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TECHNICAL HIGHLIGHT: MARCH 2018

## RWANDA HEALTH SYSTEMS STRENGTHENING (RHSS) PROJECT



Photo by Todd Shapera

# ELECTRONIC INFECTIOUS DISEASE SURVEILLANCE AND RESPONSE (eIDSR) SYSTEM IN RWANDA

## Background

Outbreaks can overwhelm weak or fragile health systems that lack the tools, infrastructure, policies, and systems to keep communities healthy and safe. Timely detection, preparedness, and appropriate response are essential for limiting both the loss of human life and crippling political and socio-economic impact of disease outbreaks. Countries must build effective and sustainable disease surveillance and reporting systems that mobilize all levels of the health system--including communities--for crisis response.

The International Health Regulations (IHR), adopted by the World Health Assembly in 2005 and entered into force in June 2007, require 196 countries to “report certain disease outbreaks and public health events to the World Health Organization.”<sup>1</sup> These mandatory reportable diseases include shigellosis, typhoid, cholera, and meningococcal

## ABOUT THE RWANDA HEALTH SYSTEMS STRENGTHENING (RHSS) PROJECT

*Supported by the U.S. Agency for International Development (USAID), the Rwanda Health Systems Strengthening (RHSS) Project (2014-2019) works with the Rwandan Ministry of Health to strengthen the health system from the central level to the provincial, district, and community levels. Implemented by Management Sciences for Health (MSH) and its partners, the RHSS Project focuses on sustainable health financing, leadership and governance, quality improvement, data for decision-making, and private sector engagement and partnership. The RHSS Project contributes to Rwanda’s Vision 2020 for a health system that guarantees universal and equitable access to health care and builds on the achievements of 2009-2014 Integrated Health Systems Strengthening Project (IHSSP) to enhance the health system’s ability to respond to change and to foster sustainable country ownership.*

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The eIDSR system is fully integrated into Rwanda's routine health reporting system, and disease surveillance and response are now standard practices across all public health facilities in Rwanda.

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meningitis. The IHR call on governments to establish core capacity requirements for disease surveillance and response,<sup>2</sup> including the development of interoperable, inter-connected electronic systems that facilitate the systematic, real-time reporting and assessment of surveillance data.

Epidemic-prone infectious diseases--such as dysentery, meningitis, malaria, and influenza-like illness (flu syndrome)--are leading public health threats in Rwanda, where they represent at least 65% of all reported medical consultations in health facilities.<sup>3</sup> These threats are compounded by the emerging and re-emerging diseases in the region and globally, including cholera, severe acute respiratory syndrome (SARS), Ebola and other viral haemorrhagic fevers. Changing climatic conditions, and growing regional and international travel and trade, also expose the Rwandan population to new and previously unknown infections that could develop into serious outbreaks.

To ensure effective surveillance and appropriate response to epidemic-prone diseases and other public health conditions, Rwanda's Ministry of Health (MoH) implemented a paper-based surveillance system in 1998, based on recommendations issued by the World Health Organization's African Regional Office (WHO/AFRO). Although health centers were expected to collect epidemiological surveillance data on selected, priority epidemic-prone diseases using standardized forms, these reports were often delayed, incomplete, and not sent to central level, leaving the MoH with an incomplete picture of the country's epidemiological situation.

In 2013, with the support of the U.S. Centers for Disease Control and Prevention, Rwanda became the first

low-income country to pioneer an electronic disease surveillance and response (eIDSR) system using mobile technology and interactive voice response.<sup>4</sup> Building on this work, the Epidemic Surveillance and Response (ESR) Division of the MoH's Rwanda Biomedical Center (RBC) and USAID's Rwanda Health Systems Strengthening (RHSS) Project, led by Management Sciences for Health (MSH), partnered with the Health Information Systems Programs (HISP) in Uganda and Tanzania to leverage their expertise of District Health Information Software (DHIS-2)<sup>5</sup>--an open source platform that Rwanda uses for reporting, analyzing, and disseminating routine health data--to customize a comprehensive eIDSR module on the platform.

This technical highlight describes the key features of the eIDSR system, preliminary results since its launch, lessons learned from implementation, and next steps.

## eIDSR in Action

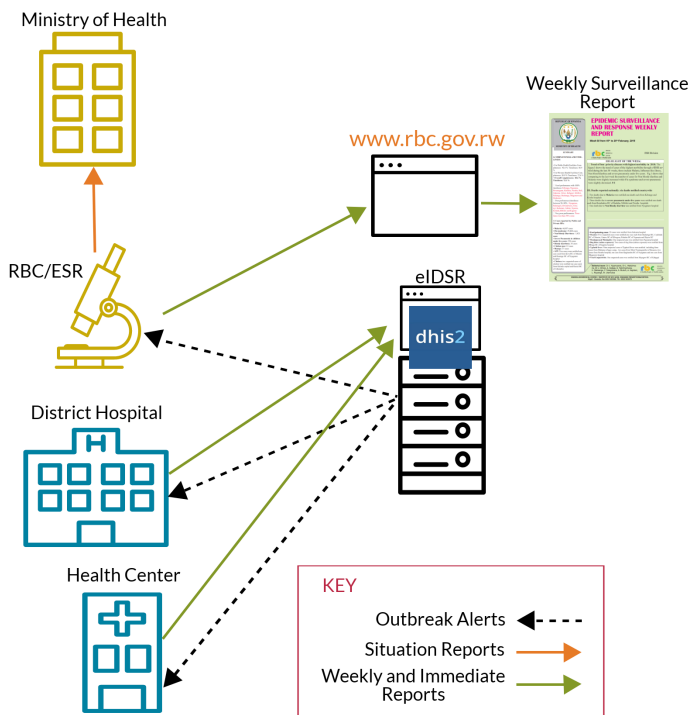
As a result of RBC's collaboration with the RHSS Project and HISP Uganda and Tanzania, the eIDSR system is now fully integrated into the DHIS-2 in Rwanda, disease surveillance is now a routine practice across all public health facilities in Rwanda.

Staff at district hospitals and health centers enter data into the eIDSR system for 24 diseases--some of which are reportable to WHO according to the IHR. Once the number of cases for a specific disease reaches a certain threshold, as defined by the RBC, the eIDSR system sends an outbreak alert to district hospitals, health centers, and the ESR team of the RBC. When an outbreak is detected,

### Key features of Rwanda's eIDSR system

- Integrated into DHIS-2
- Case-based reporting
- Patient status reporting
- Case classification updates
- Tracking of specimens referred for lab testing
- Contact tracing<sup>6</sup>
- Locations of index cases and contacts
- Outbreak alerts when threshold is reached
- Outbreak monitoring (Epi curves)
- Daily SMS/e-mail outbreak status updates to multiple users
- Real-time data analysis
- Advanced reports and analytics with data visualization
- Configurable dashboards
- Support for mobile platforms (SMS, USSD,<sup>7</sup> and Android) for alerts and data capture

Figure 1. eIDSR data flow



district focal points investigate suspected cases and confirm whether they are one of the 24 diseases under surveillance. The RBC and ESR share situation reports with the MoH and other authorities as appropriate, and publish a weekly surveillance report on the RBC website.

Figure 1 (above) illustrates how information flows among all of the users of the eIDSR system.

### Users of the eIDSR system

Users of the eIDSR system range from data managers in health facilities and district-level focal points to the national ESR team at the RBC.

**Data managers in health facilities** (hospitals, health centers, and private clinics) gather data from clinicians and enter them into the immediate and weekly reporting modules. They also update the status of suspected cases according to the protocol defined for each disease.

**District hospital eIDSR focal points**, possessing more training in disease surveillance and response, receive automated alerts from the system whenever a case is reported in their catchment area. They initially investigate and confirm reported cases, trace contacts, and act as first responders before a district or a national team is assembled to manage the response. They usually work with the data managers to enter patient status, laboratory test results, and other updates into the system.

**National ESR team** comprises surveillance and response experts from the RBC as well as experts in the fields of clinical management, communications, security, preparedness, and response. The ESR team receives automated alerts on their cell phones when possible outbreaks are detected. The ESR also team analyzes and publishes the data online in weekly epidemic surveillance and response bulletins, coordinates national-level interagency responders, and when necessary, leads field investigation and response.

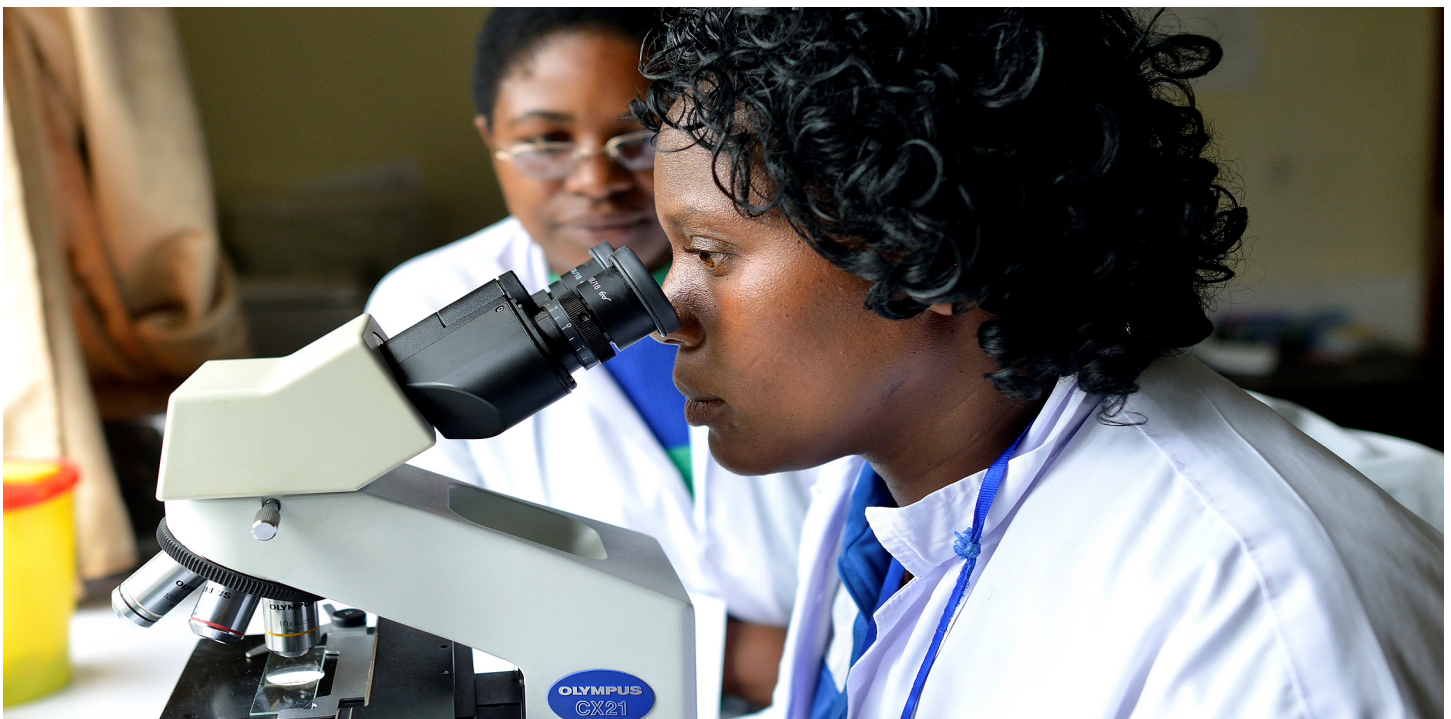


Photo by Todd Shapera

## Data collection

The eIDSR system collects data through immediate, case-based data entry into DHIS-2 and aggregate weekly reporting.

**Immediate case-based reporting** (see Figure 2 below): For each of the 20 WHO reportable diseases, eIDSR system users collect detailed patient data regarding demographics, geolocation, disease classification (confirmed or suspected), vaccination history, symptoms, patient care status, and other types of information.

The system requires users to follow up initial case entries with data on:

- Lab test request
- Lab test result
- Case status updates
- Contact tracing

Figure 2. Case tracking module (enrollment, status updates, lab, and contact tracing)

**Aggregate weekly data reporting** (see Figure 3 below): Data managers are required to submit aggregate weekly reports on the 20 reportable diseases and 4 additional epidemic-prone diseases (malaria, non-bloody diarrhea, severe pneumonia, and flu syndrome). When users do not submit reports on time, the eIDSR system sends them an automatic SMS reminder.

Figure 3. Aggregate weekly reporting of 24 diseases

Filter in section	Cases		Deaths	
	<5 years	5 years and above	<5 years	5 years and above
Diarrhoea - non bloody	4	5	0	0
Malaria	5	22	0	0
Pneumonia severe	0		0	
Flu syndrome	18	24	0	0

Filter in section	Cases		Deaths	
	Cases	Deaths	Cases	Deaths
Cholera	0	0		
Bloody Diarrhea (Shigellosis)	0	0		
Haemorrhagic fever	0	0		
Yellow Fever	0	0		

## Outbreak detection

The eIDSR system detects an outbreak when the number of suspected or confirmed cases in a district catchment area reaches one of the following thresholds, which vary according to disease:

**Numeric threshold-based detection:** the number of confirmed or suspected cases goes above a fixed threshold, determined by the RBC, based on WHO recommendations, disease severity, and other contextual factors.

**Seven-week mobile range detection:** current week cases are equal to or greater than two standard deviations above the weekly average for the previous seven weeks.

**Seasonal outbreak detection:** when comparing the weekly values for a window of  $m$  weeks with the same window over previous years (the greater number of years, the better), the current week value is greater than two standard deviations above the average for the previous window of values.

After reaching these outbreak thresholds, the system automatically creates a probable outbreak event (also using the tracker module of DHIS-2) and alerts users through email and SMS. When new cases are reported during a known outbreak, the eIDSR system prompts users to link cases with the existing outbreak. From that point on, all case data, lab confirmations, and patient status updates are automatically linked to this outbreak until it has officially ended.

## Data dashboards and visualizations

The eIDSR system features a user-customizable set of dashboards (see Figure 4 below), where general trends are visualized in maps, charts, and tables; the data are automatically updated as new reports are entered into the system. Users can also generate special reports on case definitions, outbreak thresholds, and public and private health facilities' compliance with reporting requirements.

Figure 4. Sample dashboard

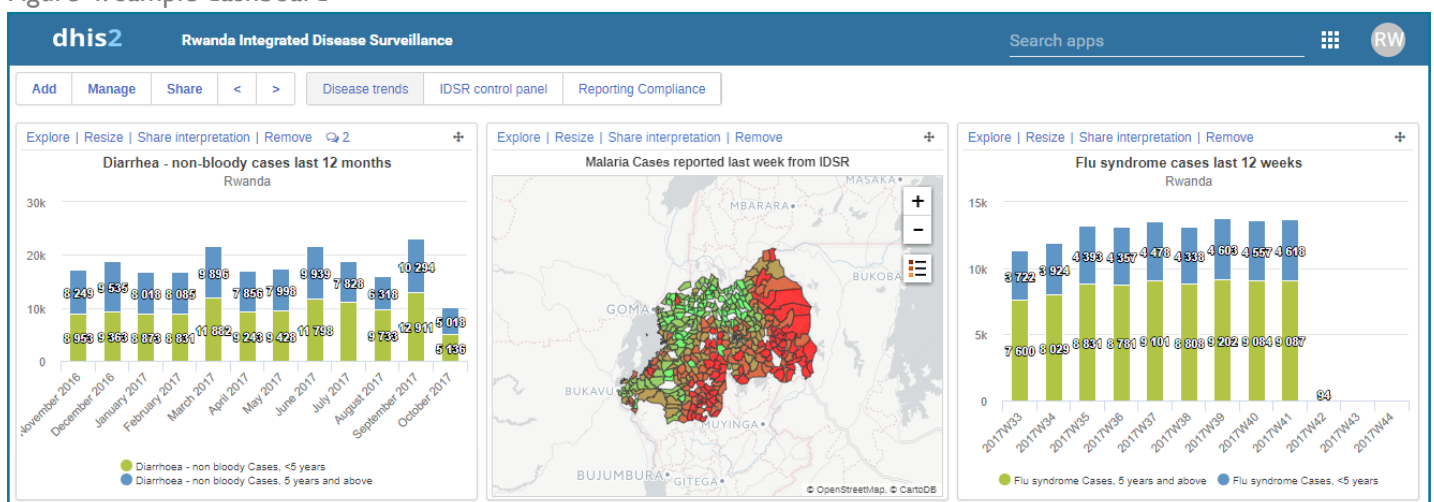


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## Results

Since 2015, the eIDSR system has identified an average of 530 probable<sup>8</sup> outbreaks per year. Surveillance teams investigated probable outbreaks, combining outbreaks for linked cases and rejecting others when suspected cases were not confirmed. From January to December 2016, the ESR Division confirmed and investigated 18 outbreaks nationwide.<sup>9</sup> Most of the outbreaks recorded, such as food poisoning and cholera, were related to conditions of poor hygiene. After central and district-level staff verified suspected cases by telephone or direct follow-up, they determined that the vast majority of probable outbreaks were false positives. In 2017, 13 out of 24 diseases accounted for almost all of the approximately 10,000 suspected cases reported to the eIDSR system in Rwanda; of these suspected cases, nine resulted in death.<sup>10</sup>

The eIDSR system is routinely capturing surveillance data on 24 diseases in near real-time, alerting health authorities to probable outbreaks and catalyzing investigation of suspected cases to confirm outbreaks. The substantial number of false positives indicates that users are submitting surveillance data, and the eIDSR system is detecting probable outbreaks, so health authorities can respond appropriately. Rwanda's MoH now has better data to strengthen preparedness and response when a true disease threat emerges.

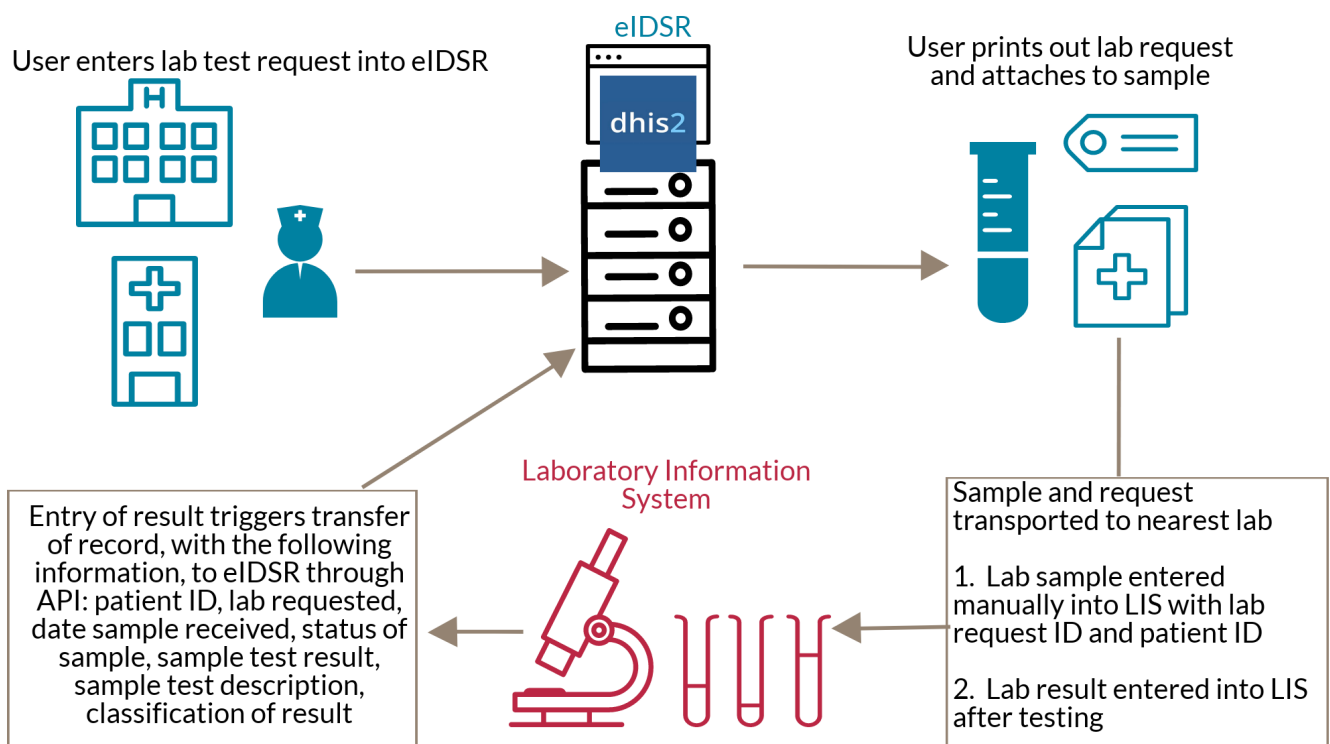
## Challenges and Lessons Learned

Throughout the design and implementation of the eIDSR system, the RHSS Project and ESR team have encountered several challenges, prompting creative solutions and resulting in the following lessons for continued maintenance of the eIDSR system and replication in other contexts.

**Build in automated data exchange with other systems.** Although the experience of implementing the eIDSR system has revealed a high level of compliance with reporting initial suspected cases, consistent follow-up has been less evident. For example, the eIDSR system does not automatically capture laboratory results. Therefore, the team is developing functionality that will enable the automatic transmission of laboratory results to the eIDSR system when they are entered into LabWare, the information system used at the National Reference Laboratory (see Figure 5 below for a proposed model of laboratory data exchange).

**Ensure DHIS-2 code and functionality are adaptable, and collaborate with the global community of DHIS-2 programmers.** The RHSS Project and ESR staff built the first version of the eIDSR system using custom code, which created challenges when upgrading to new versions of DHIS-2. DHIS-2 version 2.17 introduced changes in the programming

Figure 5. Proposed model of information flow between the eIDSR system and laboratory information systems



language, requiring programmers to rewrite all of the custom code in Angular Javascript, for which there is limited capacity in Rwanda. To overcome this challenge, the team engaged the help of experts within the global DHIS-2 community to incorporate many of the Rwanda eIDSR's special requirements, such as the three outbreak detection algorithms, into the core DHIS-2 system; now, these many of these features are available for other countries to use. Implementers should work closely with the DHIS-2 community to share blueprints and help build new functionality into the core software so others will benefit.

**Balance reporting requirements with the competing responsibilities of first-line responders.**

Requesting too much data often results in incomplete reporting. The RHSS Project team helps ensure that requests for specific types of information are necessary for disease surveillance and response; the team also carefully assesses the feasibility of imposing additional reporting burdens on busy first responders who are managing outbreak investigation and response.

**Implement automated feedback to improve the completeness of data.**

As part of the weekly reporting process, the Rwanda eIDSR system sends a reminder message to focal points who have not reported for their facility by the deadline. During the next phase of eIDSR development, similar functionality needs to be implemented to remind front-line workers when required follow-up data from specific case surveillance stages are not posted in time. For example, if a reported case of a serious epidemic-prone infection does not have a status updated for more than two days, then an SMS would be sent to the person who reported the case.

**Develop more decision-support products to translate evidence into action in real time.**

While the outbreak detection algorithms in the current system trigger alerts to take immediate actions, information sharing should be automated. For example, the ESR team pulls data from the eIDSR system to manually create the Weekly Epidemic Surveillance Bulletins that are posted on the RBC website. A standard reporting template would help automate publication of weekly bulletins in real time. Similarly, the situation report format is still very rudimentary and can be improved by including a hotspot map, an epi curve and case summary data.

**Record information on response when an outbreak is detected.**

While the DHIS-2 in its current form is capable of supporting most surveillance needs, it does not adequately capture response. For example, the 'outbreak module' does not track response measures. Users can upload an outbreak investigation report to the module, but it lacks specific fields for indicating who

is responsible for the investigation, what actions are recommended, which actions have been taken, and what additional resources are needed.

## The Way Forward

Rwanda's electronic disease surveillance and response system systematically captures data on 24 diseases in near real-time, alerting health authorities to probable outbreaks and catalyzing investigation of suspected cases to confirm outbreaks. The eIDSR also helps Rwanda comply with IHR disease reporting and capacity requirements for disease surveillance and response.

Rwanda's experience has demonstrated that the DHIS-2 platform can support most surveillance needs without major customization. As more countries adopt DHIS-2 for their routine health reporting systems, it will become an increasingly optimal platform for electronic disease surveillance and response.

Under the leadership of the ESR Division, the RHSS Project is helping to carry out the following next steps to enhance the eIDSR system:

### *Community engagement*

Community participation is critical for detecting unusual health events before they develop into public health crises. In its current form, the eIDSR system is designed for clinical providers, but MSH is building a community module to allow designated community members to enter information on unusual events, such as serious, unexplained illness, death of a group of people, and clusters of death or illness among animals from unknown causes. Serving as an early warning system, these community reports will be immediately available to decision-makers so they can act quickly to prevent the spread of disease and mitigate impact on human lives, the economy, and national security. MSH is working with eIDSR stakeholders to develop case definitions for unusual human and animal health events, a mobile application, and guidelines for community surveillance, preparedness and response. MSH is also leading operational research to assess the feasibility, effectiveness, and cost of implementation and to contribute evidence for the global adoption of the model.

### *Interconnectivity with other information systems*

MSH and the ESR team are working to link the eIDSR system with veterinary information systems, in accordance with the IHR and the One Health approach. Recognizing that the health of humans, animals and ecosystems are interconnected, One Health represents

a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate from the interaction between humans, animals, and their environments. Through information exchange with veterinary systems, the eIDSR system will alert health authorities to unusual animal disease and death, so they can take measures to prevent the spread of disease to human populations.

### *Interoperability with laboratory information systems*

The RHSS Project and the ESR team continue to work toward achieving full interoperability with the LabWare system so that lab requests and lab results are seamlessly integrated into the eIDSR system, and case data are up to date.

### *Mobile technology for real-time data collection*

MSH and the ESR team aim to equip surveillance officers with electronic tablets and/or smartphones to collect real-time data for the eIDSR system. The eIDSR system allows users to input data when offline, a particularly useful feature during active case investigation and contact tracing in villages that are outside the range of mobile networks. Once surveillance officers reconnect their tablet or smartphone to a mobile network or the Internet, data are automatically transmitted to the DHIS-2 servers.

### *Automatic updates to the RBC website*

As Rwanda's eIDSR reporting rates and data quality improve, the ESR team and MSH will have the opportunity to develop automated data portals to display weekly epidemic surveillance reports in real time on the RBC website, saving considerable effort for ESR staff.

### *Knowledge exchange*

To promote learning and the replication of similar electronic surveillance and response systems, MSH will continue to share knowledge of system adaptations and results as the eIDSR system is used over time. MSH will support the Rwanda ESR and HMIS teams to continue playing a leading role in the DHIS-2 disease surveillance community to help shape the functionality of future software versions and make new features widely available to all countries. ■



Photo by Todd Shapera

## Notes and References

- 1 World Health Organization. International Health Regulations (IHR) [http://www.who.int/topics/international\\_health\\_regulations/en/](http://www.who.int/topics/international_health_regulations/en/)
- 2 World Health Organization. Joint external evaluation tool: International Health Regulations (2005). Geneva: 2016. <http://apps.who.int/iris/handle/10665/204368>
- 3 HMIS, Annual Health Statistics Booklet 2016
- 4 The mobile health (mHealth) application TracNet collected real-time HIV/AIDS data using interactive voice response technology through any type of telephone.
- 5 Developed by the Health Information Systems Program (HISP) and managed by the University of Oslo, DHIS-2 helps governments and health organizations manage their operations more effectively, monitor processes, and improve communication. It is the preferred health management information system in 55 countries (as of 2017) across four continents. <https://www.dhis2.org/inaction>
- 6 Identification and follow-up with persons who may have been in contact with an infected person
- 7 Unstructured Supplementary Service Data (USSD) is a Global System for Mobile (GSM) communication technology that allows text exchanges between mobile phones and computer software. USSD is ideal for creating menu-driven user interfaces.
- 8 Case or outbreak that is not laboratory-confirmed and not epidemiologically linked to "confirmed" cases
- 9 Rwanda Health Statistics Booklet, 2016
- 10 Rwanda Epidemic Surveillance & Response Weekly Bulletins, RBC, Rwanda, 2017

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