interoperability, governance, and policy).

4.1.2 GEOSPATIAL TECHNOLOGIES

Geospatial technologies include satellite imagery, geo-positioning, drones, and mobile network operator (MNO) data. They can be used to improve the identification of zero-dose and under-immunized children through more accurate microplanning and identification of missed settlements. When triangulated with administrative data, geographic information system (GIS) data can map areas of missed children according to zero-dose predictors, such as socioeconomic status. GIS-enabled tools and geospatial mapping have been most widely used in polio eradication efforts. Despite advancements in the field of geospatial technologies, many LMICs are not fully benefiting from what they can offer for routine immunization. A Gavi landscape analysis noted that as polio eradication efforts progress, it will be important to have a system and mandate to transfer these tools, datasets, and investments to help national Expanded Programme on Immunization (EPI) systems benefit from geospatial data technologies in routine immunization. In particular, the analysis identified eight immunization use cases: health system mapping; population estimation/spatial distribution; microplanning; disease surveillance; vaccinator tracking; campaign monitoring; geographic accessibility modelling; and vaccination coverage modelling. (16) In this section, we focus on lessons from geospatial technology use for population estimation and microplanning to identify eligible children.

FINDINGS

Nigeria offers one of the most comprehensive and long-standing examples of geospatial technology use in polio vaccination campaigns. (16) Since 2012, the Global Polio Eradication Initiative (GPEI) has applied this technology in Nigeria to support microplanning, track polio vaccination, and provide near real-time monitoring. (17) Population estimates generated with geospatial technology in Nigeria have been shown to closely match numbers on the ground and create more accurate program targets. An important lesson from polio eradication efforts was that nearly half of polio cases were discovered in border areas between districts because health authorities did not know the exact administrative boundaries for their health zones. (11) By using geospatial technology to create detailed maps, they were able to identify previously missed populations through better delineation of health zone boundaries. (16) Geospatial technology has not been used at scale for routine immunization in Nigeria, but a few studies have documented the cost-effectiveness of GIS-based microplanning and lessons from specific projects. (18) (17) The United States Agency for International Development's (USAID) Maternal and Child Survival Program (MCSP) used GIS in 2017 to improve routine immunization microplanning in Bauchi and Sokoto States. The intervention focused on updating target population estimates generated through GPEI activities using GIS technology, and developing digital primary health care maps with the service location, reach, and gaps based on geocoordinates to inform vaccination strategies. Implementation lessons showed that digital maps were easy to use, enabling undocumented settlements and overlapping catchment areas to be identified, and providing improved information for vaccination strategies. Challenges related to the lack of a standard governance structure and system for naming health facilities and settlements, and inconsistencies across health facility lists. (17)

In India, GIS-based microplanning implemented as part of a strategy that included community mobilization, strengthened data use, and human resources and logistics planning, helped double routine immunization coverage in an urban setting. (16) In Myanmar, a pilot project illustrated the benefits of using geospatial data and technologies to support routine immunization microplanning. (16)

Other technologies providing similar capabilities, such as drones and MNO data, have not been as widely used for immunization but could be considered. In Malawi, drones are collecting aerial images that help identify infrastructure and prevent natural disasters and diseases. (13) There are documented uses of MNO data to estimate population distribution, such as in Rwanda and after the 2010 Haiti earthquake when anonymized data from 2 million mobile phones helped track population movement. (19) (20) Three elements of MNO data can generate useful insights for immunization decision-makers: user location (population size and dynamic density distribution); profile (demographic information); and usage/spend data (details on how customers use telephone and data services across voice, text, and internet connectivity). (21) Currently, PATH is exploring the use of MNO data to support routine immunization microplanning in Tanzania. Additional lessons can be learned from how MNO data analytics are being used for COVID-19 response and decision-making.

USE IN LANDSCAPE FOCUS COUNTRIES

In DRC, vaccine distribution planners used GIS data to respond to the Ebola virus outbreak. DRC also has experience using the Vaccine Tracking System**,** which works through a GPS-enabled mobile phone that vaccinators carry and that tracks the location of each settlement they visit during a campaign. Results are uploaded to a dashboard to show the level of coverage and identify areas that vaccination teams miss. For example, in the case of a measles immunization campaign, tracking focuses on finding children who did not receive a prior dose of the measles-containing vaccine. More recently, partners are exploring the use of GIS data in routine immunization planning to update health zone maps and population estimates. For example, the Geo-Referenced Infrastructure and Demographic Data for Development is implementing a participatory

mapping approach in which local health workers are trained to collect information on settlements, health facilities, and administrative boundaries that are combined with population estimates to produce maps to inform microplanning. MNO data were used during the Ebola response but not for immunization planning.

In Kenya, GIS tools have been used in polio eradication efforts, including for creating digital microplans for vaccination campaigns. We did not find evidence of widespread use of geospatial technologies to support routine immunization. However, in one study of a targeted door-to-door mobile strategy that was used to complement facility immunization, GIS data were used to map poorly performing facilities and unreached rural-urban populations. The study showed that the door-to-door strategy, based on maps of coverage inequities, resulted in a 33.5 percent increase in fully immunized children in one year (22).

In Nigeria**,** as reported above, GIS-enabled tools and geospatial mapping have been most widely used in polio eradication efforts. Some projects implemented at the state level have used GIS to enhance routine immunization microplanning, such as the MCSP, which used data generated through GPEI activities, along with GIS technology, to update target population estimates.

In Mozambique, the national immunization program does not currently use GIS tools.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

Efforts to use geospatial technologies for immunization have been largely disconnected, operating in silos and parallel to projects mapping other health services or programs. The lack of long-term investment along with government leadership and involvement in geospatial data collection, management, and updating are barriers to expanded use. In addition, while geospatial technologies users could include immunization decision-makers, program planners, and health authorities at regional and local levels, they typically lack knowledge and tools to do so. This includes capacity for geospatial data management, use of GIS products (e.g., gridded population products), and their triangulation with routine and administrative data. More work to build capacity, standardize processes, and ensure the quality of data used to generate maps is needed. Challenges to using MNO data include disparities in mobile phone ownership, reliable connectivity, and reaching agreement with the telecommunications companies to access the data.

RECOMMENDATIONS:[3]

- Immunization programs could potentially consider using geospatial data and technologies for microplanning, such as participatory mapping approaches, where appropriate.
- Donors and international partners should provide technical assistance and tools for collecting and using geospatial data; investing in the upfront and recurrent costs associated with generating and maintaining publicly available high-quality geographic data; engaging government leadership in geospatial data collection and management; and supporting partnerships between government and other local stakeholders, including universities, national statistics offices, and private sector actors that work in these areas.

[3] For more details, readers can consult UNICEF's "Guidance on the use of geospatial data and technologies in immunization programs" and the recommendations compiled by GIS and immunization experts during the technical convening on "Improving immunization coverage and reducing inequities: use of GIS in immunization programs," which took place at UNICEF Headquarters 25–26 October, 2016. (101)

4.1.3 DENOMINATOR ESTIMATION METHODOLOGIES AND EQUITY ANALYSES

Denominator estimation methodologies and equity analyses include various approaches and interim solutions for improving target population estimates for immunization when a country's administrative data are outdated or inaccurate. Since denominator challenges have technical and political dimensions, it is important to recognize that each needs its own solution. The lack of political commitment to improve the use and quality of data has been reported as a reason for the failure of immunization information systems in many settings. (23) Microplanning involves establishing a population denominator for districts and health facilities to calculate supply requirements and target program strategies. While the process relies on input from community members to provide accurate head counts, the lessons reported below are from the application of other technical approaches to fixing inaccurate denominators. Application of these approaches, however, requires governmental willingness to make the necessary improvements for more accurate target population estimates.

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Household enumeration using CHWs is a strategy for improving demographic data of households and population denominators. In Kenya, the implementation of a community strategy improved vaccination coverage. CHWs enumerated community members within their catchment, producing registers with demographic data on households. In turn, the CHWs used the information to trace mothers and ensure that their children received all recommended vaccinations. (24)

In Pakistan, polio vaccination campaigns seek to identify any child who has received no vaccine dose and refer him/her to services. In Somalia, a positive zero-dose case identification is accompanied by a cluster survey in the community to help identify system failures that may lead to non-vaccination. Once unimmunized individuals (or communities) are identified, programs can be modified to improve access equity. (11) Similar approaches have been undertaken during measles supplemental immunization activities (SIAs). It is important to note, however, that the identification of system failures alone does not necessarily lead to resolution of the problems caused them, particularly when they concern larger issues of human, financial, and material resources. This is why the advocacy component of the IRMMA framework calls for using evidence to gain political attention and resources to remedy underlying system failures.

Mozambique implemented a new methodology for calculating population denominators. It involves tailoring the population calculation for each district instead of the standard practice of applying the national population growth average to all districts. The methodology improved the accuracy of the estimates, resulting in better planning of immunization activities and more precise vaccine forecasting. Immunization coverage monitoring, which relies on a reliable population denominator, also improved. (25) New methodologies for calculating population denominators should undergo additional testing. Difficulties such as projecting internal migration patterns can limit the reliability of sub-national population estimates.

Data triangulation and equity analyses using routinely collected administrative data can help immunization decision-makers understand and identify which population sub-groups have more zero-dose and under-immunized children and tailor strategies to reach them. PAHO, for example, has trained countries to leverage their administrative and vaccination data for equity analyses, such as stratifying immunization coverage by indicators such as sex, wealth, and ethnicity. UNICEF also supported such analyses, using Gavi funding for strategic focus areas related to data during the 2016–2020 strategy period. Countries such as Tanzania are using patient-level data captured at the facility in their EIR—including birth place type, mother's HIV status, child's weight, breastfeeding status, and receipt of other interventions such as vitamin A, mebendazole, and bed nets—to analyze equity and co-coverage across health services. (26) Other potential analyses involving data triangulation include using disease surveillance data to point to areas of missed children. In Ethiopia, JSI

has supported triangulation of immunization program and vaccine supply data to gain insights on data quality and programmatic issues such as poor immunization coverage (see details in section 4.3). (27) Using administrative data for equity analyses will require improving data quality and triangulation methods.

USE IN LANDSCAPE FOCUS COUNTRIES

DRC's last national census was conducted in 1984. In 2016, DRC's EPI program conducted a village-to-village population census that identified 98 million habitants. The EPI program has since used the 2016 population figure to inform vaccination planning and projections, but entire remote communities, and mobile and migratory populations, including in urban areas, have been missed.

Kenya generally uses census data to establish a denominator for vaccinations, though in some cases a previous year's doses given are the basis for calculation.

Mozambique's methodology for estimating target populations for all health programs, including immunization, was recently revised to apply a district coefficient. This change has been documented and accepted by EPI but is pending updated 2017 census data from the National Institute of Statistics for validation before it is applied nationwide.

Nigeria calculates its target population by extrapolating from the 2006 national census figures, using a growth rate for each state and local government authority (LGA). However, the accuracy of these estimates is limited by the inability to account for inter- and intra-state migration, which significantly affects the size of populations in certain communities. (28) Strategies to improve denominators are national GIS mapping and small-scale enumeration in some LGAs.

CHALLENGES FOR EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

The main technical challenge for implementing and scaling-up novel analytic methods is the lack of clear guidance, technical assistance, and capacity for emerging methods. Political challenges, which are often overlooked, include the acceptability of alternative population estimates and commitment to improving the quality and accuracy of population data.

RECOMMENDATIONS:

- Immunization programs may consider taking action to improve the accuracy of targets (denominators) through better microplanning and by applying alternative estimation methodologies and analyses.
- Immunization programs can explore ways to better use existing data (e.g., administrative, surveillance, GIS) to analyze immunization equities to inform strategy design and advocate to mobilize resources for reaching population sub-groups with more zero-dose and under-immunized children.
- Immunization programs can also improve collaboration and coordination with the national statistics system to identify which resources exist and how they can be used to produce target population estimates.

4.2 INFORMATION SYSTEMS AND TOOLS TO REACH ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN

OVERVIEW

The lack of accurate, easy-to-access information on which vaccines a child has received and when they received them makes it difficult for vaccinators to track whether a child has received all recommended vaccines. Furthermore, the ability to locate and follow-up on children who miss vaccinations is challenged by paper-based record keeping, lack of unique identifiers, and caregiver contact information. (4) These vaccine program data, along with health system data on the vaccine supply chain, human resources, and health facilities, are needed to develop and implement tailored and sustainable strategies to ensure missed children are immunized. While the systems and tools described in this section are designed to overcome these data-related challenges, they are generally most appropriate for tracking and reaching children who have received their first vaccination. For this reason, the information systems and tools described in the previous section are necessary as a first step to identify and locate unvaccinated children and link them to immunization services.

4.2.1 ELECTRONIC IMMUNIZATION REGISTRIES

Electronic immunization registries are confidential, computerized information systems that capture the vaccine records of individual child. Because EIRs collect data at the individual patient level, they allow a better understanding of coverage gaps and can therefore support targeted outreach to different groups or individuals. EIRs can generate unique identifiers (or using existing identifiers) to facilitate individual-level monitoring and follow-up. A unique ID also solves issues that arise from children going to multiple facilities because health workers are able to verify, pull, and update the same child's record, which is stored in a central database. When developing an EIR, there are a variety of design components to choose from and options for interoperability with other tools and systems. Current systems across LMICs have used different open-source software, such as OpenSRP, OpenMRS, and District Health Information System 2 (DHIS2) Tracker. The Digital Square report funded by USAID on *Electronic Immunization Registries in Low- and Middle-Income Countries* provides a comprehensive review of the most common EIR system designs and their added value for vaccination programs. (4)

FINDINGS

Although there are limitations in an EIR's ability to capture zero-dose children—for example, unless an EIR is linked with a CBIS or birth notification system (such as self-notification by mothers who deliver at home, as discussed in section 4.1.1), children who have never been to a facility will not be in the system—some countries have adopted practices to overcome this challenge. In Pakistan, data from the EIR is triangulated with polio zero-dose registries to identify and enroll zero-dose children for routine vaccination. (4) In Colombia, records in the EIR and birth registry are compared on a monthly basis to identify discrepancies; children who are captured in one database are then added to the other for more complete population coverage. (4) EIRs can highlighting missed or overdue vaccines in an individual's record, autogenerate lists of individuals who have missed vaccinations, and aggregate data on missed vaccinations by geography to identify low-coverage areas. In Tanzania, with support from USAID, the EIR generates a defaulter report that includes the child's name, mother's name, phone number, village, and details about which vaccine was missed. (29) Some EIRs can send automated reminder/recall messages. Additional uses of EIR data are being explored for their potential to improve patient care, target quality improvement measures, and understand service delivery or care-seeking patterns and risk factors for under-immunization. An analysis of data

collected in the Tanzania EIR revealed important information about children who did not receive a vaccine despite being eligible (defined as missed opportunities for vaccination [MOV]). The analysis showed that MOV were concentrated in a small number of facilities and were most commonly due to a facility stockout. District managers can use such analyses to target quality improvement efforts. (30)

USE IN LANDSCAPE FOCUS COUNTRIES

DRC uses a paper-based system to record patient-level data in facility immunization registries and child health cards. An advocacy plan for the introduction of an EIR was developed in 2018/2019 following a learning trip to Tanzania, supported by PATH's BID initiative. Lessons from DRC's experience using DHIS2 Tracker for COVID-19 vaccine delivery could be applied to routine immunization.

DHIS2 Tracker and COVID-19 response

DHIS2 Tracker is an extension of the DHIS2 platform and functions like a client-level registry. The platform's EIR tracker metadata package enables tracking a child's immunization history and provides decision support. Countries such as Ghana and Senegal have created EIRs using DHIS2 Tracker.

COVID-19 packages have been developed to support aggregate and case-based surveillance, contact tracing, ports of entry screening, and analysis through pre-configured indicators and dashboards (see details in the "Monitor" section below). Thirty-six countries have deployed DHIS2 for COVID-19 surveillance and several countries, including Sri Lanka, Laos, Rwanda, DRC, and Mozambique, have deployed DHIS2 Tracker for COVID-19 vaccine delivery. (31) In DRC, the system is designed so that individuals can create a client record in DHIS2 Tracker and book an appointment for a COVID-19 vaccination. Then, through a partnership with the telecommunications platform Viamo, clients who are registered in DHIS2 Tracker could theoretically receive an SMS reminder about their second COVID-19 vaccine. Implementation of these processes are still in early stages and are more likely to be accessible to wealthier and more literate individuals. Early findings from DHIS2 Tracker's implementation in DRC show challenges using tablets for data entry at the facility level and human resource capacity restraints that have limited implementation of all components.

In Rwanda, the DHIS2 Tracker COVID-19 vaccination registry is linked to the National I.D. Agency. This has decreased time spent entering each client's data at the vaccine center and reduced data quality problems, since demographic data are imported directly from the national register. (32)

Kenya has piloted multiple EIRs including the Kenya Immunization Platform, developed by the MOH using OpenSRP and implemented in Siaya County; the Kilifi Vaccine Monitoring System; and those implemented by Regional Action through Data along the Uganda-Kenya border and at Academic Model for the Prevention and Treatment of HIV/AIDS clinics (4). None of these EIRs have been scaled-up nationally. In general, the Kenyan health information ecosystem is characterized as highly fragmented with partners and individual counties developing and deploying their own systems with little-to-no interoperability. Kenya is using DHIS2 Tracker but only for capturing individual-level data for other health areas.

In Mozambique, mVacciNation software developed by Mezzanine was piloted as an EIR in 2014 but is not currently used. (4) In 2020, VillageReach and PATH supported the Mozambique's EPI to conduct a readiness assessment. As a result, EPI decided to adopt DHIS2 Tracker but has yet to begin implementation.

Nigeria has yet to implement an EIR but, according to Nigeria's 2018 Gavi Programme Support Rationale for 2019–2023, the government plans to use DHIS2 Tracker as an EIR. (33) Some partner-supported programs have begun using DHIS2 tracker for tracking patient-level data for other health programs in specific facilities and states.

COVID-19 map and match

USAID funded Digital Square to map digital health tools and matching deployment opportunities in response to COVID-19, including in project countries Kenya and Mozambique. The landscape analyses found that:

- Kenya's health system uses 154 digital health tools, with at least 63 already deployed for COVID-19 response. (34)
- Mozambique's health system uses 51 digital health tools, with at least 17 already deployed for COVID-19 response. (35)

CHALLENGES FOR EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

Adopting and scaling up EIRs requires substantial initial investment in infrastructure, careful planning related to governance and policy (such as guidelines for shifting away from paper-based tools), and long-term commitment to training, supervision, and change management. While direct data entry into the EIR at point-of-service or as close to vaccination as possible is considered a best practice, in most LMICs, data are entered by a vaccinator or data clerk from a paper record. A hybrid approach, for example that leverages mobile phones or technology for digitizing paper records, could be considered along with incremental phasing in of point-of-service data entry, only once a reliable foundation of data use infrastructure, human resource capacity, and skill base has been established. (36) (37) (4)

RECOMMENDATIONS:

- Countries that have adopted DHIS2 Tracker as an EIR to track COVID-19 vaccine delivery could acertain if it is feasible and appropriate to extend its use to routine immunization. As with any type of digital health solution, the country's unique operating context and EIR system requirements should be considered when choosing the right technological platform or system.
- Countries that are considering introducing an EIR but have no experience may consider use the EIR Readiness Assessment Tool to ascertain if there is enabling environment to support an EIR and consult existing summaries of EIR tools and resources. (4) (38)

4.2.2 HOME-BASED RECORDS

A home-based record captures a person's health service history. HBRs are normally maintained by caregivers, in paper or electronic format, and used to remind health workers and families of when to return for vaccination. Depending on the country, they include vaccination-only cards, expanded vaccination-plus cards, child health books, and integrated maternal and child health books. (39) The HBR allows a caregiver to know what immunizations and other health services his/her child has received, which is particularly important when visiting a new facility. Health workers rely on the tool to determine which doses to administer and the doses they then need to record in the immunization register. In paper-based systems, the register is the basis for defaulter tracking. The HBR is also important for immunization program monitoring, including population-based surveys and surveillance, in which HBRs are used to verify a child's immunization status.

FINDINGS

HBR use has been associated with improvements in vaccination coverage. For example, in Pakistan, studies of the redesigned immunization card demonstrated a significant improvement in diphtheria, tetanus, and pertussis-containing vaccine 3 completion. (39) In DRC, where private facilities often charge for the child health cards, a promising strategy for reaching unvaccinated children has been providing the cards for free during outreach sessions, such as marketplace vaccination in Kinshasa. The intervention, which focused on improving health worker training and use of the cards and caregivers' understanding of the cards, increased vaccination coverage. (40) In Uganda, a study of HBR use in Kampala found that children with cards were 10 times more likely to be up to date on their immunization schedule. However, the same study found that children who were born at home were less likely to have a card than those delivered at a health facility. (41) Since children who never interact with the health system might not have an HBR, integrated HBRs could be a more effective way to track and reach zero-dose children whose mothers received ANC care. Integrated HBRs, such as the MCH booklet, are used in many countries, including Kenya and Niger, and are common throughout Asia, where they have been instrumental in reducing maternal and child mortality. (42) They are given to women during their first ANC visit, making it possible to identify and register children for immunization before they are born. Evidence from high-income countries suggests that such use of HBRs for MCH facilitates continuity of care. (39) There are other examples of leveraging HBRs to integrate service delivery at point of care, which could prove effective in reaching zero-dose children. For example, MCSP's review of child health and nutrition data in 24 countries found that in most countries, health workers who counsel the caretakers of sick children also record the child's immunization status, which could be an opportunity to identify zero-dose children. Ensuring that those children are vaccinated, however, may require changes in workflow processes.

Digital immunization cards

Electronic personal health records are increasing in use. Mexico and Argentina have developed digital immunization cards that provide an electronic record of each person's vaccine history. (43) The e-vaccine card is linked to the EIR, which enables health workers to follow-up on children who have missed vaccines. In Mexico, caregivers still receive a paper vaccination booklet containing a QR code that can be scanned at different facilities to pull up a child's immunization record, which mitigates limitations such as caregivers who lack internet access. It is important to consider data privacy and interoperability with the broader digital health architecture before digitizing individual health records.

USE IN LANDSCAPE FOCUS COUNTRIES

DRC uses child health cards called *Cartes de Consultation Pre-Scolaire* to record and compile data on vaccines administered. Health workers use a "tickler file" with detachable coupons from the child health card to track individual children and identify defaulters. There are problems of low availability (according to the 2015 DHS, only 71 percent ever received a card) and low retention (26 percent possessed a card). (44) Other challenges include centralized reproduction of the cards, leading to frequent stock-outs; unauthorized selling of the cards by health workers; and insufficient health worker supervision to ensure HBRs are properly used. (45)

Kenya has used the integrated MCH booklet nation-wide since 2010. According to the 2014 DHS survey, 75 percent of 12–23 month old children had a booklet or vaccination card, suggesting opportunities for strengthening ownership and retention. In Kenya, **Journey** uses near-field communication chip cards to enable families to carry their child's immunization records across the Kenya-Uganda border, avoiding loss of paper-based records. While these smart cards give migrant populations more control of their immunization records, they must visit health facilities that have the ability to read a mobile deviceto to access the information.

Mozambique uses a child health card (*cartão de saúde da criança*) to record data on vaccines administered. There are also referral templates *(guias de referencia),* that CHWs (*agentes polivalentes elementares*) use to record children's information and symptoms so they can be referred to the immunization nurses at the health facility.

Nigeria uses child vaccination cards that are created in triplicate (one copy for the caregiver, one for the health facility to track progress, and one for the community leader). The cards were redesigned to boost retention, but challenges remain: only 68 percent of children ever received a card and 40 percent possess a card. Nigeria plans to introduce an integrated MCH booklet.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

Lack of dedicated funding for printing and disseminating HBRs, in addition to confusion over which department is "responsible" for covering the costs, can lead to stock-outs. Inequities are observed when parts of the country serving poorer populations are less likely to have sufficient stocks of cards. Countries considering integrated HBRs face additional challenges with complexity of planning and designing, which requires involvement from various departments within the MOH, sometimes resulting in HBRs that are 30–50 pages. An integrated HBR's ability to reduce missed opportunities for vaccination also depends on how well services are linked and integrated at the point of care. (46) WHO has recommended additional research on the benefits of using integrated HBRs as opposed to HBRs for recording information on single aspects of care. (39) Other challenges include poor retention of the cards when caregivers are unaware of their importance, and poor use by health workers who do not complete them.

RECOMMENDATIONS:

- Countries that have not integrated MCH records (such as DRC and Mozambique) could consider developing a roadmap for an integrated HBR to facilitate earlier identification of eligible children for vaccination—for example, during the provision of ANC. Redesign should consider features to improve retention and use, as well as mechanisms for promoting better coordination between the MOH departments involved.
- Immunization programs and partners can reinforce HBR retention and use with interventions that improve health worker training and use of the cards, and caregivers' understanding of them. At the

same time, care must be taken to avoid the widespread practice by health workers of chastising, humiliating, and denying services to clients or caregivers who have lost their HBRs.

- Where feasible, digital immunization cards can be considered and linked to an EIR or other immunization digital system to enable functions such as automated vaccination prompts for caregivers.

4.2.3 CLIENT COMMUNICATION SYSTEMS

Client communication systems enable the transmission of information between health care providers and clients. They can help reach children by addressing the common reasons that immunizations may be missed, such as forgetting or missing appointments, not knowing immunization schedules, and having safety concerns. (47) Client communications can include mass communications for specific audience segments (e.g., demographic categories, geographic areas) or tailored communications for individual clients (e.g., to remind caregivers that their children are due for vaccination). Messages can be transmitted through phone calls, text messages, email, and postcards, or shared through social media platforms such as WhatsApp, Facebook, and Instagram. These systems may be most effective for reaching children who are zero-dose because their caregivers lack information on their immunization schedule or are concerned about immunization, but less effective for reaching children who are zero-dose due to poverty or remoteness.

FINDINGS

There is strong evidence that reminder and recall messages reduce dropout rates for routine childhood immunizations. (47) SMS-based platforms can use phone numbers captured in facility-based paper registers to notify caregivers of vaccinations that are due. Phone calls to caregivers by health workers are an alternative or accompaniment to sending an SMS reminder, and have shown to reduce defaulter rates. (48) For example, the phone contacts intervention in Kenya used a paper-based tickler system with minimum details (name, village, vaccines due, telephone number, name of CHW responsible for child, vaccination status) that facilitated prompt identification of defaulters. Caregiver phone ownership was high in all the facilities and a strong facilitator. Another success factor was that the approach enabled health workers to establish a personal relationship with the caregivers, understand the reason behind missing the due date, and find an appropriate time and date to vaccinate the child. (48)

Health care provider communication

To ensure that children receive vaccines on time, it is important that health workers know which vaccines children need. Leveraging technology to facilitate communication and information exchange between health care providers, supervisors, and health system managers can improve the quality of immunization services and patient outcomes. The mobile phone-based mHero app (a Digital Square global good) has been deployed widely to support communication between MOH and health workers, including in DRC and Kenya. Several countries are using mHero for COVID-19 response.

Countries that have EIRs can embed reminder and recall systems in them or link to mobile apps that support client communication. Since EIRs may exclude children who have never interacted with the health system, linking the EIR to community-based systems could be a promising strategy for reaching zero-dose children. For example, Zambia's EIR is linked to mVacc, which is built on the RapidPro and captures data on every birth within the community, including homebirths, and can send SMS notifications and reminders to caregivers. (49)

In places where literacy rates are low, voice-based and dialect-specific reminders have been used in place of SMS, such as in Nigeria (see "use in landscape focus countries" below). In the case of the mTika mobile app in Bangladesh, illiterate mothers were taught to recognize symbols used in SMS messages. (4) Communication systems are also important for conveying information about vaccination and rapidly disseminating health messages and correcting misinformation during an epidemic. In DRC, a WhatsApp Chatbot that responds to questions about COVID-19 in French, Congolese Swahili, and Lingala was developed and is helping to dispel rumors and misinformation about the vaccine. The WHO has launched a similar chatbot on Facebook Messenger to offer instant and accurate information on COVID-19.

USE IN LANDSCAPE FOCUS COUNTRIES

DRC uses a paper-based tickler file system, described previously, to enable health workers to track defaulters. The system does not use mobile technology to communicate with caregivers, but DHIS2 Tracker, which is supporting COVID-19 response in DRC, has a module that is being tested for this purpose.

In Kenya, approaches used to track defaulters include home visits by CHWs, village elders, and public health technicians, using information derived from the facility immunization registers. Kenya has a few tools, such as Jitenge and Ushauri, that send text message reminders. An intervention using text messages to remind caregivers to bring their children for their second and third doses of pentavalent vaccine in three districts was found to reduce vaccination dropout rates. (50)

In Mozambique, communication channels include community health agents, district community health committees, community radio, ICS multimedia mobile units, social media platforms, social mobilizers, and religious and community leaders. (51) EPI does not have any experience using digital client communication systems for immunization. mVacciNation included this opportunity but the tool was never adopted.

In Nigeria**,** a copy of each child's immunization card is kept at the health facility and one copy goes to the community leader to facilitate defaulter tracking. Communication channels include home visits and mobilization by community mobilizers and health influencers, promoters, and services agents. Reminders are delivered through bulk SMS messages, ring-back tunes, and vaccine reminder bands/beads. (28) SMS strategies are informed by a 2016 study that found the use of a cellphone reminder/recall system improves routine immunization completion. (52)

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

Client communication systems that are based on home visits by community health workers and community members are time-consuming and challenged by low motivation and insufficient human and financial resources. For communication strategies that use voice and SMS messaging, managing phone numbers captured in paper-based facility registers can be laborious. Digital systems that capture patient-level data, such as an EIR or CBIS, can also capture caretaker phone numbers and ease the associated data management burdens. Gaining access to phone numbers from mobile network operators to send mass communications via SMS can be a challenge. Other challenges include weak mobile phone access and/or low digital literacy, which can limit the effectiveness of SMS-based communication systems for reaching children who are zero-dose due to poverty or remoteness (e.g., factors that overlap with low mobile phone ownership).

RECOMMENDATIONS:

- Immunization programs that have systems to collect client phone numbers may consider using them for client communication to reach zero-dose and under-immunized children, considering the local context.

- Immunization programs that are not using an electronic patient record system could consider obtaining cell phone data from MNOs for mass communication.

4.3 INFORMATION SYSTEMS AND TOOLS TO MONITOR ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN

OVERVIEW

To ascertain whether programmatic strategies are reaching zero-dose children and missed communities, health workers and managers must be able to analyze, interpret, and translate data into information that is useful for decision-making and course correction. These include data on vaccine consumption patterns, vaccine-preventable disease (VPD) outbreaks, client feedback, and other data. To monitor and conduct such analyses, data on zero-dose children and missed communities must be available, which is not always the case. Even when data are available, other challenges can undermine vaccination program monitoring, such as poor data quality; complex analyses that require triangulation across multiple data sources and elements; capacity of health workers and managers to analyze data; and lack of perceived benefit by health workers to entering complete and timely data. Most of the information systems and tools reviewed in this section involve the use of aggregate data, which are useful to decision-makers at national, subnational, and health facility levels for understanding how many children are under-immunized, designing responsive strategies, and allocating resources to geographies with lagging immunization coverage. These aggregate data systems and tools must be linked to patient-level data systems and tools (such as those discussed in previous sections) for health workers to identify, reach, and monitor individual children.

4.3.1 HEALTH MANAGEMENT INFORMATION SYSTEMS

A health management information system (HMIS) records and stores aggregated service delivery data and can facilitate converting data into information for decision-making. HMISs can also collect and manage routine health indicator data, and synthesize and visualize data. Until recently, the global health field focused on digitizing and strengthening the collection, tracking, and reporting of aggregate data, such as with investments in the DHIS2. There is now more recognition of the limitations of these systems and tools. For example, monitoring trends in immunization coverage at the aggregate level masks inequities in coverage among population sub-groups. For this reason, countries are working to expand the interoperability between HMIS and systems that handle individual-level data, such as EIRs and CBIS.

FINDINGS

DHIS2 is the most widely used HMIS platform and has been adopted in more than 70 LMICs, including in all project countries. The DHIS2 toolkit for immunization includes apps and metadata packages that enable EPI program managers and district staff to identify gaps in immunization coverage, reduce stock wastage, monitor cold chain metrics, and follow up on facility reports. These include EPI dashboard and analytics packages, a bottleneck analysis app, and others. In Zambia and Tanzania, the EIR is interoperable with DHIS2, which means that program managers have access to real-time data, enabling them to monitor whether districts are on track to achieve coverage targets.

USE IN LANDSCAPE FOCUS COUNTRIES

In DRC, DHIS2 roll out began in 2016 and is used in most of the country's 516 health zones. However, according to the Comprehensive Multi-Year Plan 2020–2024, some EPI branches still use the District

Vaccination Data Management Tool because of weak internet connection and insufficient resources. Health facilities prepare and submit monthly EPI reports on the number of vaccines administered to the heath zone, where they are manually entered into DHIS2. At the provincial level, data are reviewed by the EPI branch and the EPI coordination. The National Digital Plan for 2025 outlines the need to develop a framework for the standardization and interoperability of health information systems. Strategies for improving internet connectivity are included in the Digital Plan's infrastructure pillar.

Kenya has used DHIS2 since 2010 to support collection, analysis, visualization, and sharing of aggregate and individual-level data, including mobile and offline collection using the DHIS2 Android app. DHIS2 is used to record and manage aggregate immunization service delivery data at the sub-county level and to visualize data using in-built dashboards during data review meetings. ODK-X is used to visualize immunization and other data, including cold chain, patient tracking, and geography. Also since 2010, Kenya has implemented a master facility list, a single, centrally maintained database of health facilities with a unique code for each. The code enables the master facility list to link to information systems, such as DHIS2, for greater efficiency and information exchange. Health facility registration enables workers to reach zero-dose and under-immunized children by availing information on where vaccinations are delivered.

In Mozambique, DHIS2, known as SIS-MA (*Sistema de Informação de Saúde para Monitoria e Avaliação),* is used to aggregate health facility data at the district and provincial levels. Immunization data are collected on paper forms at the facility, aggregated into the monthly data summary from the health facility, and sent to the district level, where they are aggregated, verified, and entered into DHIS2 monthly.

Nigeria fully transitioned to DHIS2 in 2018. The DHIS2 routine Immunization module is the only official electronic platform for such data in Nigeria. All health facilities offering routine immunization send monthly reports that LGA officers enter into DHIS2. A routine immunization SMS tool that makes data available immediately after immunization sessions is being implemented in 18 states to complement DHIS2 monthly reports.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

The main challenges relate to the systems and processes in place to support the tool's effective use. For example, data quality, including incomplete and inaccurate data, undermine health care worker confidence in and use. In most countries, data entry in DHIS2 is performed manually at the district level, based on paper reports submitted by health facilities. This process is administratively burdensome and prone to transcription errors. Contributing to the problem is that facility-based health workers who are responsible for entering the data may not have the capacity or autonomy to make direct use of it themselves, and, as a result, are less invested in ensuring its quality.

RECOMMENDATIONS:

- Countries could consider the feasibility of expanding community-based data collection platforms like CommCare and facility-based platforms such as EIRs that are interoperable with HMISs.
- Countries should continue to build the capacity of health personnel at all levels to use the data they generate to guide decisions on how to improve reach and quality of immunization services.

4.3.2 IMMUNIZATION COVERAGE SURVEYS

Immunization coverage surveys are used to determine immunization coverage rates and assess immunization program performance. Gavi requires post-campaign coverage surveys (PCCSs) after every SIA that it funds.

(53) While coverage surveys can produce more accurate estimates of immunization coverage than administrative data, their use is limited by cost and infrequency of data collection. For these reasons, experts are calling for coverage survey improvements and alternative analyses to improve immunization equity. (26)

FINDINGS

In 2018, the WHO revised its Vaccination Coverage Cluster Surveys Reference Manual, which includes guidance on implementation of PCCSs. The manual includes a questionnaire for routine immunization that can be added to a post-SIA/campaign coverage survey, for example to identify zero-dose children. The questionnaire, however, is used infrequently because it requires more resources to survey a larger portion of the population to accurately identify zero-dose children. A sample size that is too small might yield imprecise and/or biased results. (54) Oversampling areas where zero-dose children are predicted to live is an approach for overcoming this challenge. (55) Coverage survey improvements and alternative analyses identified by the literature review include:

- Continuous household surveys and surveillance are used in Kenya to increase year-round monitoring of malaria transmission. Community interviewers revisit selected houses within the enumeration area on a rolling basis, providing real-time data on incidence. Countries implementing continuous DHSs could use a similar approach to monitor vaccination trends on a timelier basis and adjust programmatic strategies to reach unvaccinated populations. (11)
- SMS and phone surveys to reduce the cost of interviewing in rural and areas that are unstable or impossible to reach have been used primarily in emergency settings. For example, during the Ebola outbreak in Liberia, questions were sent to people via SMS to gather data on health knowledge and practices and formulate an emergency communication response. (11) Rapid phone surveys are also used to monitor the effects of COVID-19 on households and individuals (see text box).

COVID-19 phone surveys

Social distancing practices have limited the use of traditional, face-to-face interviews in population-based surveys. In response to this challenge, the World Bank is supporting the use of phone surveys to monitor COVID-19's consequences on people and households. Data collection is underway in Burkina Faso, Ethiopia, Malawi, Mali, Nigeria, Uganda, and Tanzania. Surveys cover knowledge and concerns about the pandemic, access to food and other basic needs, employment and income loss, and safety nets and coping strategies. Immunization program managers use the information to design, target, and monitor interventions. Data obtained from phone surveys must be interpreted with caution due to the potential biases resulting from mobile phone ownership levels, the inability to verify responses, and non-response. (56)

Phone surveys have also been used in the context of polio SIAs, such as in Chad where the strategy involved the use of a call center, for which sub-districts managers established a telephone directory of contacts for each village under their responsibility. On the eve of the vaccination campaign, they called to inform village leaders of the occasion, and after the campaign to 27erify that vaccinators had visited the areas. (57)

- Lot quality assurance sampling (LQAS) is a population-based survey-monitoring tool that applies a statistically reliable sampling method to classify geographical areas (lots) as having "acceptable" or "not acceptable" vaccination coverage. (58) The tool makes it easy for immunization program

managers to detect pockets of under-immunized children. When combined with other monitoring tools, LQAS can be used in regions that are known to have poor-quality administrative data to detect communities that are more likely to have a high proportion of zero-dose children, and target follow-up activities in them. (59) LQAS has been used for routine immunization in Bangladesh and for polio vaccination campaign monitoring. (60) In Nigeria, it was piloted to evaluate the 2009 oral poliovirus vaccine campaign coverage and has been adapted for routine immunization. Nigeria now implements quarterly routine immunization LQAS in all states to provide data for rapid decision making and improvements. LQAS conducted between 2018 and 2019 showed an increase in the number of LGAs with acceptable vaccination coverage scores from 111 (14 percent) in Q2 of 2018 to 252 (33 percent) in Q2 of 2019. (61) Studies of LQAS use in Nigeria and Pakistan showed that it was better at detecting areas of weak coverage compared to independent monitoring data. In both countries, independent monitoring data systematically underestimated the fraction of children missed during vaccination campaigns. (62) Other countries, including Afghanistan, India, Angola, Chad, Niger, and DRC used LQAS to support their polio eradication efforts. Innovations for routine immunization in contexts where mobile phone ownership is strong (such as urban settings) include the collection and analysis of LQAS data via mobile phones, such as the 2012 pilot in Nigeria, which used the Magpi application.

USE IN LANDSCAPE FOCUS COUNTRIES

DRC conducted a sub-national coverage survey in 2020 that was representative at the provincial level and in some cases at the health zone level. These data can be used to inform planning and prioritization of interventions to specific health zones, although their uptake and use has been limited. DRC has experience using LQAS to monitor immunization campaigns, such as for polio.

Kenya Red Cross included large-scale surveys to identify missed children and to assess vaccination coverage as the first and last steps in a five-point plan to find under-vaccinated children and the reasons. (63) The Kilifi Vaccine monitoring system visits households annually to update coverage numbers but has been shown to overestimate immunization coverage. (64) Kenya used LQAS in polio SIAs in 2018 and 2019 (65).

Mozambique conducted a sub-national coverage survey in 2021 that produced estimates for 14 priority districts, which were more helpful for planning than provincial-level estimates produced by period DHS surveys. Mozambique is using LQAS to assess malaria program performance and uncover local variability that national-level surveys mask. (66) We are unaware of the use of LQAS use for immunization.

Nigeria conducts PCCSs, for example following the 2018 and 2019 reactive vaccination campaigns to meningitis outbreaks. Data from the 2017–2018 measles PCCS have been used by groups such as GRID^3 to estimate the number of children who have not received a prior dose of measles vaccine following the SIA. (67) Other routinely conducted surveys include NDHS, NICS/MICS, and NNHS, which help validate the quality of administrative data.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

The main challenge for implementing and scaling-up novel survey or analytic methods is the lack of clear guidance, technical assistance, funding, and capacity. LQAS can be resource-intensive and time-consuming and requires experienced surveyors with training to ensure proper implementation.

RECOMMENDATIONS:

- Countries that have challenges monitoring immunization program performance because of poor-quality administrative data could consider context-appropriate survey alternatives, innovative data collection, and analytic approaches to monitor immunization coverage. For example, periodic LQAS or rapid household surveys can enhance existing routine monitoring practices by identifying pockets of missed children and underserved communities.
- Consider implementing LQAS in conjunction with other monitoring systems and tools, such as HMIS, in under-performing regions to identify communities with a higher probability of zero-dose children and to inform targeted outreach. This is recommended particularly in urban settings, where micro-level survey methods perform better than coverage surveys in identifying high-risk pockets of missed children and underserved communities.
- Immunization programs should strengthen mechanisms for sharing data collected during campaign coverage surveys with health facilities and health zone authorities and reinforce the capacity of health workers to use the information to follow-up with under-vaccinated children and target outreach to communities with a high proportion of zero-dose children.

4.3.3 MONITORING CHARTS AND DATA DASHBOARDS

Monitoring charts and data dashboards are digital and paper-based tools that help health workers analyze routine immunization data and make decisions to improve services. The overwhelming quantity of data available to decision makers can make it difficult to decipher and extract meaningful information. (68) Monitoring charts and data dashboards overcome this challenge by condensing large amounts of data into digestible information and user-friendly visualizations.

FINDINGS

Immunization monitoring charts are widely used globally and recommended as part of the monitoring for action component of the Reaching Every District (RED) strategy. An evaluation of RED in nine countries[4] found that monitoring charts displayed at health facilities helped workers understand their facility's performance. (69) In Kyrgyzstan, simple paper-based tools such as worksheets to help compile data, perform indicator calculations, and plot graphs, improved data quality and health workers' ability to detect and react to problems. (70) In Zimbabwe, Malawi, India, and Timor-Leste, the My Village My Home tool has helped CHWs and community members track vaccinations of individual infants. (71) Although the tool was primarily intended to strengthen community participation in vaccination, it proved equally effective at helping capture children who had never received vaccinations. RED categorization, described in the strategy, has been introduced widely at the health facility level in Uganda and Ethiopia. Using a simple rubric, it enables health workers to use data that they are already collecting to determine if the main impediments to high and equitable coverage are due to low access, low continued use of services, or a combination of the two. This information has guided the actions of local non-health actors to allocate resources in support of routine immunization. (72) In Uganda, RED categorization was added into the national HMIS at MOH's request.

With the expansion of digital tools to collect and manage data and analysis, health workers are increasingly using dashboards to monitor immunization program performance. The DHIS2 toolkit for immunization includes an EPI dashboard and analytics package with pre-configured WHO-recommended dashboards and

[4]Benin, Cameroon, the DRC, Ethiopia, Ghana, Madagascar, Sierra Leone, Togo, and Uganda.

indicators for analysis of routine immunization data reported from facilities. Dashboard packages can be installed in a country's DHIS2 and indicators mapped to existing data elements. For example, in Nigeria, the CDC piloted a routine immunization module within DHIS2 with a data dashboard configured for health workers at facility, district, state, and national levels. The project increased the use of data at all levels. Facilities use the dashboards to minimize dropout rates and low vaccine coverage by compiling lists of defaulters and convening community meetings to help with defaulter tracking, and exploring why caregivers do not follow the immunization schedule. At the district level, the dashboards are used to track facility performance and immunization coverage trends, target facilities for training or supportive supervision, and identify inconsistencies in immunization data. (73) EIRs can also be designed with automated dashboard features, such as the Zambia EIR, which hosts district dashboards to allow for easy monitoring of facility data inputs.

USE IN LANDSCAPE FOCUS COUNTRIES

In DRC facilities, immunization coverage and drop-out rates are plotted on paper charts. However, the RED evaluation in DRC found that facility-based health workers have difficulty plotting monitoring charts and interpreting coverage data. (69) Routine immunization dashboards at health zone and provincial levels support data analysis and decision making but are underutilized.

Kenya uses the DHIS2 dashboards to visualize aggregated immunization service delivery data.

In Mozambique, paper monitoring charts are often posted on walls of facilities. DHIS2 dashboards are used at national, provincial, and district levels. The data interoperability platform, Zenysis, with support from Gavi, is partnering with the government to support its COVID-19 response efforts. The investment is working to integrate data from multiple information systems into a single platform and create data visualizations and dashboards.

In Nigeria, following the success of the routine immunization data dashboard pilot in Kano State, the module was scaled nationally between 2014 and 2019 with funding from the Bill & Melinda Gates Foundation. The routine immunization dashboard has 21 indicators[5] that are each reported using a graph, map, or table and update automatically when new raw data are entered in DHIS2. (74) Monitoring and evaluation results from project reports show that the intervention package, which included user-specific training modules, hands-on-learning and support, and monthly meetings to review and analyze data, increased the use of immunization data at facility and district levels. (73) (75)

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

The main challenges are weak capacity of district and health facility staff to continuously and critically review the information presented in monitoring charts and data dashboards. Similarly, for monitoring charts, health workers lack knowledge about how to plot and interpret immunization coverage data. (76) (77) As with the challenges related to HMIS, the use of monitoring charts and data dashboards by health workers is also limited due to poor data quality.

[5] Indicators are divided into seven categories: data reporting (including reporting rates and timeliness); coverage and drop-out rates; routine immunization vaccination sessions; supervision; vaccine logistics; cold chain functionality; and routine immunization funding disbursed to health facilities.

RECOMMENDATIONS:

- Immunization programs should strengthen health worker capacity to interpret and use data from monitoring charts and dashboards to inform their management decisions. This is particularly needed at the community and facility levels, where the ability to close coverage gaps is most lacking.
- Immunization programs should ensure that performance review meetings occurr regularly and use monitoring charts and data dashboards to facilitate data analysis and identify problems and devise solutions. (78)
- Immunization programs should foster a culture of data use at all levels by creating mechanisms for participatory feedback with health staff partners, local officials, and communities.

4.3.4 DATA QUALITY ASSESSMENTS

Data quality assessments review the quality of vaccination data gathered by the health information system. Without accurate data on immunization coverage, program managers are unable to determine if strategies are reducing the number of unvaccinated children. There are various methodologies for assessing data quality. In recent years, these have expanded to include a broader assessment of the systemic issues underlying poor data quality with more attention on the people and enabling environments that are required for functional information systems. (79)

FINDINGS

The WHO immunization Data Quality Self-Assessment (DQSA) is the most frequently used. (80) It includes tools for reviewing data accuracy at facility and district levels and a questionnaire covering different immunization monitoring issues such as availability of vaccination cards and use of tally sheets. Data accuracy is assessed through different verification processes at multiple points along the immunization coverage data reporting flow, to determine that data have been accurately recorded and reported through health information system channels. The DQSA also has components such as immunization card recording and population denominators that could be used for monitoring of zero-dose and under-immunized children, but the potential benefits of their use have not been documented.

Achieving better data quality with EIRs

EIRs can improve data accuracy with built-in validation and automated calculations that help limit data entry and manual calculation errors. Studies have found high levels of accuracy of EIR compared to paper-based records, and high data completeness. (4) Data that are entered as close to the vaccine event as possible improves data timeliness and quality. (81) In Uruguay, data entry has been embedded into the vaccination workflow, contributing to a strong culture of recording immunizations immediately upon vaccination. (82)

The Immunization Information System Assessment (IISA) is a methodology developed by the WHO and CDC to identify root causes of immunization data quality problems and facilitate development of data improvement plans. Topic areas examined include recording and data verification; data reporting and analysis; denominators; and workforce, training, and human resources. IISAs were first conducted in Kenya and Ghana in 2015 and 2016. In Kenya, root causes of poor-quality data identified by the assessment were low levels of confidence in target population data and infrequent analysis and use of immunization data. One of the actions taken as part of Kenya's data quality improvement plan (DQIP) was convening national and county target-setting workshops, but it is not clear if these workshops have improved outcomes. (83) Other literature reviews have found

evidence of immunization data quality improvement following the implementation of different data quality assessment (DQA) approaches (37).

USE IN LANDSCAPE FOCUS COUNTRIES

The last data quality survey (DQS) in the DRC was conducted in 2015 by 19 EPI branches across 11 provinces. (7) DRC has had an immunization DQIP in place since 2014, but implementation is sub-optimal due to lack of funding. Gavi is funding WHO technical assistance in six provinces for training data validation committees, holding monthly data review meetings, and preparing monthly data quality assurance reports.

Other data quality initiatives that are underway include the national malaria program's centers of excellence (COE), supported in 79 health facilities by USAID/PMI and MEASURE Evaluation, to model good data quality practices. (14) The COE are the only health facilities in DRC to enter malaria data directly into DHIS2, which reduces the workload at the health zone level and transcription errors. The COE approach was adopted in the 2018–2020 national health strategy and scale-up is being supported by donors such as the Global Fund. DRC's EPI can explore options for partnership to improve immunization data quality.

Kenya has used IISAs as mentioned above.

In Mozambique, DQS is used during supervision visits to ensure facility data are correctly documented. Facilities use Excel to quantitatively evaluate data quality.

Nigeria had a DQIP for 2017–2020 to strengthen the completeness, timeliness, and precision of immunization data from all states. The strategies include establishing data quality implementation teams/technical working groups, developing standard operating procedures for conducting data quality review meetings, and conducting regular DQSs and DQAs.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

DQAs can be labor-intensive, requiring health worker time and resources as well as training on how to perform a DQA and analyze the results. Behavioral factors such as the perceived benefits of DQAs influence whether they are conducted on a regular basis. Also, a DQA does not guarantee that results will be acted upon to improve data quality; DQIP implementation depends on the existence of adequate resources and political will. Facilities with human resources constraints are less likely to fully implement activities to improve data quality and use.

RECOMMENDATIONS:

- Immunization programs may consider approaches for ensuring data quality that are context-appropriate and can be easily integrated into existing practices. For example, a less labor-intensive approach could be incorporating data quality indicators with regular reviews of immunization coverage indicators.
- Immunization programs must consider data quality and use within broader immunization advocacy agendas to ensure that program budgets include adequate resources for monitoring data quality.
- Immunization programs and partners should invest in strategies that support data use practices among front-line health workers. Experience suggests that as health workers learn to use the data they produce, they are better able to identify inconsistencies and take corrective action to improve its quality. (84)

- Countries should leverage the capabilities of digital information systems and tools such as built-in data validation and automated indicator calculations to minimize errors, and implement workflow practices that facilitate quality such as data entry as close to the vaccine event as possible.

4.3.5 CLIENT FEEDBACK SYSTEMS

Client feedback systems gather responses to health services received so that health workers can mitigate challenges that prevent caregivers from brining children to the facility for vaccination. Caregivers who do not have a channel for complaints or suggestions or whose complaints are ignored may cease seeking health services. Mechanisms for soliciting feedback are especially important for improving vaccination equity in urban settings, where caregivers are more likely to feel social distance and discrimination. (85)

FINDINGS

In South Africa, the MomConnect mHealth initiative uses SMS texts to register pregnancies and send health promotion messages and includes a feedback mechanism. Complaints received through the system have highlighted issues such as shortage of drugs and vaccines, long wait times, clinical abuse, and patient neglect by health care professionals. (10) Complaints to the helpdesk have reportedly resulted in improvements in the quality of care such as responding to stock-outs of essential medicines at all clinics. (86) (87) In other programs, SMS surveys were used to solicit feedback from patients after health services were provided in Burundi, Cote d'Ivoire, Haiti, and Malawi as part of the LINKAGES (linkages across the continuum of HIV services for affected populations) project. (85)

Not all systems require a technological platform. Uganda, for example, leverages community structures to solicit client feedback on health services. Complaints are brought to health unit management committees that help monitor and elevate quality concerns to the health facility. (11) Other types of promising problem-solving models involve active partnership between health systems and communities. (88) For example, quality improvement teams convene health personnel and community representatives to solve problems. (89) In Pakistan, polio campaigns have organized forums for discussion with female doctors, religious figures, female vaccinators, and women who have recently vaccinated their children. These forums allow participants to receive answers to their questions and alleviate fears about vaccination. (85) In DRC during the 2018–2020 Ebola outbreak, local volunteers gathered perspectives by recording unstructured, open-ended questions, and comments from community members during Ebola awareness activities. Comments were coded, analyzed, and used by health authorities to make course corrections. (90)

Social listening and monitoring tools

Social listening and monitoring tools provide a passive form of feedback by collecting data from social and traditional media platforms to track online discussions, trends, and sentiments about health topics. Such tools have been widely used during the COVID-19 pandemic to dispel rumors and misinformation that contribute to vaccine hesitancy. For example, in Cote d'Ivoire, a real-time COVID-19 rumor-tracking system captured more than 1,750 pieces of misinformation over six months and helped the MOH counter the false reports. (91)

USE IN LANDSCAPE FOCUS COUNTRIES

In DRC we did not find any information about the existence of mechanisms for gathering client feedback on immunization services. Since the project has found that poor-quality services and mistreatment discourage caregivers from bringing their children in for routine immunization, a client feedback system could provide

immunization program managers with critical information about service quality issues that undermine immunization. However, such systems assume that health workers are able and willing to take action on such feedback.

Kenya has been using social listening tools in the context of COVID-19. UNICEF partnered with a communications company to set up a call center to provide COVID-19 information and use a chat bot, which together track misinformation raised by callers. Africa's Voices Foundation uses radio and SMS to track trends and misinformation. UNICEF's Internet of Good Things administers online polls and tracks information gaps and risk perceptions. (92)

In Mozambique**,** the National Strategy for Quality and Humanization of Health Care 2017–2023 provides a framework for quality improvement and respectful health care. Co-management and humanization committees operating at the community level play a critical role in improving the quality of facility- and community-based health service delivery. While there is no formalized mechanism for clients to provide direct feedback on immunization services, partners have supported the use of tools such as the Health Service Quality Scorecard to enhance regular community monitoring and analysis of health services and strengthen social accountability mechanisms. (93)

In Nigeria we did not find information about a formal mechanism to incorporate client feedback in immunization monitoring systems. Most formal feedback systems are based on DQA and supportive supervision between local, state, and federal agencies.

CHALLENGES TO EXPANDING (OR IMPROVING) THE SYSTEM OR TOOL

SMS-based feedback mechanisms require mobile phone ownership and could exclude already underserved individuals without phones. In addition, costs associated with sending an SMS could pose a barrier. Clients may be uncomfortable providing honest feedback as they may not have much choice in where they are seen and may require the services. Health workers and their supervisors may have inappropriate or non-productive means of managing that feedback.

RECOMMENDATIONS:

- Immunization programs, and the PHC system more broadly, could explore the utility of anonymous feedback mechanisms for clients, health staff, and volunteers, in addition to social listening and monitoring tools for gathering data on immunization service quality, perceptions, and rumors about vaccines.
- Train and support health workers and program managers to triangulate community feedback with routine data and use the information to improve immunization services.

4.4 ADDITIONAL INFORMATION SYSTEMS THAT FACILITATE ROUTINE IMMUNIZATION PROGRAMS TO IDENTIFY, REACH, AND MONITOR ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN

We identified four additional information systems (Table 2) that gather health system information that, when triangulated with immunization data, immunization program managers can use to identify, reach, and monitor zero-dose and under-immunized children. When these systems are interoperable with immunization information systems, such as EIRs, they can help create efficiencies in data entry (e.g., minimizing re-entry) and make data more readily available to immunization program managers for vaccination planning.

TABLE 2. INFORMATION SYSTEMS THAT HELP IDENTIFY, REACH, AND MONITOR ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN

System	Use case for identifying, reaching, and monitoring	Deployed in landscape focus countries
Human resource information systems enable managers to oversee the health workforce by having access to up-to-date and accurate information on the current number of health workers, where they are deployed and their skills, and information on vacant posts. **Digital global good:** iHRIS	**Reaching:** To plan immunization activities and make decisions about how to allocate finite resources to reach zero-dose children, immunization program managers need information on the number of health workers available in target communities and if they have the knowledge and skills to provide immunization services.	DRC, Kenya, Mozambique, Nigeria
Logistics management information systems enable managers to oversee commodity supply chains by enabling forecasting, inventory management, distribution planning and reporting, equipment management, etc. **Digital global goods:** OpenLMIS, DHIS2	**Reaching:** To ensure that vaccine delivery reaches zero-dose children and missed communities, immunization program managers need logistics data and information on vaccine stock availability to plan delivery, make decisions about distribution points, and ensure adequate cold chain capacity.	DRC (DHIS2 and infoMed RDC); Kenya (CHANJO); Mozambique (SELV); Nigeria (NAVISION)
Facility management information systems enable managers to oversee service delivery by having access to up-to-date and accurate information on the name and location of health facilities and types of services offered. **Digital global good:** Facility Match	**Reaching:** Immunization program managers need access to information on health facilities to plan for vaccine service delivery. By triangulating data on facility location with data on weak immunization coverage, program managers can plan services to better reach zero-dose children.	DRC, Kenya, Nigeria
Public health and disease surveillance systems capture data for public health planning and response, including on notifiable diseases. Systems enable managers to conduct epidemiological analysis, oversee health service delivery, and facilitate disease control and outbreak management. **Digital global goods:** mHero, Reveal, SORMAS	**Identifying:** Immunization program managers can use information on VPD outbreaks to identify pockets of under-immunized children and missed communities. **Monitoring:** Immunization program managers need information on VPD trends and outbreaks to know if programmatic strategies are reaching all eligible children and use the information to target outreach.	DRC (mHero); Kenya (mHero and Reveal); Nigeria (Reveal and SORMAS); Mozambique (DHIS2)

5. SUMMARY OF KEY CONCLUSIONS AND STRATEGIC RECOMMENDATIONS

The landscape analysis identified a total of 11 information systems and tools with strong potential to support the data-related demands of health workers and immunization program managers to identify, reach, and

monitor zero-dose and under-immunized children. Considering findings across systems and tools, we generated the following key conclusions and strategic recommendations:

1. Health information systems and data tools must be used to improve the accuracy of immunization program targets (denominators), considering the need for shorter-term solutions alongside longer ones. Technical solutions will require government commitment to make improvements for more accurate population estimates. Inaccurate population denominators are an underlying crosscutting problem affecting each identifying, reaching, and monitoring intervention area of the IRMMA framework. The various tools to solve the problem are underused.

   Short-term:

   - Decision-makers may consider recent innovations in reviewing and adjusting sub-national population estimates to improve accuracy. This is most relevant for contexts with low migration and recent region-specific population growth data.

   - Decision-makers and funders can support increased investment in community mapping and enumeration, which may range from paper-based (low-tech) to geospatial mapping (high-tech), or a combination of the two, as part of improved microplanning for RED/Reaching Every Community.

   - Investments in coverage surveys or coverage and equity assessments can use novel approaches such as oversampling to identify zero-dose children and LQAS to identify under-immunized communities, and triangulate coverage data with disease surveillance, campaign, and stock management data.

   Long-term:

   - Funders and partners should invest in broader efforts to strengthen health information systems, and the foundational eHealth building blocks necessary for their success. This will require an investment approach that is coordinated across health programs and aligned with national priorities. Stronger CRVS systems, for example, have benefits that extend beyond immunization programs and will need coordinated investment.

2. Immunization programs should consider the feasibility of expanding the use of health information systems and data tools to determine where zero-dose and under-immunized children live, making it easier for health workers and immunization program managers to find missed children in different settings (e.g., urban, remote rural, fragile). Despite advancements in technological solutions, such as geospatial technology, many LMICs are not yet fully benefiting from what they can offer for routine immunization. In addition, data already collected by immunization programs and other health and social safety net programs could be better leveraged to find children who miss routine immunizations.

   Short-to-medium term:

   - In contexts with substantial uncertainty about the presence and size of missed communities, decision-makers and funders should consider the use of geospatial data and technology. This can range from plotting facility locations and administrative boundaries to using satellite imagery to identify communities and estimate the number of vaccine-eligible children. The use of such methods will be enhanced by community involvement to ground truth and refine data and secure its acceptance by those to be reached with immunization and other services.

- Immunization programs should explore ways to better use existing data (e.g., immunization campaign coverage, administrative, surveillance data) to detect communities and individual children who have missed immunizations. This could include a positive zero-dose case identification during campaign coverage survey.

3. The goal of a system that records all births and tracks each child's vaccination status is longer-term for many countries, but in the short term there are specific steps to faciliate identification, reaching, and monitoring individual children. Digital health information systems and tools such as DHIS2 have achieved scale but only manage aggregate data. While some countries have made progress introducing an EIR, which captures patient-level data in health facilities, this solution is limited in its ability to identify, reach, and monitor children who never interact with the health system.

   Short-term:

   - Countries without an EIR that are using DHIS2 Tracker for COVID-19 could explore its use for routine immunization, in comparison to other EIR tool options. This would entail a comprehensive review of the specific problems the vaccination program is trying to solve to determine which technology platform or system is most appropriate.

   - Invest in data capacity at community and facility levels, including health worker skills and practices related to collecting, recording, managing, and analyzing data.

   - Explore systems and tools that can facilitate integration and triangulation of information across health programs to identify zero-dose children in the community (e.g., village birth registries/SMS birth notifications, CBIS, integrated HBRs, triangulation between maternal health and immunization registries).

   - Strengthen the use of client communication systems including, where feasible, SMS to notify caregivers of vaccinations that are due.

   Medium-term:

   - Countries and funders should consider investing in digitizing data collection at community and facility levels. For example, investments in CBIS could initially target the most underserved areas to identify and register children least likely to interact with the health system. Digitizing data collection will require coordinated action and broader investment in the foundational eHealth building blocks, such as support for the development of national digital health strategies.

   Long-term:

   - Countries should establish interoperability between information systems and tools at all levels of the health system (e.g., CBIS linked to an EIR that links with HMIS).

4. Immunization programs should consider expanding monitoring systems to include different types of data and analyses to inform performance improvement and to understand who and where zero-dose and under-immunized children are and why they have not been reached. In parallel, the skills and decision-making processes that enable health workers to use data must be reinforced. Most routine immunization monitoring systems rely primarily on tracking the number of vaccine doses administered. However, when immunization coverage is triangulated with other data (e.g., supply chain, demographic, equity), it can provide deeper insights to support the identification and reach of zero-dose and under-immunized

children. At facility and community levels, immunization data are underutilized because of health workers' limited skills in data analysis and interpretation, lack of trust in the data due to concerns with its quality, and lack agency to act on the data, among other factors. For these reasons, health workers need tools, processes, and some degree of autonomy at sub-national levels that support data use to inform course correction. Most recommendations can be implemented in the short-term.

Short-term:

- Immunization programs should invest in tools that facilitate data analysis and use, such as data dashboards, and explore systems and tools for collecting different kinds of data, such as qualitative from client feedback mechanisms, surveillance on VPD outbreaks, and vaccine consumption.
- Immunization programs could consider the use of rapid survey tools such as LQAS to supplement routine monitoring to identify communities with immunization coverage under an acceptable threshold.
- Immunization programs and partners should strengthen investments in strategies that support data use practices, with a particular focus on front-line health workers. Readers can refer to recent reviews of immunization data use interventions for more information on best practices. (37) (76)
- Incorporate data quality monitoring alongside coverage monitoring.

5. Immunization programs could explore opportunities to leverage and adapt digital tools deployed for COVID-19 to routine immunization. Numerous digital tools have been adapted and deployed for use cases including vaccine planning, delivery, and monitoring for COVID-19. Operational lessons from these deployments can inform country decisions about investments in systems and tools for routine immunization.

   Short-to-medium term:

   - Countries that have adopted DHIS2 Tracker to track COVID-19 vaccine delivery could ascertain if implementing an EIR is feasible, and if DHIS2 Tracker or another EIR tool is appropriate for routine immunization.
   - Other digital tools deployed for COVID-19 have been used for immunization in some countries but may not be widely scaled and could be considered. These include:
     - Rapid phone surveys to monitor coverage.
     - Client communication systems (e.g., SMS, WhatsApp Chatbot) to send reminder messages and health information.
     - Social listening and monitoring tools to inform strategies to dispel rumors and misinformation.

ANNEX 1. FUNCTIONAL REQUIREMENTS OF IMMUNIZATION INFORMATION SYSTEMS AND DATA TOOLS

Functional requirements are defined as *what* the system or tool can do and *how* end users interact with it. Previous bodies of work have established functional requirements broadly for immunization information systems (IISs), including the CDC IIS Functional Standards, the Public Health Informatics Institute IIS Requirements projects, the Digital Square EIR Landscape, and VillageReach EIR landscape. Drawing from these sources, we developed a list of adapted functional requirements that are suited for supporting immunization decision-makers to identify, reach, and monitor zero-dose and under-immunized children.

Intervention area	Description of functional requirement
Identify	• **Population data & denominators:** capture child data (e.g., birth, death) by geography or catchment area. • **Enrollment at birth:** registers a child for vaccination as close to birth as possible, ensuring an accurate denominator and tracking vaccination status. • **Unique identifiers:** use a number or system for identifying each child registered for vaccination; enable vaccination tracking. • **Triangulation with data from other sources:** incorporates data from additional sources (e.g., CHWs) and sectors (e.g., humanitarian and social safety net operations) and triangulates data to determine the actual number of eligible children in a target area. • **Nonroutine vaccine event data:** capture vaccination data in nonroutine settings, such as outreach events, health fairs, and vaccination campaigns. Enable registration of individuals who are vaccinated during the outreach services or campaigns but not yet registered in the system. • **Decision support:** provides data-driven support to help health workers make decisions about patient care, such as creating patient vaccination schedules, generating lists of patients due for vaccination, and reminders of missed vaccinations.
Reach	• **Individual demographic data:** captures data—including unique ID, name, sex, date of birth, caregiver contact information, place of residence, and status—about each person in the system. Inclusion of sociodemographic information (e.g., economic, ethnic, linguistic, relgious data) can support equity analyses of risk factors for under-vaccination. • **Vaccine event data and records:** capture information on the vaccine event (e.g., date, antigen, dose, place, vaccinator, administration strategy) that is used to record the vaccine history of each individual and assess whether s/he received the right vaccine at the right time. • **Linkages to other health areas:** include the capture of data on services that are typically delivered alongside vaccination, such as weight measurement/growth monitoring, vitamin A administration, and use of bed nets, which could provide opportunities to identify under-immunized children. • **Reminder and recall messages:** send manual and automated client messages via various mechanisms (e.g., phone calls, SMS, email, postcards) to provide reminders. • **Human resource tracking:** captures data on human resources to enable immunization service planning. • **Financial resource management:** captures data on government and partner financial commitments to enable immunization service planning.

	• **Service delivery planning and management:** captures data to support immunization planning and management, such as geographic and population data to inform microplanning. • **Health facility data:** ability to have a complete list of health facilities in the implementation jurisdiction that is searchable, making it possible to understand where vaccinations are delivered and plan for vaccine service delivery.
Monitor	• **Identification of under-vaccinated individuals:** ability to triangulate across datasets to identify zero-dose children and calculate the appropriate vaccination schedules and highlight patients who have missed vaccination or are overdue, enabling follow-up. • **Surveillance and outbreak detection:** ability to detect outbreaks of VPDs and identify geographic regions most affected, which could inform targeting and microplanning. • **Stock management:** prevents stockouts by facilitating stock forecasting and planning. Includes the ability to signal when vaccination stocks are low and reorder them. Is useful for understanding consumption patterns. • **Data use practices:** support the use of data through features that include aggregation, visualization, dashboards, and generation of reports on vaccination coverage, defaulters, etc. to support follow-up. Uses data from different sources, including client feedback, rumor monitoring, adverse event reporting, etc. to understand immunization performance and inform course correction.

ANNEX 2. SUMMARY TABLE MAPPING OF INFORMATION SYSTEMS AND TOOLS

The table below lists the information systems and data tools identified by the landscape analysis (in the row headings). The color-coded cells indicate which functional requirements (in the column headings) each system/tool is either already achieving or has the potential to achieve. The landscape focus countries are listed next to a system/tool if the country is using or has used it for immunization in the past five years, including any use (e.g., it does not need to be institutionalized at a national scale).

TABLE 1. INFORMATION SYSTEMS AND TOOLS TO MEET THE FUNCTIONAL REQUIREMENTS TO IDENTIFY, MONITOR, AND REACH ZERO-DOSE AND UNDER-IMMUNIZED CHILDREN, AND INDICATION OF THEIR CURRENT USE IN DRC, KENYA, MOZAMBIQUE, AND NIGERIA

Tools	Countries	Identify						Track								Monitor			
		Population data & denominators	Enrollment at birth	Unique identifiers	Triangulation with data from other sources	Nonroutine vaccine event data	Clinical decision support	Individual demograpic data	Vaccine event data and records	Linkages to other health areas	Reminder and recall messages	Human resource tracking	Financial resource management	Service delivery planning and management	Health facility data	Identification of undervaccinated individuals	Surveillance and outbreak detection	Stock management	Data use practices
Community-based information systems (CBIS)	Kenya, Nigeria	■	■	■	■	■	■	■	■	■	■			■		■	■	■	■
Geospatial technologies	DRC, Kenya, Nigeria, Mozambique	■			■	■		■						■		■	■		
Denominator estimation methodologies and equity analyses	DRC, Kenya, Nigeria, Mozambique	■			■	■		■						■		■			
Electronic Immunization Registries (EIRs)	Kenya	■	■	■	■	■	■	■	■	■	■	■		■	■	■		■	■
Home-based record (HBR)	DRC, Kenya, Nigeria, Mozambique		■	■		■	■	■	■	■	■			■		■			■
Client communication systems	DRC, Kenya, Nigeria, Mozambique										■					■			
Health management information system (HMIS)	DRC, Kenya, Nigeria, Mozambique						■							■	■		■	■	■
Immunization coverage surveys	DRC, Kenya, Nigeria, Mozambique	■						■						■		■			
Monitoring charts and data dashboards	DRC, Kenya, Nigeria				■		■			■	■			■		■	■	■	■
Data quality assessments	Kenya, Nigeria, Mozambique															■			■
Client feedback systems	Kenya, Mozambique									■				■					■
Human resource information systems	DRC, Kenya, Nigeria, Mozambique											■		■					■
Logistics Management Information System (LMIS)	DRC, Kenya, Nigeria, Mozambique													■				■	■
Financial management information systems	DRC, Kenya, Nigeria													■	■				■
Public health and disease surveillance systems	DRC, Kenya, Nigeria, Mozambique													■		■	■		■

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