WORKING PAPER

Data Visualization That Works

Facilitating HIV Program Targeting: Case Examples and Considerations

MEASURE Evaluation

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With the introduction and strengthening of electronic health information systems, health data have become increasingly available in digital formats. Access to data, however, is not sufficient. Data must be processed, analyzed, and presented to decision makers in usable formats. The ability simply to read data is typically not enough, either. Data *visualization* can help would-be data users to see patterns, trends, and correlations that might go undetected in text-based or numerically-based data**.**

High-quality data displayed in a format that facilitates decision making helps program managers and policy makers effectively allocate limited resources.

Multiple software platforms, either open-source or proprietary, are available to facilitate data visualization. These software applications, many of which are interactive, provide tools to develop charts, maps, infographics, timelines, and other visual tools. MEASURE Evaluation sought to understand this emerging field beyond simply what the literature says and to begin to showcase evidence of how such tools are being used in the field to **improve the use of data in HIV programs** and the impact they have on decision making.

Method and Findings

MEASURE Evaluation sought to understand how data visualization tools are being used in the field to improve the use of data in HIV programs and to see what kind of impact they have on decision making. MEASURE Evaluation contacted 45 people from 17 implementing partners of the President's Emergency Plan for AIDS Relief (PEPFAR) to ask how they use data visualization techniques and software. Respondents named data dashboards or maps as the most typical types of visualization. Our team identified 16 potential case examples of data visualization but, for inclusion in this brief, we required that that the respondents be able to cite **how the visualization influenced program targeting and improvement**. Many respondents could cite multiple examples of robust data visualizations, but only some could point to specific decisions that were made based on these products. Those examples are the ones included here.

Difficulty following up with decision makers who used data visualizations was the challenge mentioned most often—because of the time lag from visualization development to decisions prompted by the visualization to program changes. Also, many partners developed and implemented the data visualization but were not involved in encouraging its use, and thus didn't have a mandate to track how it had been used. Two organizations had excellent examples of how the visualization influenced program improvement, but they declined to be included in this brief because they intend to publish in the peer-reviewed literature.

Of the three remaining examples, we investigated specific drivers of success in the process of developing and using the data visualization in decision making. We also include a fourth example that did not result in data-informed decision making, because it does illustrate the complexities involved in developing data dashboards.

Lessons Learned and Considerations

Our interviews with respondents uncovered important facilitators and barriers to the development of data visualization and its successful use in decision making. Some examples of learning are presented here, with the more detailed case studies following.

- C**ollaborate with data users during visualization development** to ensure the relevance of the visualization to their decision making needs. *Example:* In Zambia, initial meetings with the MOH ensured that the dashboard developers understood exactly what information was needed to monitor a program on the prevention of mother-to-child transmission of HIV (PMTCT). These early meetings also facilitated a solid understanding of the data that existed to populate the dashboard, as well as the data that didn't exist but were needed. Collaboration should also be across departments to ensure that support for the visualization rests with the institution and not with an individual. The initial geospatial information system (GIS) dashboard developed in Zambia was never used because the key supporter left his post.
- C**onsider developing proxy indicators through estimation or modeling techniques,** because often data needed to create the visualization are not available. (A proxy indicator is a variable used to stand in for one that is difficult to measure directly or one that has not yet been measured.) Interpretation of the visualization should consider the limitations of this approach, which are meant to serve until more precise data are available. *Examples:* South Africa, where up-to-date HIV prevalence data were not available at the district level, developed a method to estimate these figures using proxies so that program planning and targeting could continue. The Zambia case study also involves developing proxy indicators.
- **Include training on how to interpret visualizations.** Reading a heat map or a dashboard is not always intuitive. Program staff need to discuss the data that make up the visualization and also how useful the visualization may be, as well as the programmatic implications of the data. *Examples:* In South Africa, the district team members were trained on how to interpret maps in order to understand their implications for the team's day-to-day work. In Tanzania, Maternal and Child Health Integrated Program (MCHIP) staff were trained to use the GIS database and interpret the results to inform future site targeting. In Namibia, discussions and trainings around data visualization interpretation were crucial, because government staff there had never had the opportunity, as a group, to discuss, interpret, and use data to target and modify programs.
- **Standardize data sources** so that indicators can be calculated and data sources can be combined, based on one or more common elements, such as districts or states. Allocate sufficient time for cleaning and matching data. Often, the facility lists—commonly the linking elements across databases—do not match perfectly. Furthermore, even the most accurate data source may have spelling errors or duplicates, or the facilities may be mapped to the wrong district or province. *Example*: For the dashboard in Zambia, the facilities were matched manually. This involved first identifying the most comprehensive and accurate data source, and setting that as the master to which the other data sources would be matched. Then, in Excel, the list of facilities and all their attributes (sometimes called metadata) was cleaned by finding and fixing spelling errors and incorrect hierarchy of districts or provinces. Human judgment was also used to detect small differences in a name because of an extra space or slight difference in spelling. Next, duplicate facility names were identified and removed. Finally, a manual search was done for facilities that weren't matched. This process was repeated for the second data source and then the third data source.

- **Ensure good data quality.** As part of the initial development of a GIS or dashboard system, the team should review the data and identify quality issues such as missing data, duplicate data, or incorrectly formatted data. The ongoing data quality burden of a project must be taken into consideration for the long-term use of a dashboard to succeed. This requires ongoing human resource oversight, to ensure that data are being loaded on schedule and pass quality checks. If users realize they cannot trust the data to help them make decisions, they may not return to the visualization. *Example:* A dashboard used in Thailand is not included in this brief because, although it was used successfully for two years to target HIV programs, it had to be taken offline due to issues with data quality. This illustrates that even mature dashboards are subject to recurring data quality issues.
- **Consider sustainability when selecting GIS and dashboard software**. Data visualizations vary in cost and level of sophistication. Open source software is available free of charge but still requires resources to adapt and maintain it. Determining the best tools for your organization will depend on the kinds of visualization needed, ease of access, and the length of time the data visualization will be needed to inform decision making. Finding programming experts who understand data warehousing and data visualization can be challenging. The long-term funding and staff resources needed to maintain the visualization software and sustain data management should be discussed during dashboard development. Local commitment for maintaining the data sources, updating the visualizations if necessary, ensuring data quality and managing the database is critical to sustaining the visualization. *Example:* All case studies cited here, except South Africa, expected to continue data visualization but not one of them had plans for sustainability, so the programs are at risk when the projects supporting them end.

Lessons from the Field: Case Studies

Case 1. South Africa: Using Proxies to Map HIV Services in Nkomazi District

South Africa has one of the highest adult HIV prevalence rates in the world (18.8%). Mpumalanga province has the second-highest prevalence in the country at 14.1 percent. Within this province, Nkomazi district is significant, because it borders Swaziland and Mozambique and has a large population of migrant workers. Many of these workers are undocumented, and many are HIV-positive.

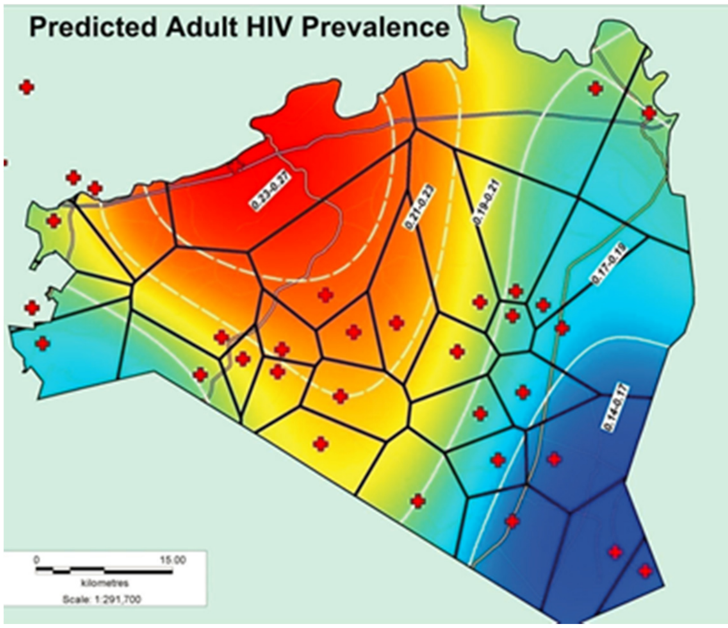
In 2012, the Nkomazi AIDS Council wanted to know the locations in the district of people living with HIV (PLHIV), sexually active youth, and men having sex with men (MSM)—including undocumented migrant workers—and if and how they accessed the district's health facilities and other healthcare services. The council worked in collaboration with the Sexual HIV Prevention Program (SHIPP)—funded by the U.S. Agency for International Development (USAID) and implemented by Futures Group (now named Palladium)—and with the Ehlanzeni district municipality, Nkomazi local municipality, and experts from the University of KwaZulu-Natal (KZN). Together, they sought to identify the locations of HIV services in relation to the areas of highest HIV prevalence.

Method

SHIPP and the University of KZN collaborated closely with a working group of the Nkomazi AIDS Council and with the Nkomazi Department of Health (DOH) to create maps that displayed estimated HIV prevalence and HIV service availability. Dr. Frank Tanser, of the University of KZN, developed a four-step method to estimate and map HIV prevalence from routinely collected data from antenatal care (ANC) clinics. These data were linked to geographic coordinates to generate a heat map of estimated HIV prevalence in the region re 1).

A GIS allows other data to be overlaid on the HIV data, such as population distribution, the geographic distribution of health facilities, and the locations of roads and administrative boundaries. This ultimately creates a map that gives a more accurate picture of disease distribution and access to health facilities in the area as well as the number of villages that use a specific facility.

Figure 1. Predicted adult HIV prevalence



This map shows predicted HIV prevalence in Nkomazi district, red being the highest and blue being the lowest. The red crosses represent the locations of health facilities in the district. The areas with the highest predicted HIV prevalence also have the fewest facilities nearby. Source: Dr. Frank Tanser, University of KwaZulu-Natal

Program Targeting

The maps created by the University of KZN, the Nkomazi AIDS Council's working group, and SHIPP were excellent tools to facilitate the council's use of data in decision making. The maps illuminated the presence of areas of high HIV prevalence that were far from health facilities or in remote areas where access to facilities was difficult, as well as the number of villages accessing a particular health facility. When district health workers went to these areas to investigate why prevalence was so high, as well as how access could be improved, they discovered that many of these areas were farms where migrant workers lived. The workers were either unable to access services because of distance or were unwilling to access them because of stigma or fear of deportation. In response to this barrier, the Nkomazi AIDS Council, in partnership with the business sector in the municipality, organized transportation to take farm workers—a different group each week—to health facilities for HIV testing and treatment. The council also organized trainings for migrant farm workers on their legal rights as non-South Africans and their right to care where they could safely access services. The council helped some farm workers get the legal documentation that health facilities required to provide treatment. Finally, the council collaborated with the International Organization on Migration, which is now a part of the district support structure for migrant workers. Two years after the maps were created, these interventions are continuing in Nkomazi.

Case 2. Tanzania: Mapping to Target VMMC Services

HIV prevalence in Tanzania is 5.3 percent. However, the epidemic shows strong regional variation, with the highest prevalence rate in the Njombe region, at 14.9 percent. In 2009, the Tanzania Ministry of Health and Social Welfare (MOHSW) developed a national strategy for scaling up voluntary medical male circumcision (VMMC) as a strategy to reduce new HIV infections, prioritizing 11 regions with high HIV prevalence and low circumcision rates. Several priority regions were assigned to each PEPFAR implementing project working on VMMC in the country. One of those identified was JHPIEGO, which was implementing the Maternal and Child Health Integrated Program ((MCHIP)) project in two of the 11 priority regions. Through MCHIP and other initiatives, the MOHSW had a five-year goal of reaching almost 265,000 males, ages 10–34 years, with VMMC services by 2014.

> Data visualization painted a vivid picture of where HIV services and access were needed. When this activity began, Nkomazi had the highest HIV prevalence of all districts in the province (42.7%). In 2013–2014, Nkomazi's prevalence had fallen to 40.5 percent, lowering its ranking to third-highest. The use of data visualizations enabled decision makers target HIV services to populations that were not accessing them.

To identify VMMC scale-up sites, MCHIP worked with district health management teams (DHMTs) and with health facilities chosen for their local knowledge and readiness to initiate the new service. This approach was time-consuming and resource-intensive. Moreover, district health teams often had limited or outdated information on the facilities. Many facilities selected were difficult to locate and not properly equipped for VMMC services. Because information on the facilities was incomplete, scaling up VMMC was ineffective.

Method

To address this problem, MCHIP adopted a new scale-up model: a "parent-child" approach that relies on clusters of health facilities. The "parent" site is the one that is best-equipped and most centrally located. As demand for VMMC grows at the parent site, smaller "child" sites are opened nearby. This model enables MCHIP to scale up VMMC services even in remote rural areas. MCHIP first collected data on all health facilities where it worked. These data included information on services provided, location, hours, staff, availability of electricity and running water, number of beds, and so forth. The data collectors used handheld GPS devices to record the geographic coordinates of the health facilities for storage in a GIS database. All data associated with each health facility were linked to these coordinates and also stored in the GIS. The project also collected data for the GIS on accessibility, including the location, quality, and seasonality of roads leading to each health facility. They used these data to identify facilities that best met the criteria of parent and child sites. Then they worked with community leaders such as DHMT members and facility heads to set up VMMC services and increase knowledge of and demand for the services in each location.

This improved site selection process enabled MCHIP to have up-to-date information on the location, accessibility, and functionality of all health facilities where it was working. The use of a web-based GIS allowed information to be available to all MCHIP staff, who were trained to use the system and analyze and understand the maps and data. They also developed an offline version of the system that could be used in rural areas with low connectivity. Staff were able to collect and import data even when Internet service was down and import it into the online system once service was restored.

Program Targeting

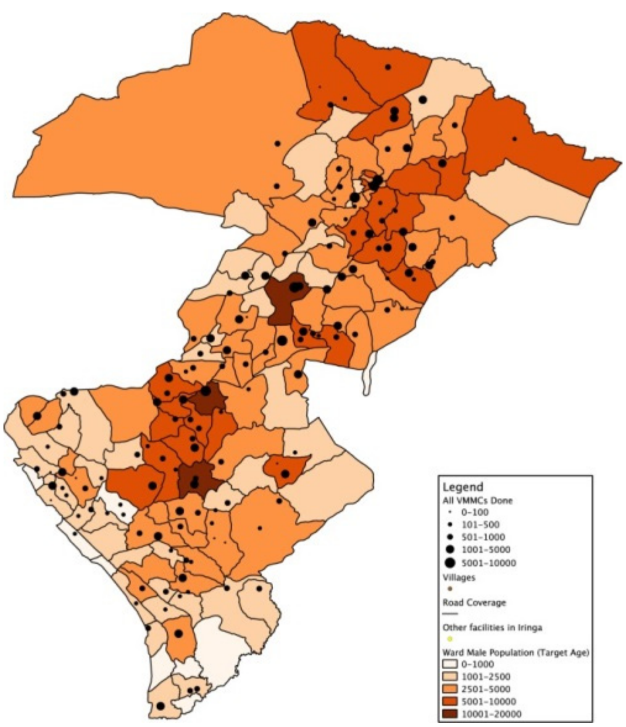
From 2012–2014, MCHIP mapped 1,170 health facilities in Iringa and Njombe. In 2011, prior to the use of GIS mapping to aid in VMMC targeting, the project performed almost 50,000 circumcisions at 29 facilities. In 2014, the project performed more than 130,000 circumcisions at 420 facilities. Cumulatively, the project has circumcised more than 500,000 males since 2009—85 percent of them since 2012. Additionally, these two regions went from having the lowest prevalence of VMMC in Tanzania (29.1% in 2009) to one of the highest (82% in 2014), exceeding the MOHSW's regional targets.

> In 2014, MCHIP decided to change its process for selecting scale-up sites. It wanted to see the geographic distribution of all sites compared to the sites where it was operating. It also wanted additional data about each site, to target new facilities and populations more effectively.

Sustainability of the Data Visualization

MCHIP created the VMMC GIS database for its internal purposes. However, the project recognizes the value of the system to the government and other partners jointly involved in the scale-up of VMMC. The project is currently discussing with MOHSW the feasibility of transferring the data and software to the ministry, which would give it ownership and control of the database's operations. Ultimately, this would allow the MOHSW to apply a proven approach to scale up services in all of the VMMC priority districts, not just the ones that MCHIP supported. MCHIP's decision to use an open source platform for all of its data and mapping software ensures that transfer to the MOHSW can be done easily and without licensing fees.

Figure 2. Distribution of male population, ages 10–49, layered with number of VMMCs performed, by ward, Iringa and Njombe regions, Tanzania, August 2013



Source: Mahler, H., Searle, S., Plotkin, M., Kulindwa, Y., Greenberg, S., & Mlanga, E., et al. (2015). Covering the last kilometer: using GIS to scale-up voluntary medical male circumcision services in Iringa and Njombe Regions, Tanzania. *Global Health: Science and Practice* 3(3): 503-515. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4570020/.

Case 3. Namibia: Data Dashboard Targeting HIV Testing and Treatment Programs for Pregnant Women

Namibia's HIV prevalence is high: 16 percent. Nevertheless, HIV funding from donors is diminishing. In response to this, USAID is helping the Government of Namibia (GON) to improve its capacity to manage resources for the epidemic effectively and efficiently. The GON needed a better way to compile data on HIV from a variety of data sources and platforms into a single database that would be accessible and easy to use. USAID called on the Namibia Institutional Strengthening Project—a USAID-funded program implemented by Pact, Synergos, and the Health Information Systems Program (HISP)—to work with the GON on this.

Dashboard Development

An essential function of the data warehouse was a dashboard that provided a user-friendly visualization of the compiled data. The GON had already been using DHIS 2 (a web-based, open source information system) for some of its health data, so the platform for creating the dashboard was familiar. Additionally, DHIS 2 provides a built-in mechanism for data visualization.

Much of the data entry process was manual, as many of the required data sources were on paper or in PDF format. The data were entered in a format that could be imported into the DHIS 2 system. Where possible, the central data warehouse also automatically pulled and incorporated data from other online systems.

> The project was to build a central data warehouse and a data dashboard. A data warehouse is an organized, central data repository where data from multiple sources are transformed to create a single database for reporting and analysis. This kind of database standardizes and links data through one or more common elements across all of the sources: surveys, reports on programs, and census data, among others.

Namibia's HIV strategic plan focuses on four areas: population, care and treatment, prevalence, and impact mitigation. The project displayed the data based on these four areas in order to ensure that it linked as much as possible to ongoing HIV programs. In each of the four sections of the dashboard, data are displayed at the national and regional levels. Each section has graphs and charts of the chosen indicators related to each focus area. For example, a user can choose to look at prevalence at the national level and see graphs on HIV testing among adults, the percentage of the population never tested for HIV, condom distribution rates, male circumcision rates, and so forth. The project rolled out the dashboard in all 14 regions of Namibia. Once the data warehouse and dashboard were created, the project trained MOH staff to use it. Particularly at lower levels of the government, many of the staff weren't data-literate, so there was also training to help them understand and interpret the data displayed in the dashboards.

Program Targeting

The project held multiple workshops and meetings to review the dashboard, in order to focus on coordination and collaboration among partners involved in the regional HIV response and on reaching the "90-90-90" targets of the Joint United Nations Programme on HIV/AIDS (UNAIDS): by 2020, 90 percent of PLHIV will know their status, 90 percent of these will be on sustained antiretroviral therapy (ART), and 90 percent of these will be virally suppressed.

For many participants, these workshops were the first time they had ever interpreted, discussed, and understood the data they collect. The project used the dashboards to start a regional conversation about what the indicators and charts mean. For example, if the chart said that there are 26,000 PLHIV in the region and only 13,000 of them are receiving ART, they discussed what this meant for the program. They raised additional questions to help inform this specific finding. For example, what do the same data say when they are disaggregated by age and sex? What can be learned by looking at the data geospatially? At each workshop, participants went back to the same data. From the additional analysis and discussion of the findings, the group identified priority activities to address the testing and treatment gap. The participants used the dashboards to deepen and broaden their understanding of HIV in their region. Never before had they had the tools or capacity to view their data holistically and interpret the data to make informed program decisions.

During one meeting, the group identified a crucial gap in HIV services: pregnant women were testing positive for HIV but were not initiating ART. The participants discussed how they could improve treatment rates for HIV-positive pregnant women and identified a solution: The NGOs that were doing testing in the region could conduct their door-to-door HIV testing to coincide with days promoting ANC in government health facilities. This way, pregnant women who tested positive could go to the ANC clinic the same day to receive treatment. The NGOs agreed to the change, launching a collaboration made possible by the data review and discussion. Using dashboards to easily view and interpret data catalyzed a solutions that enhanced the efficiency and effectiveness of Namibia's HIV program.

Sustainability of the Dashboard

The Namibia Institutional Strengthening Project, which funded the dashboard development, ended in 2015. Now the project is transferring ownership to the Ministry of Health (MOH), which involves building MOH capacity to use, manage, and maintain the dashboard. Database management and maintenance includes processes such as data element naming, indicator formulation, and denominator standardization. It also involves ensuring that any new data are compiled, cleaned, standardized, and uploaded to the data warehouse. HISP will also work with the MOH to raise awareness of the value of the dashboard to HIV program resource management and targeting, to make demand for the data visualizations long-term. When the MOH has the skills to assume ownership, HISP will remain involved to provide quality assurance assistance. A long-term plan for funding the continued upkeep of the dashboard remains to be developed.

Figure 3. Screenshot of Namibia's DHIS 2 Dashboard

Case 4. Zambia: A Data Dashboard Responding to PMTCT Program Needs

HIV is a major development challenge for Zambia, where prevalence is 12.4 percent: one of the highest rates in the world. Pregnant women carry a large burden of the infection. According to the 2014 UNAIDS Global AIDS Progress Report, Zambia has a mother-to child transmission rate of 12 percent. To contribute to the efforts to reduce HIV prevalence in Zambia, in 2011 the Clinton Health Access Initiative (CHAI) asked Futures Group to develop a GIS to map the location of facilities providing HIV care and treatment services in the country. To do this, Futures Group used Google Maps: a free and open source software. The GIS included information on type of facility (private, government, NGO); level of facility (primary, secondary, tertiary); and services offered at each facility (PMTCT, early infant diagnosis, ART, and CD4 testing). However, due to management changes at CHAI as well as data quality issues and the lack of a complete and up-to-date master facility list, the GIS never went live.

In an effort to repurpose the existing system, Futures Group shared what it had developed with technical working groups and with the Zambia Ministry of Community Development, Mother, and Child Health (MCDMCH). The head of prevention of PMTCT within MCDMCH was interested in using this type of data visualization to understand early warning indicators of a need for PMTCT services and develop a way to analyze them geographically. The dashboard would also provide a central location for housing PMTCT data from three different data sources: DHIS 2 (collecting aggregated health indicators); the electronic logistics management information system (eLMIS) for drug and commodity inventory tracking and logistics; and Mwana, a system providing real-time laboratory results to clients by SMS). The MOH monitoring and evaluation staff are pulling data from one or more of these data sources individually, combing them manually, calculating indicators on spreadsheets, and then displaying the results in graphs in Excel or PowerPoint. This is a slow and difficult task and, as a result, is done only periodically. The promise of having a central repository for these data and the ability to quickly and easily access the data at any time could help MCDMCH manage the PMTCT program more effectively.

Dashboard Development

In March 2015, a workshop was held with developers and intended users of the dashboard (the MCDMCH) to understand data needs and information challenges. Based on discussions, it was decided that the dashboard would accomplish the following tasks:

- Pull together PMTCT data from the three information systems into a central dashboard that includes graphs, tables, and maps that all relevant stakeholders can access easily.
- Provide early warning indicators of the need for prompt and appropriate action on the PMTCT program.
- Allow MCDMCH to monitor the PMTCT program, evaluate its effectiveness, and provide feedback for continuous improvement.

Concurrent to the workshop, a PMTCT working group determined it needed a new set of PMTCT indicators for the dashboard that also included early warning indicators. When the dashboard developers began to look at the indicators, they realized that much of the new data required was not currently being collected at the facility level, so the indicators could not be calculated. Although Zambia intended to build or update systems and registers to collect the data needed for the new indicators, this would likely take several years. In the interim, it was necessary for the developers and the PMTCT program to agree on proxy indicators that could be used until new indicator data were collected. In November 2015, the proxy indicators were determined.

Table 1. Example of missing data and the development of a proxy indicator

Requested Indicator	Numerator/ Denominator	Challenge	Proxy Indicator Numerator/Denominator	Limitations
Proportion of HIV-exposed infants (HEI) tested at 12 months	Number tested at 12 months/ number of HEI born 12 months prior	Existing indicator captures the number of infants tested by 12 months. Data on the number of HEI born is not collected.	Number tested by 12 months/number of HIV-positive pregnant women in reporting period	The number of HIV-positive pregnant women in the reporting period may misrepresent the desired denominator because of: 1) fluctuation in the number of HIV-positive women at a clinic where PMTCT is provided; 2) stock-out of HIV test kits; and 3) changes over time in incidence rates. By using the number of infants tested by 12 months, the numerator may be skewed, because infants tested up until 12 months of age are included, but new births

				during the same period are not represented.
Percentage of HEI alive at 2 months and on cotrimoxazole (CTX) prophylaxis	Number of HEI on CTX at 2 months/ number of HEI born 2 months ago	Existing sources don't collect the number of HEI born in a reporting period.	Number of HEIs on CTX within 2 months/HEI reached by 2 months	The percentage of HEI on CTX at 2 months could be inflated, because the denominator only includes those infants who were actually reached at 2 months.

Next Steps

The dashboard's development is under way. The developers are using a free and open source software. They are also in the process of updating Mwana so that data can be pushed directly into this new dashboard system. (Application programming interfaces [APIs] already exist to pull data from DHIS 2 and eLMIS.) One challenge for this dashboard is getting up-to-date data from the three source systems. This process has been time-consuming, because the programming is difficult and data cleaning is done manually at this point. Eventually, the data will need to be imported on schedule and without human intervention. Achieving this will be aided by the use of OpenHIE—a mediator software that manages data exports and schedules processes. The dashboard's graphic display, with the ability to drill down and filter information, is being programmed now. The stakeholders will meet again this year to review the visualizations and indicators and give feedback on the dashboard's usability.

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