World Health Organization

Investment case for vaccine-preventable diseases surveillance in the African Region

2020-2030

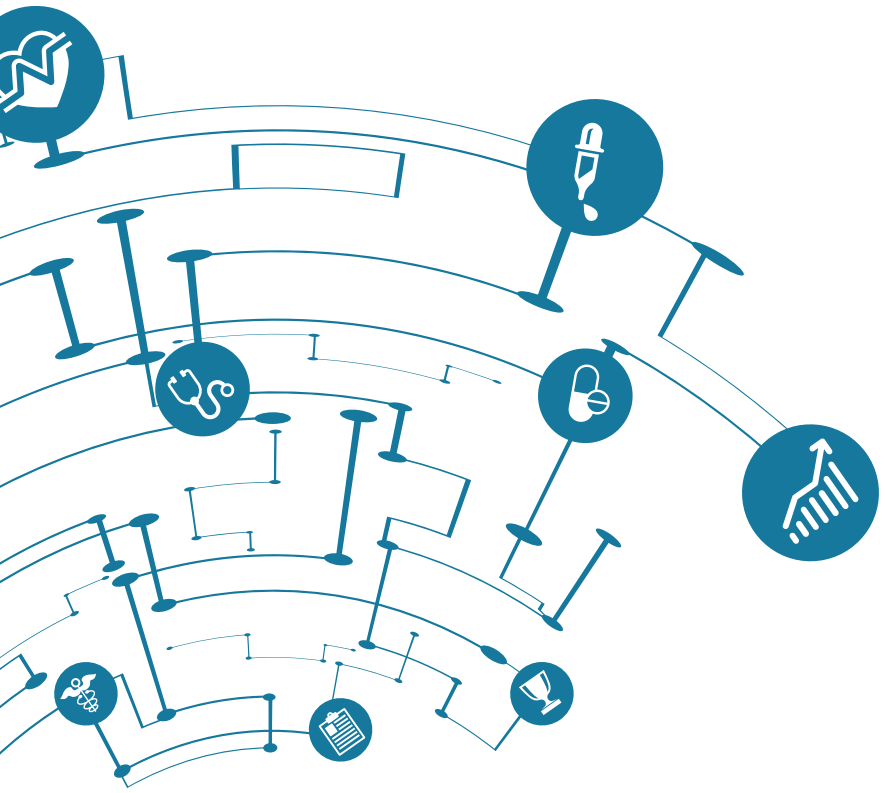
Investment case for vaccine-preventable diseases surveillance in the African Region, 2020–2030

ISBN: 978-929023438-8

Suggested citation. Investment case for vaccine-preventable diseases surveillance in the African Region, 2020–2030. Brazzaville: WHO Regional Office for Africa; 2019. Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Printed in the WHO Regional Office for Africa, Congo Republic.



Investment case for vaccine-preventable diseases surveillance in the African Region

2020–2030

TABLE OF CONTENTS

INTRODUCTION

Context of vaccine-preventable diseases surveillance in the African Region

In January 2017 the Addis Declaration on Immunization (ADI) *(1)* was endorsed by Heads of State from across Africa at the 28th African Union Summit. One of the 10 ADI commitments aims at "Attaining and maintaining **high quality surveillance for targeted vaccine-preventable diseases**".

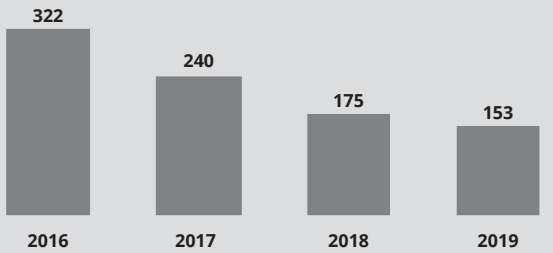
As the African Region embarks on implementing the ADI roadmap *(2)*, availability of high-quality surveillance data is critical to drive strategic decision-making for immunization programmes.

In response to the Ebola Virus Disease (EVD) outbreak in West Africa the Global Health Security Agenda (GHSA) *(3)* recommended the **strengthening of health security** and having **flexible surveillance systems** by implementing the International Health Regulations (IHR, 2005) *(4)*.

In the African Region surveillance of vaccine-preventable diseases (VPDs) is implemented in the context of the Regional Integrated Disease Surveillance and Response (IDSR) *(5)* strategy. WHO developed the IDSR approach for improving public health surveillance and response by linking community, health facility, district and national levels. The IDSR promotes the rational and efficient use of resources by **integrating and streamlining common surveillance activities**.

For the past two decades VPD surveillance in the African Region has been heavily supported by funding from the Global Polio Eradication Initiative (GPEI) *(6)*. However, as the GPEI draws closer to eradicating polio, its budget has decreased substantially and will continue to decrease further in the coming years.

GPEI budget for African Region *(7, 8)*
2016–2019 ($ million)



The **closing of the GPEI presents important risks for the VPD surveillance system in the Region** if funding streams to support VPD surveillance are not identified. The GPEI recognizes **surveillance as one of the essential functions** that will need to continue even after global polio certification. Funding for VPD surveillance (e.g. measles, new vaccine / sentinel surveillance for rotavirus, invasive pneumococcal diseases) has declined markedly over the past two years. Furthermore, by 2030, in addition to the phasing out of the GPEI most countries will also **transition out of receiving support from Gavi** *(9)*.

Context

In June 2017 the Regional Immunization Technical Advisory Group (RITAG) recognized the "polio post-certification strategy as an **opportunity to reconsider the current and future priorities for [...] VPD surveillance** in the African Region" *(10)*. As such, the RITAG recommended that "WHO Regional Office for Africa (AFRO) works with Member States on a **regional Investment case** that details the budget required to support the **core laboratory and epidemiology surveillance activities** that address new and existing priority VPD threats" *(10)*.

In May 2018 the WHO Regional Offices for Africa and Eastern Mediterranean presented the WHO Business Case for immunization activities on the African continent *(11)* during the 71st World Health Assembly *(12);*

Sources: 1- ADI, 2016; 2- ADI Roadmap, 2017; 3- GHSA Framework, 2018; 4- IHR, 2005; 5- IDSR Technical Guidelines; 6- GPEI website, 2018; 7- WHO, Polio Transition Planning, 2017; 8- WHO AFRO, Budget dashboard, 2017; 9- Gavi website, 2018; 10- RITAG Report, 2017; 11- Business case for WHO immunization activities on the African Continent, 2018; 12- 71st World Health Assembly, 2018.

this emphasized the importance of a **country-led and tailor-made approach** to the development of immunization and VPD surveillance activities. **VPD surveillance was identified as a key component** to strengthening national immunization systems.

Therefore the investment case for VPD surveillance is a **continuation of the WHO Business Case for immunization activities on the African continent**, and should contribute to **accelerating the effective implementation of the IHR 2005** *(4)* **in all countries** through development of an **early-warning function** integrated into a sensitive and flexible surveillance system and improve the overall health of the population.

Aim and rationale

The investment case for VPD surveillance aims to reinforce **Member States ownership, strengthen coordination and articulate VPD surveillance within a broader disease surveillance system.** It also highlights a holistic approach to better take into account community based surveillance, preventive promotive services, zoonotic diseases and vector control, but also the role played by non-medical determinants such as information, education or climate change.

This document addresses four main issues:

- The Member States aim to meet Global Vaccine Action Plan 2011-2020 (GVAP) *(13)* and Regional Strategic Plan for Immunization 2014-2020 (RSPI) *(14)* targets, and the fifth ADI commitment to attain and maintain high-quality surveillance for targeted VPD,
- The VPD surveillance system should be maintained and reinforced in the post-polio eradication era in the African Region to respond appropriately to emerging public health threats and adapt rapidly to changing technologies,
- The need to address emerging and existing VPD public health risks and the increasing threats of AMR, and
- The urgent need for all institutions, establishments and organizations in the African Region to address health security issues through an effective implementation of the GHSA.

Content

Following the RITAG's recommendation, WHO embarked on the development of this investment case to support Member States.

Through this work, WHO is communicating a bold vision and ambition for VPD surveillance in the African Region for 2020–2030.

The document covers five main sections:

- A **situation analysis**, demonstrating that VPDs remain a major threat to the African Region which require significant investments to strengthen national surveillance systems and laboratory networks,

- A **maturity grid and country categorization**, highlighting the disparity between countries in terms of maturity, and promoting a **tailor-made approach** for countries to increase ownership and performance of their national surveillance systems and laboratory networks,

- An **ambition for 2030** stating a clear aim, objectives, key performance indicators (KPIs) and targets defined by Member States for their VPD surveillance systems and laboratory networks,

- A focus on the **strategic importance of VPD surveillance and some value-added activities,** demonstrating that Member States can leverage their existing surveillance and laboratory infrastructure better in order to get more value from their systems, and

- A focus on **new technologies and innovations for VPD surveillance,** demonstrating that there is a clear opportunity to make a technological leap.

The document covers the period **2020–2030,** and the scope covers **all existing VPDs**, including those for which new vaccines will become routinely available in future (e.g. for malaria, EVD, Chikungunya), and encompasses the following activities:
Case-based surveillance,

- Sentinel site surveillance,
- Community based surveillance (CBS),
- Aggregate surveillance, and
- Diagnostic laboratory networks.

Following this work, the next steps are being considered:

- develop national investment cases with a number of selected countries
- provide a standardized approach and toolkit to support countries in developing their own investment cases for VPD surveillance

Sources: 4- IHR, 2005; 13- GVAP 2011-2020, 2013; 14- RSPI 2014-2020, 2015.

OVERVIEW

Section one examines the current situation of vaccine-preventable diseases surveillance in the African Region.

With more than thirty million children under-five suffering from vaccine-preventable diseases (VPDs) every year in Africa, VPDs remain a major threat, requiring significant investments in surveillance systems and laboratory networks in the African Region.
In line with the recommendations of the IHR 2005 and the Regional IDSR strategy, the RSPI 2014-2020 promoted sensitive and high-quality surveillance tools, including laboratory confirmation of pathogens. For the past two decades the GPEI has made a significant contribution to the development of VPD surveillance systems across the continent and disease-specific laboratory networks were also created by Partners to support other elimination and disease-control initiatives and objectives.
However VPD surveillance expenditure remain low in the African Region, as reported in countries comprehensive Multi-Year Plans. Most countries did not report having a dedicated budget for laboratory reagents, overheads and personnel costs. The total funding gap was estimated at $16.7 million per year, representing 26% of the total needs.
Currently, countries in the African Region face major challenges in both the strategic planning and operation of their surveillance systems: fragmentation, lack of public resources, difficulties in harnessing the power of community-based surveillance, disease-specific approach, difficulties with staff retention and training, and transportation issues. By 2030 the complexity and demand for VPD surveillance is expected to widen. In collaboration with partners the countries are developing plans to improve their health security capacity, including surveillance and laboratory networks.

Section two presents an immunization maturity grid and a country categorization designed to help countries identify a tailored plan for improving their VPD surveillance systems.

Six components have been identified for improving VPD surveillance systems including laboratories: Governance and management, Standard setting for surveillance, Surveillance process and reporting, Laboratory network, Specimen management and Detection and response.

Based on these components, a maturity grid was developed to help countries identify a tailored path for improving VPD surveillance systems including laboratories. 47 countries in the African Region were assessed using the maturity grid and grouped into four categories on a scale from 1 (low maturity) to 4 (high maturity). This tool should help all countries in the African Region to reach a satisfactory level of maturity (levels 3 and 4) since each country can get a clear understanding of its maturity over the six components and will be able to adopt an approach that is tailor-made according to its maturity levels, in order to strengthen its surveillance system and laboratory network. Over time countries will repurpose their efforts as they advance on the maturity scale.
Milestones have been defined to serve as intermediary objectives toward the 2030 targets and governance mechanisms will have to be implemented at country level to facilitate monitoring and evaluation.

Section three sets a new ambition for 2030 and presents its impact in terms of lives saved, cases averted and economic benefits.

All countries in the African Region have committed to universal immunization coverage and high-quality surveillance but there are still challenges and barriers in achieving RSPI targets in the African Region. Strengthening surveillance systems and laboratory networks is an opportunity to accelerate efforts towards achieving RSPI targets and beyond. This work sets an ambition for 2030 with a clear aim. Objectives, KPIs and specific targets for 2030 have been defined for each surveillance component. Each objective has been defined to enable countries to assess their performance according to a common framework. KPIs and targets for 2030 have been assigned to each objective. Reaching this ambition for 2030 will save at least 710,000 lives, avert close to 20.7 million cases and save $21 billion over ten years. The return on investment is estimated to be 44.6 fold. However if current VPD surveillance efforts are not maintained, there is a risk to reverse progress made, leading to more than 900,000 deaths and additional costs of $22.4 billion.

Section four illustrates the importance to have strong VPD surveillance systems through a surveillance value framework.

Surveillance activities are essential to detect and respond early to risks and outbreaks to mitigate their impact on national security, the local economy and public health. African countries must develop more advanced functions to capture the added value of their surveillance systems and laboratory networks better. While the initial costs for basic surveillance functions are high, additional investments for more advanced functions are low and lead to high-value and ROI. Establishing a surveillance system and laboratory network from the very beginning entails high investment and operating costs. In comparison, the development and implementation of more advanced surveillance functions in countries which already have functioning systems represents a lower investment and will lead to high value and ROI in terms of health and economic benefits.

Section five presents, for illustrative purposes only, a non-exhaustive list of technologies and innovations that have had, so far, concrete impacts on the six components of VPD surveillance.

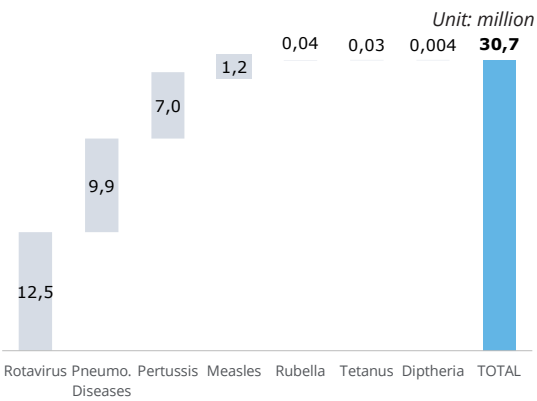
Mobile technologies have been one of the first driver of change in VPD surveillance over the last years. In Africa 80% of the population is expected to have a mobile phone by 2020. Technologies such as geographic information systems (GIS) make it easier to study trends, outbreaks and immunization. New approaches such as Internet- based surveillance have emerged to harness the power of big data. Event-Based Surveillance systems combine high computing capabilities with real-time multi-channel analysis of data sources. Once a case has been investigated a specimen is taken for laboratory confirmation. Several specimen transport techniques have been developed. The African Region has the opportunity to make a technological leap in laboratory techniques. Point of care testing is helpful for rapid confirmation, management and containment of cases. Capacity building is critical for the efficiency of surveillance networks, and e-learning could facilitate access to VPD surveillance training. Once sensitized the community is a valuable source of information able to fill gaps in surveillance. Performance-based financing can boost efficiency of surveillance systems by providing incentives. Outbreak insurance will help countries prevent pandemic risks during an outbreak through a fast-disbursing financial mechanism.

SECTION 1:
SITUATION ANALYSIS

VPDs remain a major threat to Africa, requiring significant investments in surveillance systems and laboratory networks

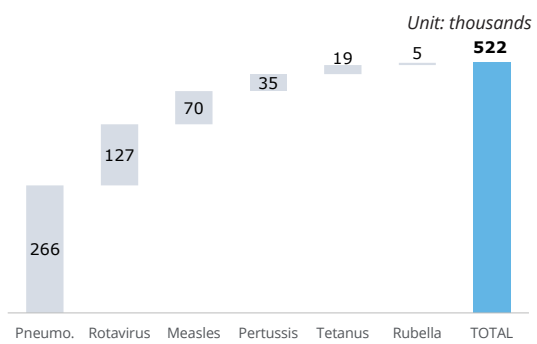
More than 30 million children on the African continent who are under the age of five years suffer from VPDs every year *(15-20)*.

Estimated under-five cases per VPD in Africa*, 2015 *(15-20)*



Of these children over half a million die from VPDs every year due to limited access to immunization services *(15-24)*.

Estimated under-five deaths per VPD in Africa, 2015** *(15-24)*



The African Region has included elimination and control goals against major VPDs and intensive laboratory supported disease surveillance as critical elements of its strategic plan for immunization

In 2014, in line with the recommendations of the IHR 2005 *(4)* and the Regional IDSR strategy *(5)*, the RSPI 2014-2020 *(14)* promoted sensitive and high-quality surveillance tools linked to the IDSR platform, including laboratory confirmation of pathogens.

> *"By 2020 the capacity of surveillance systems and the scope of work of laboratory services will have expanded to meet evolving needs of the immunization programme, including needs resulting from the introduction of new vaccines or new technologies, or the launching of new initiatives"*
>
> RSPI 2014-2020 *(14)*

For the past two decades the GPEI has made a significant contribution to the development of VPD surveillance systems across the continent

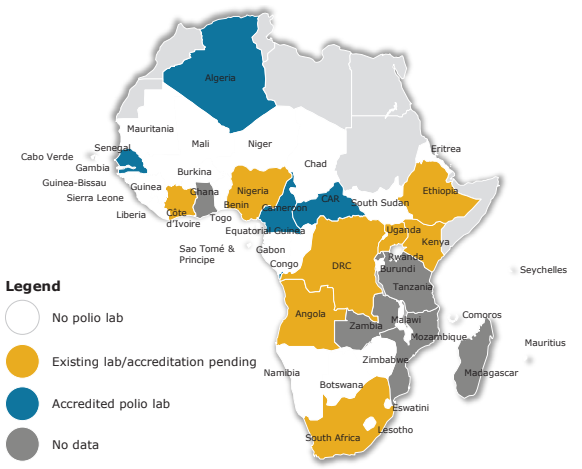
VPD surveillance in the African Region has been strongly supported by funding from the GPEI. The Global Polio Laboratory Network (GPLN) *(25)* was established in 1993 by GPEI and various governments. It consists of 146 WHO accredited polio laboratories (16 laboratories in the African Region) processing over 220,000 stool specimens and more than 8,000 sewage specimens a year. In Africa the percentage of adequate stool specimens that are collected is 95% (2016).

Sources: 15- MCEE, WHO, 2016; 16- Model Univac, 2016; 17- World population prospects, 2017; 18- Global Health Data Exchange, 2017; 19- Ibinda et al., Plos ONE, 2015; 20- Van Den Ent et al., 2012; 21- Disease burden estimates, WHO, 2016; 22- Martinez-Quintana et al., Rev Panam Salud Publica, 2015; 23- Zhou et al., The Journal of Infectious Diseases, 2004; 24- Child Causes of Deaths, WHO, 2017; 4- IHR, 2005; 5- IDSR Technical Guidelines; 14- RSPI 2014-2020, 2015 25- GPEI Fact Sheet, 2018.
Notes: * Tetanus incidence for under-fives computed based on fatality rate (~60%) and total number of deaths for under-five (i.e., 49000) ; Rubella (CRS) estimates from 2008 using the medium interval; ** Pneumococcal mortality recomputed based on 2008 figures as proportion of acute respiratory infections deaths. Rotavirus mortality was based on 2013 data. CRS mortality was estimated using 2008 incidence and probability of live-birth death (figure extracted from a US publication, therefore most likely underestimating number of deaths in Africa).

Thanks to the GPEI and GPLN, polio has almost been eradicated:

- Polio cases dropped by 99.9% globally since 1988,
- Two out of three wild polio strains seem to have been eliminated,
- Polio remains endemic in only one country in Africa (i.e. Nigeria, last case seen in 2016),
- Polio eradication will generate savings of $50 billion globally over the next 20 years, garnered from health systems and burden of disease benefits.

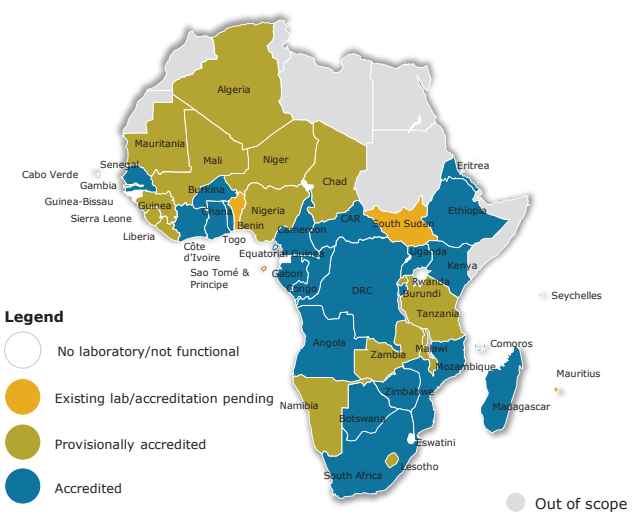
Polio Laboratory Network, 2018 *(26)*



Disease-specific laboratory networks were also created by Partners to support other elimination and disease-control initiatives and objectives

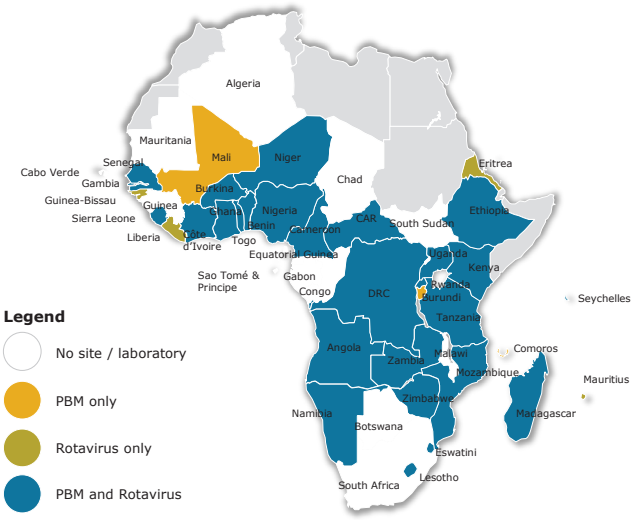
The Global Measles and Rubella Laboratory Network was established in 2000 and consists of 49 laboratories in 44 countries in the African Region *(27)*.

Measles and Rubella Laboratory Network, 2018 *(27)*



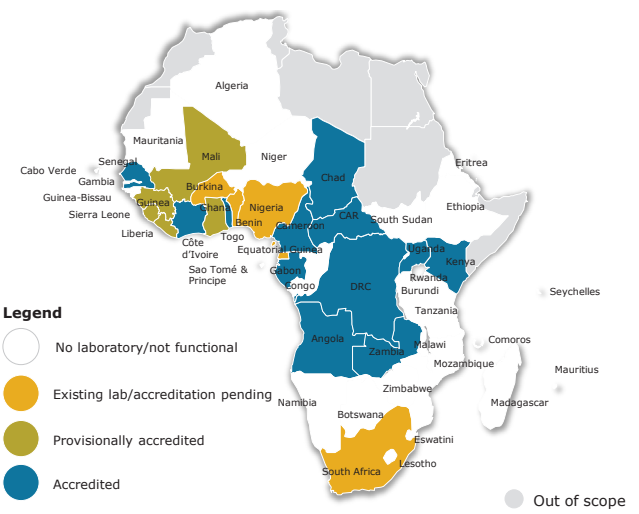
The Paediatric Bacterial Meningitis and Rotavirus Laboratory Networks were established in 2001 and consist of 32 sentinel site laboratories in the African Region *(28)*.

Paediatric Bacterial Meningitis and Rotavirus Laboratory Networks, 2018 *(28)*



The Yellow Fever Laboratory Network consists of 21 laboratories in the African Region *(29)*.

Yellow Fever Laboratory Network, 2018*



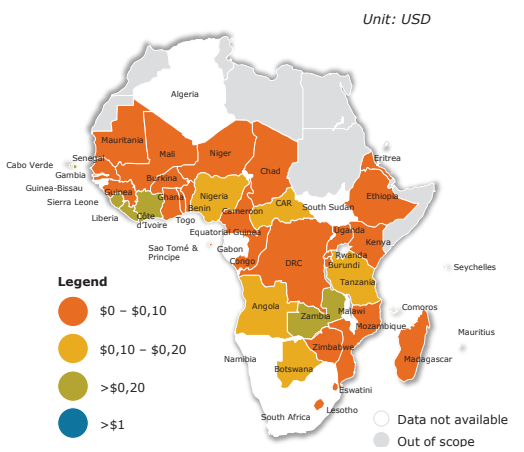
Sources: 26- GPLN, GPEI, 2018; 27- GMRLN, WHO, 2018; 28- PBM Surveillance in Africa, CDC and WHO, 2018; 29- Garske et al., PLoS medicine, 2014.
Note: * Based on WHO Internal expertise, 2018.

VPD surveillance expenditure remain low in countries from the African Region, as reported in their comprehensive Multi-Year Plans

In order to forecast their expenditure for immunization and surveillance activities better, countries in the African Region use comprehensive Multi-Year Plans (cMYPs). Hossein et al. (2018) *(30)* analyzed VPD surveillance expenditure on detection and notification, case and outbreak verification and investigation, data management, laboratory and supportive activities.

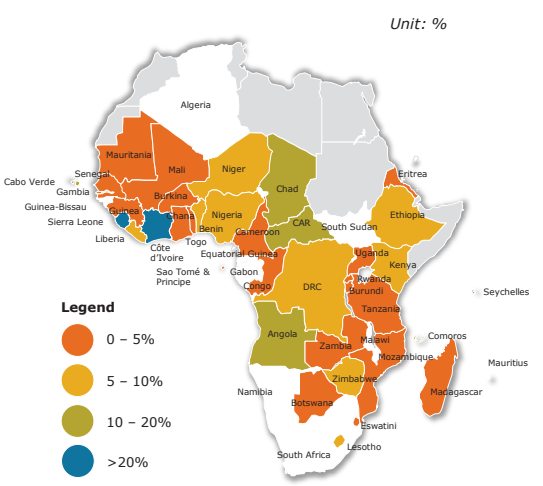
Excluding personnel costs, their analysis shows that **not a single country in the African Region spent more than $1 per capita per year** on VPD surveillance-related activities in 2015. Most of these funds come from donors contributions. Based on countries' cMYPs for 2017, almost 86% of the available funding comes from partners *(31)*.

VPD surveillance expenditure* per capita, 2015 *(30)*



Only **eight countries in the African Region spent over 10% of their routine immunization (RI)** expenditure on surveillance activities.

VPD surveillance expenditure* as a percentage of RI expenditure, 2015 *(30)*



Most countries in the African Region did not report having a dedicated budget for laboratory reagents, overheads and personnel costs

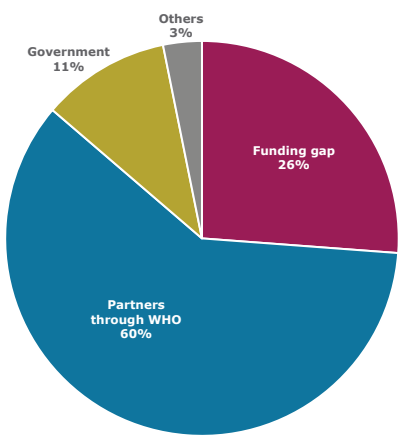
While 76% of countries explicitly budgeted for surveillance personnel in 2015, only 37% reported dedicated expenditure for laboratory personnel, 22% for overheads and 14% for laboratory reagents *(30)*.

Costs for which countries explicitly reported a dedicated budget* *(30)*

Surveillance cost category	% of countries
Laboratory reagents	14%
Laboratory overheads	22%
Laboratory personnel	37%
Surveillance-specific transport	51%
Equipment and supplies	57%
Surveillance-specific personnel	76%

The total funding gap was estimated at $16.7 million per year, representing 26% of the total needs

Disease surveillance* funding sources, 2017 *(31)*
for 36 countries in the African Region



The share of Government funding was also very low, covering 11% of the total needs expressed ($6.7 million). However, these results may not describe the actual situation with sufficient precision for several reasons: (i) data entry is declarative, (ii) it does not take into account wages and perdiem for surveillance staff*, (iii) forecasts are made using linear assumptions based on expenditures that occurred during the baseline year, (iv) the baseline year's expenditures may be over or underestimated depending on whether a VPD outbreak has occurred, and (v) baseline years vary across countries, thus limiting comparability.

Sources: 30- Hossein et al., Vaccine, 2018; 31- Costing tools for cMYPs, 36 countries, 2017.
Note: * VPD surveillance expenditure as expressed in cMYPs only takes into account the following items detection and notification, case and outbreak verification and investigation, data management, laboratory and supportive activities.

Countries in the African Region face major challenges in both the strategic planning and operation of their surveillance systems

Countries in the African Region face a series of challenges with their surveillance systems*, as outlined below.

Fragmented systems

- Regional IDSR strategy outlines the standards, but funding and coordination of VPD surveillance systems are fragmented (e.g. disease-specific systems, multiple departments/units, health facilities vs laboratories vs communities).
- Most of the time these organizational units (e.g. programmes, laboratories, health facilities) work in silos leading to issues around communication, data reconciliation, process harmonization and the like.

Lack of public resources

- All countries have developed surveillance systems based on public health facilities and laboratories.
- However, private laboratories and independent research institutes exist in most countries but are not leveraged for VPD surveillance (e.g. polymerase chain reaction (PCR) core capacity exists in 35 countries).

Difficulties in harnessing the power of community-based surveillance

- CBS allows early detection, access to remote areas and increased population awareness, prevention and containment.
- CBS is still weak in most countries in the African Region due to political and operational factors including training, logistics, telecommunications, high number of false cases reported, and costs (manpower intensive).

Vertical (disease-specific) approach

- Most programmes and strategies are disease-specific, like the GPEI, Measles and Rubella Initiative or Eliminating Yellow Fever Epidemics.
- Most of the surveillance efforts and investments are focusing on these diseases, resulting in funding discrepancies between programmes, inadequate surveillance of some diseases (e.g. pertussis, hepatitis B, cholera) and lack of transversal communication and coordination.

Difficulties with staff retention and training

- Governments and public health officers observe a high turnover of qualified human resources for health (HRH) (e.g. laboratory staff, surveillance officers, Expanded Programmes on Immunization (EPI) managers).
- Staff retention in "hard to reach" or conflict areas is still a major challenge, even though these may be reservoirs of VPDs.
- Elimination/eradication programmes require the recruitment and training of field epidemiologists, proactive surveillance officers and "disease detectives".
- Surveillance is not a prominent part of the pre-service medical curricula. There is a need to build upon existing training programmes such as the Field Epidemiology Training Programme or Training Programmes in Epidemiology and Public Health Interventions Network.

Transportation issues

- Transportation of specimens (e.g. measles, yellow fever) relies on the GPEI cost reimbursement mechanism and partially depends on the polio funding and incentive scheme. The later can also hamper clinical specimen collection for other diseases.
- Transportation and logistics remain a major challenge due to bad infrastructure (e.g. roads, railways, post offices) and lack of equipment (e.g. vehicles, motorbikes, fuel and lubricants, generators to maintain reverse cold chain).
- Countries experience difficulty in finding reliable and quality transportation companies, especially for cross-border shipments of specimens due to quality control requirements. Since the EVD outbreak some courier companies refuse to transport hazardous clinical specimens.

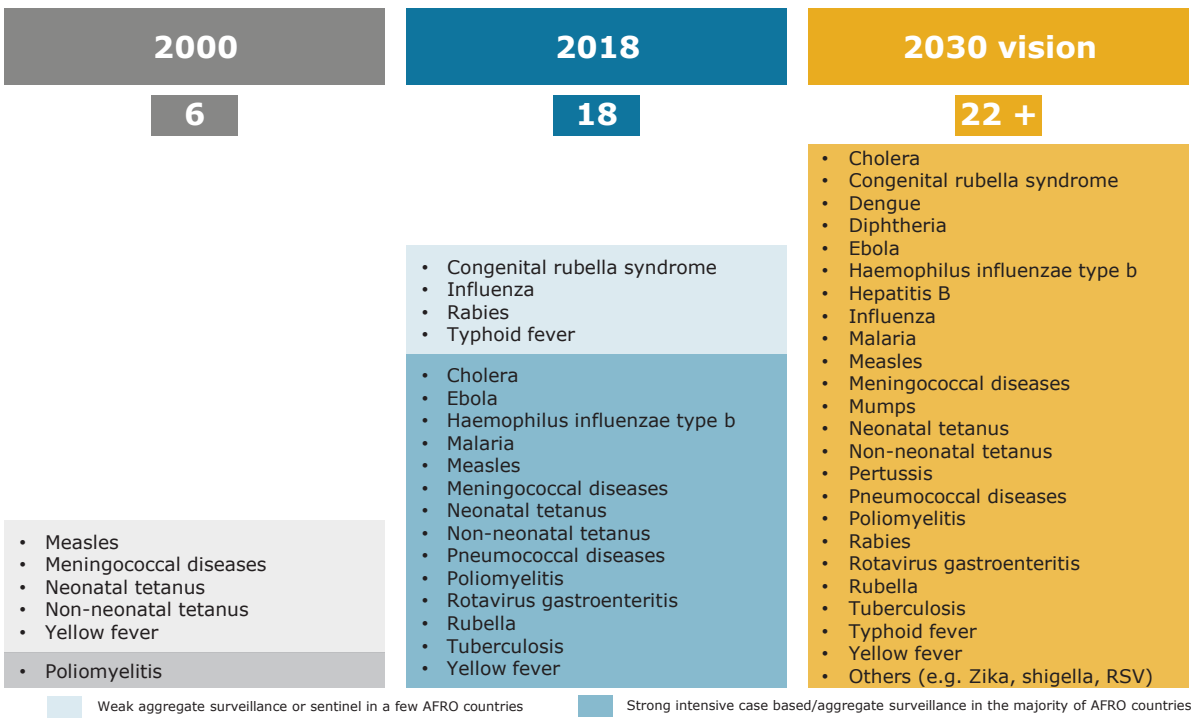
Note: *Base on one-on-one interviews with more than 70 surveillance officers from Ministries of Health, WHO staff and partners, July–August 2018.

By 2030 the complexity and demand for VPD surveillance is expected to widen

The number of VPDs under surveillance has risen from 4 diseases to at least 15 diseases in many countries between 2000 and 2018. These target diseases are expected to increase by 2030.

In addition, the need for sensitive surveillance will increase in order to accelerate the achievement of VPD programmes' objectives.

Evolution of the scope of VPD surveillance activities in the African Region, 2000–2030*



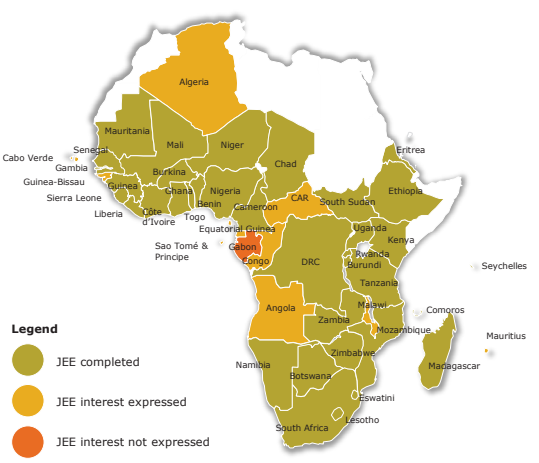
In collaboration with partners the countries are developing plans to improve their health security capacity, including surveillance and laboratory networks

In the context of strengthening countries' capacity to implement the IHR 2005 *(4)*, WHO is leading a joint external evaluation (JEE) exercise on countries' core surveillance capacities. Thirty-seven countries have completed a JEE; only one (Gabon) expressed no interest in performing a JEE *(32)*.

A JEE is a voluntary, collaborative, multisectoral process to assess the capacity of a country to prevent, detect and rapidly respond to public health risks. JEEs include surveillance and laboratory-specific indicators.

Of the 37 countries, none had sustainable capacity (grade 5/5) for 11 of the 13 JEE indicators related to detection**. Most of them had at best "developed capacity" (grade 3/5). However, 19 countries subsequently developed National Action Plans on Health Security (NAPHS) to strengthen their capacity, including immunization and VPD surveillance (including laboratory networks).

JEEs completed and planned, July 2018 *(32)*



Source: 4- IHR, 2005; 32- Talisuna, WHO, 2018, Kigali, Rwanda.
Note: * Based on WHO Internal expertise, 2018. ** Workforce, reporting, real time surveillance and national laboratory system

SECTION 2:
MATURITY GRID AND COUNTRY CATEGORIZATION

Six components have been identified for improving VPD surveillance systems including laboratories

Given the current situation and the variability of VPD surveillance systems and laboratory networks in the African Region, six components were identified as common and stable areas for assessment and future improvement.

Governance and management

- Governance (e.g. supranational, national, sub-national, district) and accountability,
- Legal framework, strategic planning and system design,
- Financial management, resource management and relationships with partners, and
- Coordination (e.g. EPI and surveillance programmes, emergencies and disease control).

Standard setting for surveillance

- Setting of standards, norms and guidelines,
- Communication, training, coordination, networking and mentoring (including for CBS),
- Compliance with guidelines, standard case definitions, procedures and tools, and
- Monitoring and evaluation, including quality management.

Surveillance process and reporting

- Heath facilities acting as reporting sites (e.g. population coverage, silent areas),
- Health workers and communities (community based surveillance) trained and/or sensitized,
- Case detection, notification, investigation, confirmation and response, and
- Data management, quality data, reconciliation, analysis and decision-making.

Laboratory network

- Staff trained according to standardized protocols,
- Quality controls and accreditations,
- Equipment (e.g. ELISA, PCR, etc.), reagents (e.g. kits, strips) and supplies (e.g. slides, tubes), and
- Laboratory bio-containment and bio-security, access and risk management.

Specimen management

- Specimen collection, packaging, transportation and payment,
- Transportation system performance (e.g. volume, quality, timeliness),
- Storage, reverse cold chain and security protocols, and
- Transportation equipment (e.g. vehicles, fuel and lubricants) and supplies (e.g. specimen collection kits).

Detection and response

- Epidemic preparedness (e.g. plans, stockpiling, isolation facilities),
- Outbreak detection, confirmation, risk mapping, assessment and mitigation plans,
- Emergency response performance (e.g. emergency operation center (EoC) set up, staff mobilization, containment), and
- Community awareness and communication strategy.

A maturity grid was developed based on the six components identified for improving VPD surveillance systems including laboratories

In order to assess the maturity and performance of a country's surveillance system and laboratory network a four-level maturity grid was developed for the six components.

Each component's level of maturity is defined and rated from 1 to 4, with level 1 referring to low maturity and level 4 to the highest level of maturity. Levels 2 and 3 indicate the movement towards high maturity.

The maturity grid defines the ability of a country to plan, design, fund, implement, operate, monitor and evaluate its surveillance system and laboratory network efficiently. A thorough assessment across all six components was carried out to gauge the capacity of countries to move from a weak to a strong level of functioning. Results from JEEs have been used as inputs in the methodology.

VPD surveillance and laboratory maturity grid*

Maturity	Governance and management	Standard setting for surveillance	Surveillance process and reporting	Laboratory network	Specimen management	Detection and response
4	Strong country ownership. Local funding. Coordination with EPI. Use of data and little reliance on partners	Strong guidance and standards setting from national level for implementation and monitoring of surveillance activities	Surveillance performance in accordance with standards. Strong local capacity	VPD surveillance laboratories accredited. Strong laboratory performance. Good coordination with EPI programme and data harmonized with the surveillance programme	Good quality of specimens. Timely arrival at laboratory	Strong political and operational readiness. Good coordination among local stakeholders
3	Surveillance governance, legal framework and enforceable regulation in place. Surveillance activities budgeted and mainly self funded	Guidelines and standards developed with the support of partners. Training sessions organized. Basic monitoring in place	Surveillance performance in accordance with most standards. Good local capacity	Most VPD laboratories accredited. Good laboratory performance. Good coordination with EPI programme. Few gaps in data harmonization	Most specimens arrive on time and with good quality	Good political readiness but some operations are relying on partners. Coordination with local stakeholders
2	Weak governance of surveillance. Strategic planning and management activities assisted by partners. Mainly dependent on external funding	Guidelines and standards under development with the support of partners. Field staff not trained. Monitoring led by partners	Surveillance performance in accordance with few standards. Ongoing field capacity building	Few VPD laboratories accredited. Laboratory performance in construction. Gaps in coordination and in data harmonization with the surveillance programme	Few specimens arrive on time and with good quality	Political and operational readiness depending on partner's leadership. Design of coordination mechanisms with local stakeholders with the support of partners
1	Very poor government ownership. Surveillance not a priority. No local funding	Weak guidance and standards setting from national level, huge disconnect between national policies and field implementation	Major gaps in surveillance capacity and performance. Weak support for field activities from national level	VPD surveillance labs not accredited/provisionally accredited. Weak lab performance. Gaps in coordination and in data harmonization with the surveillance programme	Major gaps in specimen quality and timeliness of specimen arrival at laboratory	Lack of political and operational readiness. Poor coordination among local stakeholders. Dependence on partner resources

Note: * Based on WHO, Internal expertise, 2018.

47 countries in the African Region were assessed using the maturity grid and grouped into four categories on a scale from 1 (low maturity) to 4 (high maturity)

Based on this assessment countries have been grouped into four Categories, highlighting the level of effort needed to develop functioning surveillance systems and laboratory networks.

Category One refers to countries with a weak surveillance system (including laboratory network) with major gaps across multiple components.

Category Two refers to countries with significant deficiencies in their surveillance system and laboratory network. These countries have deficiencies in several components, including the Surveillance process and reporting component.

Category Three refers to countries with some deficiencies in their surveillance system and laboratory network. These countries have a relatively good performance in the Surveillance process and reporting component.

Category Four refers to countries with strong surveillance systems, and may have targeted areas for improvement. These have the ability to plan, implement, monitor and evaluate surveillance and laboratory networks and quality data.

The methodology is presented in Annex A.

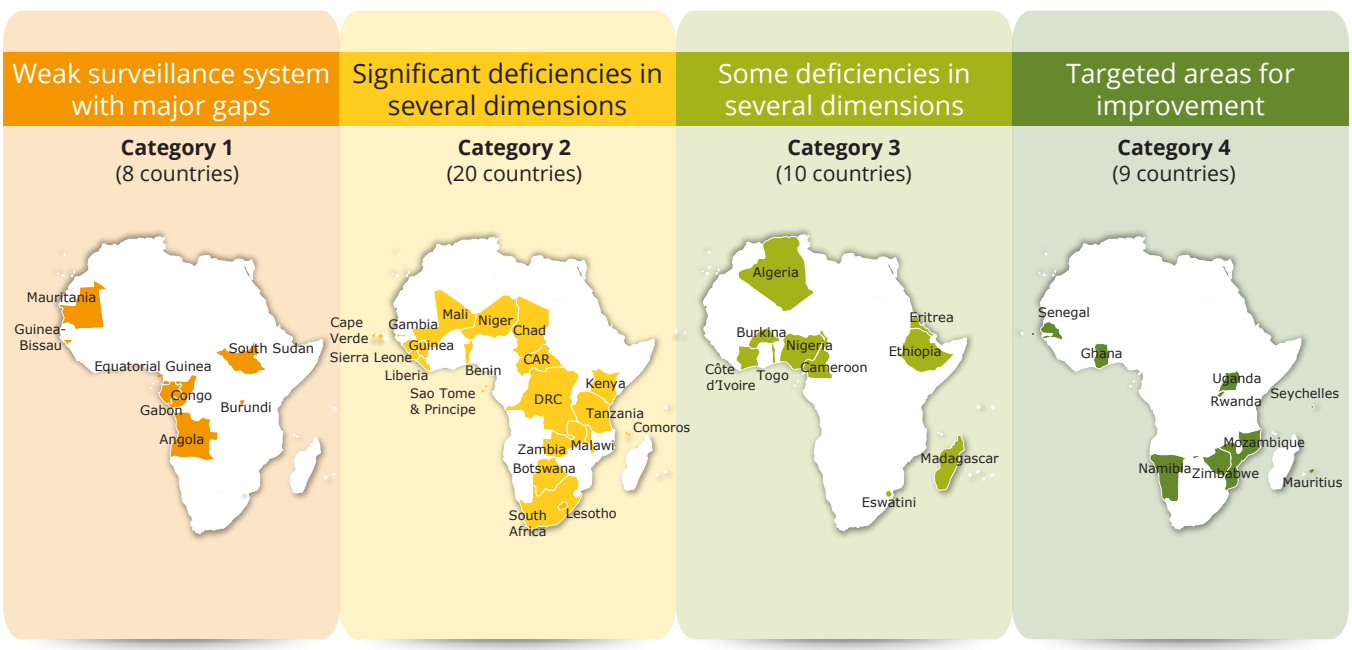
By 2030 all countries in the African Region will reach a satisfactory level of maturity (levels 3 and 4)

As of the end of 2018, based on the maturity grid, 28 countries in the African region had weak surveillance systems (Categories 1 and 2), with persistent deficiencies across several dimensions, including the surveillance process and reporting.

A clear target was defined for each component for 2030. These targets will be shared among Member States to serve as a common platform to inform technical support from all stakeholders.

These targets will promote the empowerment of countries so that they may develop sustainable, effective, cost-efficient and quality-oriented surveillance systems and laboratory networks.

Country categorization*

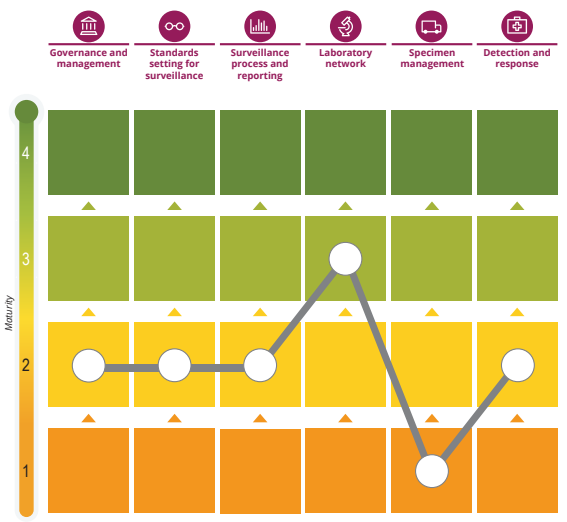


Note: * Based on WHO, Internal expertise, 2018.

Each country can get a clear understanding of its maturity over the six components

Country A has been assessed as a Category 2 country, with gaps in Specimen management, Surveillance process and reporting as well as in Governance and management components.
As a result the Government of Country A will adapt its strategy and investments to deploy activities to address these specific shortfalls.

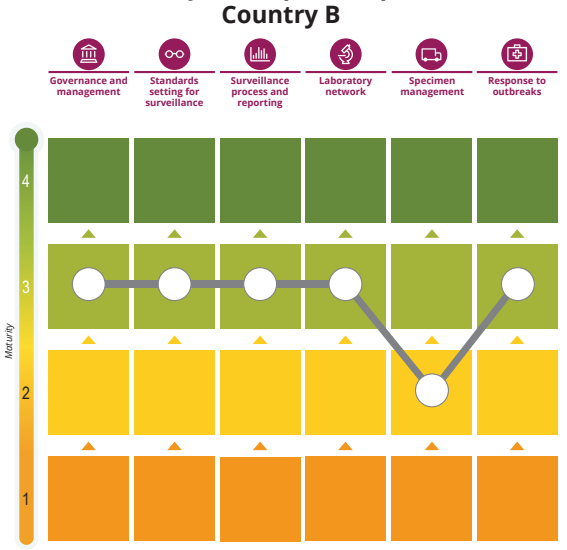
Maturity levels per component
Country A



Country B has been assessed as a Category 3 country with a major gap in terms of specimen management and minor deficiencies in its surveillance system and laboratory network.

The Government of Country B will be able to prioritize its investments by targeting these specific areas in order to enhance the overall effectiveness of its VPD surveillance system.

Maturity levels per component
Country B



Milestones have been defined to serve as intermediary objectives toward the 2030 targets

With the assumption that external factors (e.g. protracted emergencies, conflicts, natural disasters) will not impact surveillance systems and laboratory networks negatively, it is expected that all countries will reach either Category 3 (20% of countries) or Category 4 (80% of countries) by 2030.

In order for this to be accomplished the countries will have to make progress on all six components.

2030 targets and milestones

	2019	2021	2024	2027	2030
Category 1	8	4	2	-	-
Category 2	20	15	10	5	-
Category 3	10	12	12	12	9
Category 4	9	16	23	30	38

All countries will move to Categories 3 and 4

Governance mechanisms will have to be implemented to facilitate monitoring and evaluation

Based on the design of its surveillance system as well as existing institutions and organizations, each country should identify the most appropriate governance mechanism to monitor and evaluate progress.
WHO and Partners willing to get involved will support countries in this process, where necessary.

Note: * As part of monitoring and evaluation teams, countries may consider National Council for Science and Technology or Ministry of Health research directorate or disease surveillance unit, EPI or other key national institutions (e.g. National Public Health Institute).

Each country will adopt an approach that is tailor-made according to its maturity levels, in order to strengthen its surveillance system and laboratory network

Based on its maturity profile each country – with the support of partners – will be able to identify a concrete action plan to reinforce its VPD surveillance system.

Specific activities were identified to be used as guidelines for each maturity component in order to move from a lower to a higher maturity level.

The example below illustrates this approach using the Governance and management component.

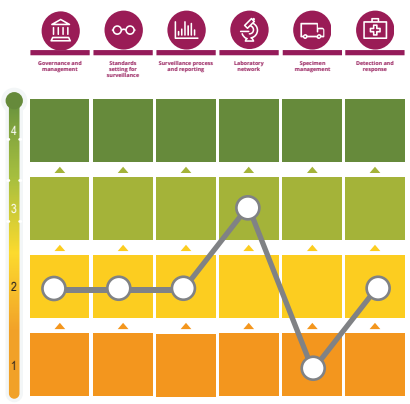
Being assessed as level 1 (low maturity) on the Governance and management component, a country may want to focus on the adaptation and ratification of policies and guidelines, norms and standards as well as to perform a JEE in order to develop a strategic plan and subsequent roadmap.

If assessed as level 4 (high maturity) on this component, a country is more likely to try to elaborate sophisticated multisectoral coordination and cross-border collaboration.

Example of Country A

Today Country A is assessed as falling into Category 2 and needs to reinforce five out of six of the components of surveillance.

Country A profile



Country A will be able to identify a tailored action plan based on key activities, depending on its maturity level per component.

For example, in order to reinforce its Specimen management (which is at level 1), Country A could implement some of the activities recommended for the first level of the component.

Recommended sets of actions for Specimen management

Non-exhaustive

SPECIMEN MANAGEMENT

Level 1	Level 2	Level 3	Level 4
• Set up guidelines for national specimen transportation and security protocols • Appoint a national transport focal person in charge of coordination, monitoring and evaluation • Identify and map hubs and routes, and develop a plan for each hub and route • Create a line in the Ministry of Health budget dedicated to specimen transportation • Identify and train relevant private and non-profit organizations to the transportation of specimens	• Establish a national coordination mechanism (including private sector) for specimen transportation • Secure yearly disbursement of the budget line for specimen transportation • Advocate and mobilize additional resources for specimen transportation	• Monitor the performance of the national specimen transportation network • Implement corrective actions	• Include innovative approaches to specimen transportation (drones, smart radio frequency identifications (RFID) tags, etc.)

Likewise, to enhance its Governance and management Country A will find guidance in the recommended activities at level 2 for this component.

Recommended sets of actions for Governance and management

Non-exhaustive

GOVERNANCE AND MANAGEMENT

Level 1	Level 2	Level 3	Level 4
• Adapt and adopt policies and guidelines as well as norms and standards • Perform a Joint External Evaluation with the technical support of partners • Develop a costed strategic plan for surveillance activities (cMYP, NAPHS, etc.) • Define national coordination procedures for greater integration between EPI and surveillance programmes, better emergencies and disease control	• Fund and implement strategic plan • Set up coordination bodies for surveillance and laboratory network • Establish a National Public Health Institute (NPHI) to coordinate all surveillance systems and laboratory network • Dedicate a budget line for surveillance staff, equipment, infrastructure and operations • Manage relationships with partners	• Design multisectoral strategy for enhanced surveillance of zoonotic and environment-borne diseases • Improve financial management • Improve human resources management • Deploy accountability framework and incentives	• Elaborate multi-sectoral plan and coordination mechanisms

Over time countries will repurpose their efforts as they advance on the maturity scale

By regularly assessing the maturity of their national surveillance systems, countries in the African Region will be able to measure their progress in the six components on the maturity grid and to revise their action plans accordingly.

Example of Country A

Today Country A belongs to Category 2 and its objective is to gradually transition to Category 3 or 4.

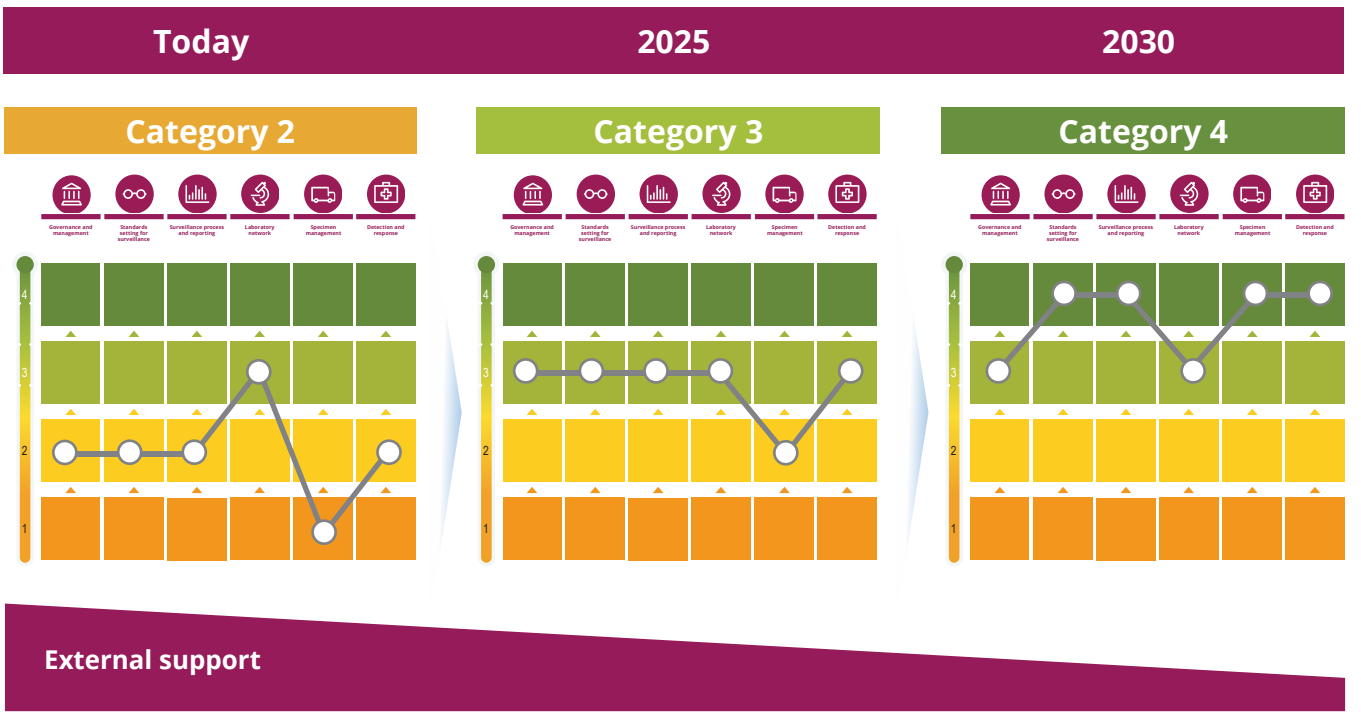
As Country A makes progress in each component it will repurpose its efforts towards better ownership and sustainability.

Thanks to a tailored action plan, Country A should be able to reach Category 3 by 2025.

Country A will regularly review its action plan based on its achievements, guidance from RITAG and the NITAG, and reach Category 4 by 2030.

This tailored approach will entail the countries progressively building capacity, gaining ownership, and transitioning to a model where they plan, operate, monitor and evaluate their surveillance systems and laboratory networks in an autonomous manner.

Evolution of maturity levels
Country A



AMBITION FOR 2030

All countries in the African region have committed to universal immunization coverage and high-quality surveillance

In 2007 the Global Framework for Immunization Monitoring and Surveillance (GFIMS) *(33)* was developed to serve as a guide for VPD surveillance.

In 2014 countries in the African Region developed the Regional Strategic Plan for Immunization (RSPI) *(14)* with four strategic objectives:

- To improve immunization coverage beyond the current levels,
- To complete interruption of wild poliovirus transmission and ensure virus containment,
- To attain the elimination of measles and make progress in the elimination of rubella and congenital rubella syndrome, and
- To attain and maintain elimination or control of other VPDs.

An unprecedented milestone was reached with the endorsement of the ADI *(1)* by all Heads of State during the African Union Summit in January 2017. This Declaration incorporates specific commitments for universal and equitable access to immunization.

The fifth ADI commitment prioritizes "Attaining and maintaining **high quality surveillance for targeted vaccine-preventable diseases**" *(1).*

Despite the fact that all countries in the African Region have committed to universal immunization coverage and quality VPD surveillance, there are still challenges and barriers to achieving RSPI targets *(14)* by 2020.

Countries in the African Region therefore need to accelerate efforts towards meeting the 2020 targets and beyond. This document sets a new ambition for 2030 in terms of VPD surveillance and laboratory networks. The ambition for 2030 will ultimately help countries reach broader goals such as Universal Health Coverage (UHC) and the Sustainable Development Goals (SDGs).

There are still challenges and barriers in achieving RSPI targets *(14)* in the African Region

National ownership of the surveillance systems and laboratory networks remains suboptimal.

There are still inequities in access to immunization (unreached areas and children) and the performance of surveillance (silent areas).

Increasing numbers of **outbreaks and humanitarian emergencies** strain the health systems and surveillance in particular.

Evolving **demographic trends** in the African Region with rapid urbanization.

Limited data quality and use at both local and national levels, with difficulty in interconnecting EPI and laboratory data.

GPEI *(6)* and Gavi *(9)* transitions will negatively impact the levels of funding support for VPD surveillance and laboratory activities.

Inadequate emphasis on surveillance in preservice curricula and insufficient inservice training for health workers contributed to gaps in surveillance performance.

Procurement and supply chain management remain inadequate, with unreliable demand forecasting and shortages.

Under-use of community engagement limits the sensitivity of the system and the timeliness of case detection.

Sources: 33- GFIMS, 2007; 14- RSPI 2014-2020, 2015; 1- ADI, 2016; 6- GPEI website, 2018; 9- Gavi website, 2018.

Strengthening surveillance systems and laboratory networks is an opportunity to accelerate efforts towards achieving RSPI targets *(14)* and beyond

Strategic investment with clear benefits

Having a surveillance system should be considered a strategic investment and an insurance policy.

The return on investment (ROI) is clear when comparing the costs of running a surveillance system with the costs of an outbreak response, considering the health and economic impacts. In addition, a robust surveillance system (including laboratory network) contributes to the measurement of the efficiency of immunization programmes, allowing them to be adjusted accordingly.

Unlock untapped potential

In most countries surveillance systems are primarily used for case detection, reporting and statistics.

A major challenge is use of surveillance data for effective decision-making purposes. In most countries surveillance data are underutilized for:

- Programme monitoring and evaluation,
- Investment optimization,
- Planning and budgeting,
- Resource mobilization, and
- Predictive analysis and propagation models.

Opportunity for making a leap in technology

Surveillance has an opportunity to benefit from advances in technology (e.g. using rapid diagnostic tests (RDT), molecular testing, mobile applications and devices, geo-tagged data, drones, social media, big data, analytics, cloud computing). Countries could leverage innovation in surveillance to reduce the costs thereof while improving its overall value.

An ambition for 2030 with a clear aim

By 2030, as part of efforts to ensure national health security and achieve SDG 3, countries will own, sustainably fund and maintain high-quality surveillance systems and laboratory infrastructure, within the context of a broader well-coordinated surveillance system, to optimize the performance of their national immunization programmes and achieve their disease control objectives, leveraging reliable VPD surveillance data.

Objectives, KPIs and specific targets for 2030 have been defined for each surveillance component

Components	Governance and management	Standards setting for surveillance	Surveillance process and reporting	Laboratory network	Specimen Management	Detection and response
Sub-component	Oversight and coordination System design and planning Financial sustainability and management Human resource management Capacity building and training Accountability	Norms, standards and guidelines Monitoring and evaluation, including quality management New vaccine surveillance Vaccine safety surveillance	Case detection and notification Investigation and response Data management Quality data Data analysis and visualization Data-driven decisions Cross-border collaboration	Network coordination Laboratory equipment and supplies Laboratory standard operating procedures Accreditation External Quality Assessment Quality, health, safety and environment	Specimen collection Specimen packaging Specimen transportation Payment for transportation Innovation	Preparedness Early detection and rapid assessment VPD outbreak response and monitoring

Source: 14- RSPI 2014-2020, 2015.

Each objective has been defined to enable countries to assess their performance according to a common framework

During a workshop held in Kigali from 21 to 23 November 2018* Member States, WHO and partners outlined the main objectives to be achieved by 2030.

The ambition for 2030 encompasses 30 objectives encompassing all components of VPD surveillance and laboratory networks.

KPIs and targets for 2030 have been assigned to each objective

Based as far as possible on existing literature *(34)* and indicators which are already available and measured regularly, KPIs have been identified for each objective. For each KPI the target is the number of countries among the 47 Member States in the African Region that need to reach it by 2030.

Example "Financial Management" *(34)*
Objective, KPI and target

GOVERNANCE AND MANAGEMENT			
Subcomponent	Objective	KPI	2030 target
Financial management	By 2030 Member States will mobilize sufficient resources and ensure the financial sustainability of their VPD surveillance and laboratory capacities	**KPI**: Evidence of a budget line for surveillance activities and tools (e.g. reporting forms, feedback bulletins, communication, supervision, training) **Value**: Yes/No/Unknown	100% 47/47 of WHO African Region countries

Health–Economic Impact Model

The Health–Economic Impact Model aims to quantify the ROI for the development of VPD surveillance systems and laboratory networks which would be derived by moving from the current situation to the ambition for 2030.

The underlying assumption is that the investments made by 2030 will strengthen the surveillance system so that it is more effective and generates greater health and economic benefits.

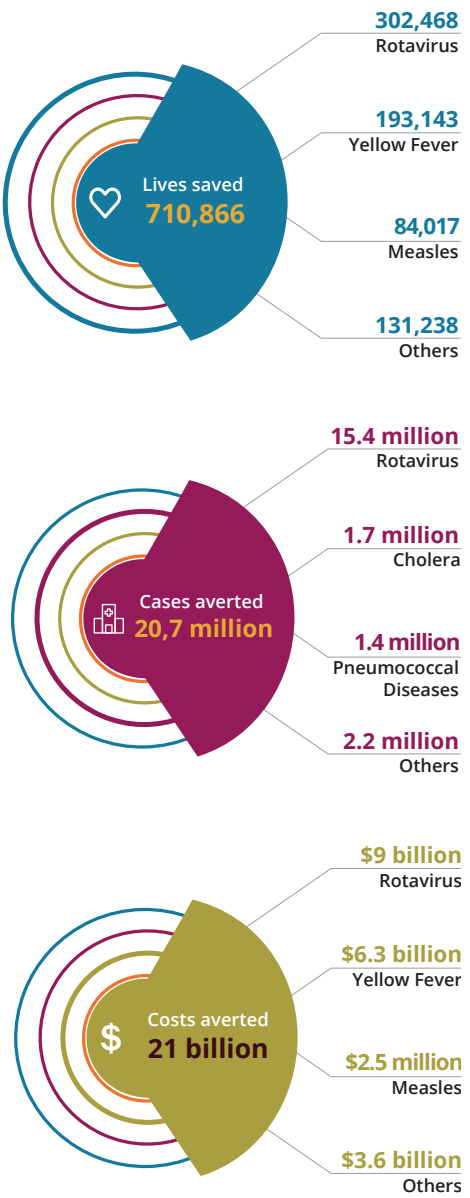
Enhanced VPD surveillance systems and laboratory networks will lead to significant benefits:
- Minimize the magnitude of VPD-related outbreaks,
- Enhance immunization coverage by better optimization of routine and supplementary immunization activities,
- More efficient use of expensive and scarce vaccines,
- Allow closer monitoring of changes in epidemiological profiles to improve the effectiveness of immunization, and
- Enhanced data for evidence-based decision-making and prioritization of "top killer" VPDs.

Source: 34- Guide to Monitoring and Evaluating, WHO, 2006.
Note: *Africa VPD Surveillance Stakeholders' Consultation, Kigali, Rwanda, 21–23 November 2018.

The ambition for 2030 will save at least 710,000 lives, avert 20.7 million cases and save $21 billion over ten years. The return on investment is estimated to be 44.6 fold

Based on the Deloitte health-economic impact modeling, reaching the ambition for 2030 for six major VPDs (rotavirus, yellow fever, cholera, pneumococcal diseases, measles, and meningitis) will save more than 710,000 lives over the next decade. It will generate $21 billion of net economic benefits with a multiplying factor of 44.6 as a return on investment.

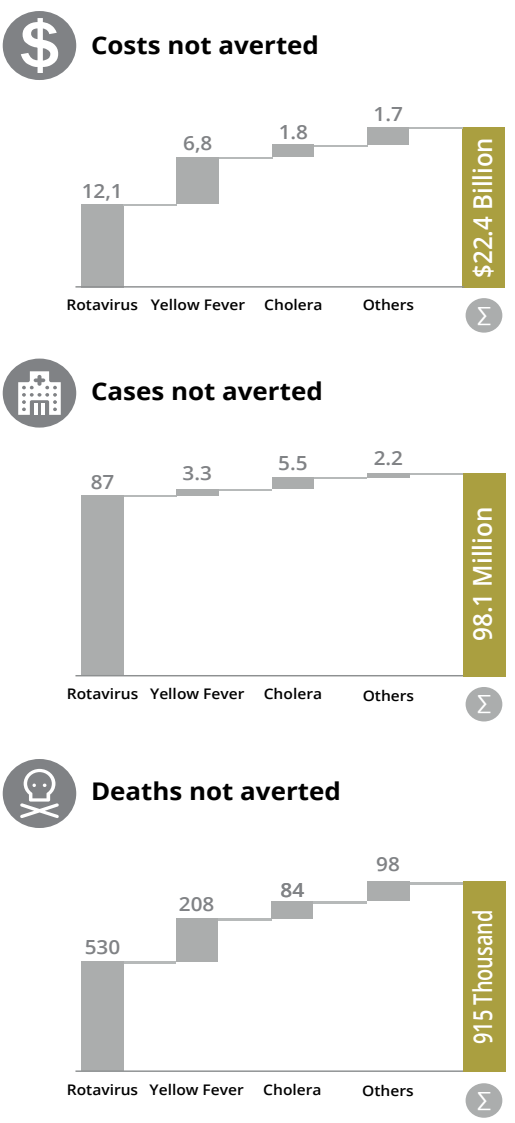
Ambition for 2030 scenario *(35)*



If current VPD surveillance efforts are not maintained, there is a risk to reverse progress made, leading to more than 915,000 deaths and additional costs of $22.4 billion in countries

In this worst case scenario, rotavirus alone would incur costs of $12.1 billion, accounting for over 50% of the total costs. Yellow fever related costs would be estimated at $6.8 billion. Cholera would cost up to $1.8 billion while the other VPDs modeled would account for close to $1.7 billion.

Worst case scenario *(35)*



Source: 35- Deloitte health-economic impact calculator, 2018 (methodology and limitations available in Annex B).
Note: Excluded hepatitis B from the modeling due to natural history of the disease with chronic phase in adulthood (e.g. cirrhosis, liver cancer) implying more advanced modeling (i.e. dynamic). Excluded tetanus from the modeling because of high immunization coverages that undermine the criticality of surveillance.

WHAT NEEDS TO BE DONE IN ORDER TO REINFORCE COUNTRY OWNERSHIP*

Definition of country ownership

Country ownership refers, among other things, to the ability to provide leadership (e.g. strategic vision, governance, decision-making), mobilize resource and ensure technical coordination.

What does country ownership of surveillance systems look like?

In terms of VPDs surveillance country ownership means that a Member State will develop a vision and policies coordinated by a single body, which is responsible for strategic and operational planning, resource coordination (e.g. budget line, human and technical resources, resource mobilization) and an adequate information system (e.g. data collection process, decision-making, KPIs).

What are the key steps?

For a Member State to ensure adequate country ownership, major steps will include:

- Advocacy with decision-makers to raise awareness of the importance of surveillance,
- Resource mobilization,
- Communication and community engagement,
- Accountability at all levels, and
- Quality technical support which is well coordinated.

In order to develop country ownership it is important to raise awareness not only among national authorities but also among stakeholders (e.g. communities, civil society, partners, Non-Governmental Organizations (NGOs), and private sector actors).

What are the current gaps?

The following gaps are observed in some countries:

- Fragmentation of the organizations working on surveillance,
- Insufficient mobilization of Civil Society Organizations (CSOs) and communities for disease surveillance,
- Insufficient legal framework which does not allow the effective functioning of the system and its governance,
- Low institutional capacity with limited resources (e.g. finance, human resources, equipment),
- Lack of an accountability framework for clarifying responsibilities at all levels,
- Absence of negative and positive incentives,
- Almost no domestic funding for disease surveillance (e.g. government, private sector),
- Weak capacity of national actors in resource mobilization,
- Poor data quality and information analysis capacity,
- Low dissemination and use of information for action,
- Lack of data showing the economic burden of diseases, and
- Low use of media for surveillance advocacy.

What are potential solutions?

Member States can assess the opportunity to set up a single structure for disease surveillance (e.g. aggregate surveillance, case-based surveillance, laboratory).

Countries can shape a strategic vision for disease surveillance, and establish a legal framework and appropriate mechanisms for resource mobilization in order to coordinate partners' action and funding.

In terms of advocacy, countries can raise awareness of the importance of disease surveillance among politicians, communities, opinion leaders, etc. They can appoint individual and institutional champions (e.g. First Ladies, CSOs, experts, NITAGs).

Setting up adequate information systems will ensure the availability of quality data, analysis and visualization, and proper use thereof for decision-making at all levels.

The development of surveillance information systems will lead to a necessary evolution in HRH skills.

National research can be encouraged to demonstrate the effectiveness of real-time surveillance, early identification of outbreaks and rapid response.

In summary, country ownership is about demonstrating a strong political will, shaping a vision, setting the right priorities, dedicating sustainable funds, leveraging adequate institutional and human resources, and using data for evidence-based decision-making and accountability at all levels.

Note: *Based on workshops held at the Africa VPD Surveillance Stakeholders' Consultation, Kigali, Rwanda, 21–23 November 2018.

SECTION 4:
IMPORTANCE OF VPD SURVEILLANCE AND VALUE-ADDED ACTIVITIES

Surveillance activities are essential to detect and respond early to risks and outbreaks to mitigate their impact on national security, the local economy and public health

VPD surveillance is the foundation of disease control strategies and the most effective way to detect and respond early to outbreaks to mitigate their impact on national security, the local economy and public health systems.

In an era of globalization, infectious diseases and their pandemic potential are a massive threat to **national security**: 34% of all deaths worldwide are now attributable to infectious diseases while war accounts for only 0.64% *(36)*.

Because of their high morbidity and mortality, VPD outbreaks exert a huge strain on national public health and the labour force, leading to political instability, class conflict and economic volatility.

VPD outbreaks generate extreme direct and indirect costs that could have been curtailed with the help of a better surveillance system and prevention and public healthcare interventions. For instance, during the 2015-2016 yellow fever outbreak in Angola, the relatively lengthy time needed to confirm the outbreak and trigger a response contributed to the spread of the outbreak to the Democratic Republic of Congo (DRC), requiring the shipment of an additional 10 million doses of vaccine for outbreak response over a 10-month period *(37)*.

These costs can have a significant impact on the public finances and debt ratios of a country.

Below are examples of direct cost analyses of three major VPD outbreaks in the African Region: (i) the EVD outbreak in West Africa in 2015, (ii) measles outbreak in Ethiopia in 2012, and (iii) meningitis outbreak in Burkina Faso in 2007.

Direct costs of three VPD outbreaks in the African Region

EVD outbreak (West Africa, 2015) *(38, 39)*

22,859 cases

9,162 deaths

$3.6 billion

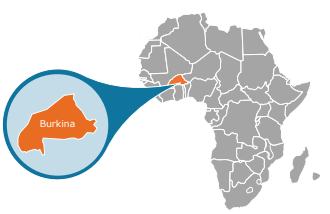
Measles outbreak (Ethiopia, 2012) *(40)*

1 zone (Keffa)

5,257 cases

$758,869

Meningitis outbreak (Burkina Faso, 2007) *(41)*



1 country

1,325 cases

$9.4 million

Sources: 36- Evans, Global Security Studies, 2010; 37- Hampton, Goel, 2018; 38- UNECA, 2015; 39- CDC website, 2016; 40- Wallace et al., Vaccine, 2014; 41- Colombini et al., Vaccine, 2011.

Outbreaks have a direct impact on **local economies** by reducing trade, productivity, household consumption and tourism.

They also have a negative impact on the business environment, limiting foreign direct investment and trade which leads to a decline in Gross Domestic Product (GDP).

Because of the Ebola outbreak, Sierra Leone went from having annual GDP growth of 20.7% in 2013 to a 20.6% decline in GDP in 2015 *(42, 43)*.

Global growth can also be threatened by the uncontrolled spread of an outbreak and the exporting of cases internationally.

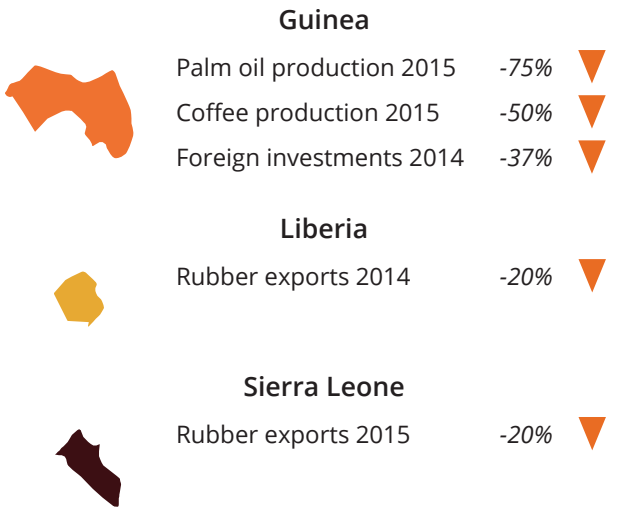
Predicted global costs of an influenza pandemic *(44)*

Scenario	Deaths	Impact on Global GDP (1st year)	
		Value	Growth rate
Mild	1,4 million	- $300 billion	-1 pp.
Worst	142 million	- $4.4 trillion	-12.6 pp.

pp.: percentage points

Beyond these macroscopic effects, epidemics have a profound impact on industry. This is reflected in particular in a decline in production, exports and foreign investments, but also in lay-offs.

EVD outbreak impact on major industries *(45)*



Health workers often account for a significant proportion of the cases and deaths associated with VPD outbreaks.

During **measles** outbreaks health workers are up to **19 times more likely to acquire the disease** than the rest of the population *(46)*.

x19

Globally any outbreak seriously disrupts the local health system because of a change in priorities and the contraction of the available HRH.

In the African Region, because health workers are already below optimal levels the loss of a single health worker can have a significant impact on the functioning of the national health system. The West African EVD outbreak resulted in a 23% decrease in health services delivery in Sierra Leone.

Ultimately, cases and deaths due to other diseases and the lack of availability of healthcare services are likely to increase during outbreaks.

EVD outbreak estimated impact on other diseases *(39)*

- 1,091 additional deaths due to HIV
- 2,714 additional deaths due to tuberculosis
- 6,818 additional deaths due to malaria
- 10,600 additional deaths due to lack of healthcare services

Sources: 42- Sierra Leone GDP growth, World Bank, 2018; 43- Ebola impact update, World Bank, 2016; 44- McKibbin and Sidorenko, CAMA Working Papers, 2006; 45- USAID, The Business Case for prevention, preparedness & response to pandemics, epidemics & outbreaks, 2017; 46- Torner et Al. Human vaccines & Immunotherapeutics, 2014; 39- CDC website, 2016.

Countries in the African Region must develop more advanced functions to capture the added value of their surveillance systems and laboratory networks better

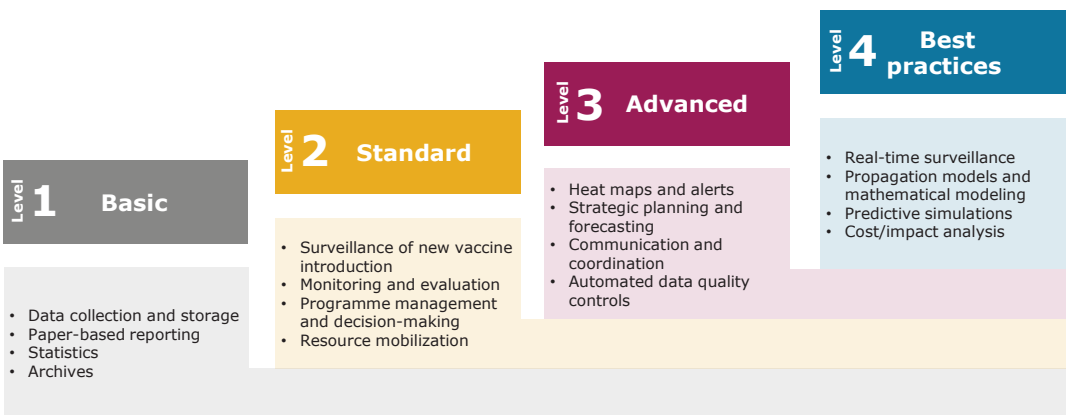
With the support of WHO, the Centers for Disease Control and Prevention (CDC) and other partners most countries in the African Region have invested in the establishment of a surveillance and laboratory infrastructure. Existing surveillance systems and laboratory networks are used mainly to provide basic functions such as data collection and storage of printed reports, statistics and archives.

Manual activities, data quality and visualization remain major challenges. Decision-making is often delayed because this depends on a thorough review and analysis of surveillance data by epidemiologists, increasing the likelihood that a deadly outbreak will not be detected in time. As a consequence, decision-makers and politicians may question the value and ROI of their current national surveillance system and laboratory network.

The actual value of a surveillance system lies in its ability to facilitate decision-making, anticipate outbreaks, optimize immunization programmes' costs and facilitate resource mobilization activities.

Countries in the African Region must therefore develop more advanced functions to optimize the value of their surveillance systems and laboratory networks. However, the strengthening of surveillance systems may, initially, lead to an increase in the number of cases due to increased sensitivity,

Surveillance functions and levels

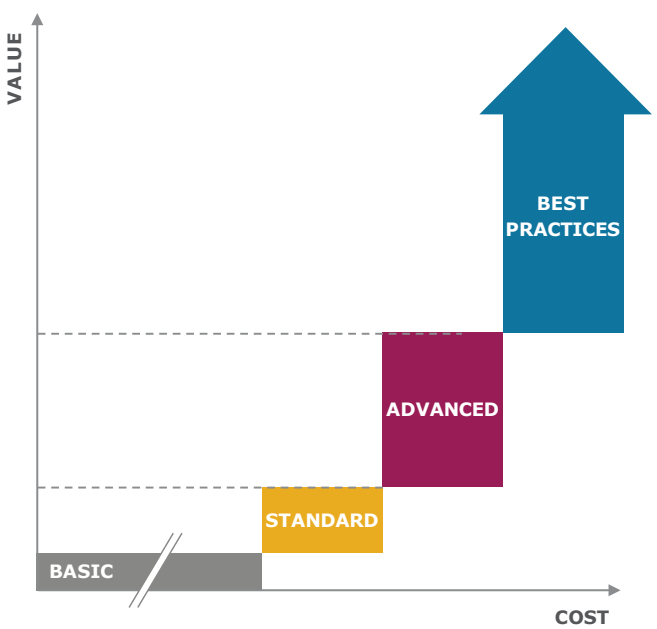


While the initial costs for basic surveillance functions are high, additional investments for more advanced functions are low and lead to high value and ROI

Establishing a surveillance system and laboratory network from the very beginning entails high investment costs (e.g. decentralized surveillance sites and equipment, personnel and training, laboratory network, transportation system and vehicles) and high operating costs (e.g. staff, reagents, specimen transportation).

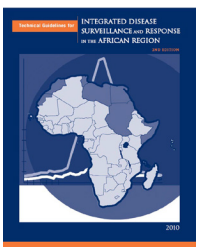
In comparison, the development and implementation of more advanced surveillance functions in countries which already have functioning systems represents a lower investment (e.g. centralized information system, business intelligence, big data and analytics).

Setting up more advanced functions will lead to high value and ROI in terms of health and economic benefits, such as: (i) rapid and evidence-based decision-making, (ii) avoidance of outbreak response costs, (iii) optimization of immunization costs, (iv) prevention of VPD treatments, and (v) increased productivity (GDP).



Level 1 Basic functions

Most countries have developed **basic surveillance functions** with the support of partners.

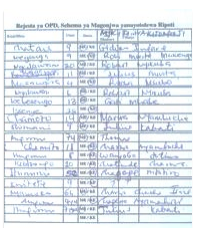


Governance and regulatory framework (e.g. standards and norms, policies and guidelines).

Surveillance infrastructure and transportation network (e.g. premises, equipment, vehicles, cold chain).

Staff recruitment, training and retention (e.g. case definitions, specimen collection procedures).

Laboratory capacity and network (e.g. infrastructure, equipment, staff, maintenance, stocks).



Surveillance reporting process (e.g. registers, visits to collect information, compilation, verification and analysis of data, statistics).

Level 2 Standard functions

Surveillance to support decision on new vaccine introduction and impact monitoring can be performed building on a basic surveillance system.

New vaccine surveillance *(47, 48, 33)*

Pre-vaccine introduction → **Impact of introduction** → **Long-term monitoring**

- **Pre-vaccine introduction:** Before the vaccine is introduced it is key to document the disease burden to support decision-making about the timing of vaccine introduction and define a baseline for monitoring and evaluation activities.
- **Impact of introduction:** This allows for monitoring of trends to demonstrate the impact of new vaccines on disease burden and epidemiology as well as their cost-effectiveness.
- **Long-term monitoring:** Surveillance measures changes in the disease and the epidemiological profile as well as progress toward VPD eradication, elimination and/or control goals. Surveillance ensures vaccine safety by documenting adverse events following immunization (AEFIs).

Surveillance allows for better **monitoring and evaluation** of the immunization programmes:

- Triangulation between surveillance and immunization data facilitates the identification of immunization gaps (undervaccinated areas and unvaccinated children).
- Surveillance data are essential to provide a basket of vital vaccines adapted to the country's current epidemiological profile and to design routine immunization (RI) and supplementary immunization activities (SIA).
- The effectiveness of the immunization programme is optimized through a more adequate definition of the frequency and geographical scope of SIAs, and the response to the outbreak is properly scaled, guided, monitored and measured.

"For VPDs in the eradication and elimination phases, a single case can indicate an outbreak and signal a gap in the immunization programme. [...] For endemic VPDs, the trend of cases going up or down can provide a broad signal on the impact of a vaccine programme"

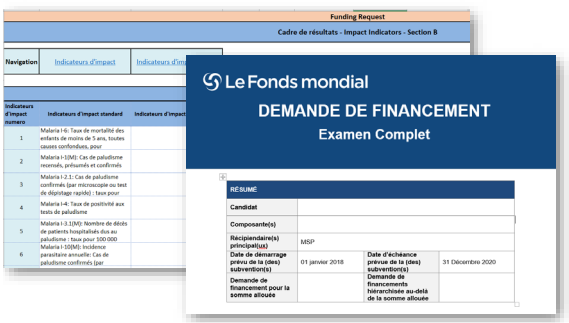
VPD Surveillance Standards, 2018 *(49)*

Sources: 47- Cohen et al., Vaccine, 2018, 48- Mwenda, WHO/AFRO, 2018; 33- GFIMS, 2007; 49- Overview of VPD Surveillance Principles, WHO, 2018.

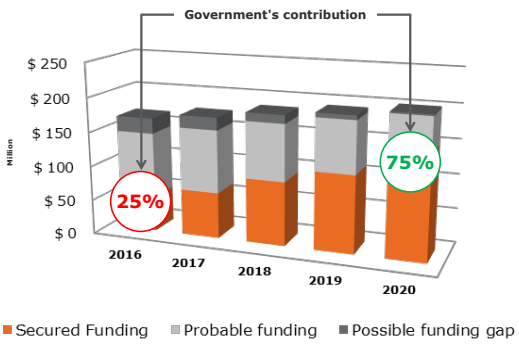
Up-to-date epidemiological data can make a difference in ensuring long-term funding and ownership by strengthening evidence-based **advocacy and resource mobilization**:

- Surveillance data are useful in convincing politicians and decision-makers to invest in surveillance and immunization programmes,
- When mobilizing local or donor funding for targeted VPD control initiatives, use of surveillance data is important to clarify the magnitude of diseases and monitor the impact of planned interventions. This demonstrates country ownership and accountability,
- Surveillance data are useful in convincing potential new donors to assist, with better diversification of the financing portfolio.

Funding request for The Global Fund *(50)*



Securing funding over time *(51)*



Level 3 Advanced

Governments and Ministries of Health are looking for a cost-efficient way to use their human and financial resources.

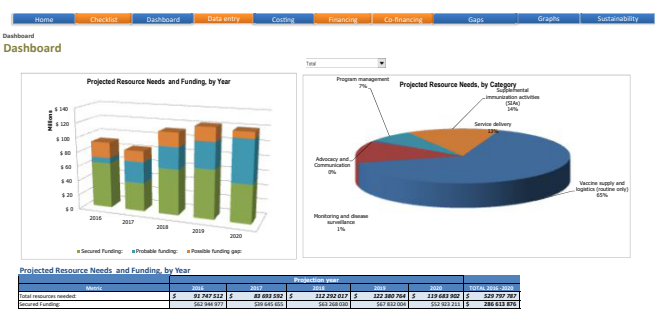
Surveillance data facilitate **strategic planning** by allowing better prioritization, cost allocations and investments to target the most vulnerable populations and areas, as well as the most harmful diseases *(52)*.

Sensitive surveillance allows for more precise mapping of risks, as well as **forecasting** of needs when budgeting and costing for vaccine and equipment procurement, infrastructure maintenance and human resources recruitment (e.g. cMYPs, National Health Development Plans).

Surveillance data are also enablers of **coordination and communication** with partners, CSOs and the population at large.

Good quality surveillance allows for **better accountability** and the possibility of revising priorities in the event of threats to the population.

cMYPs dashboard *(51)*

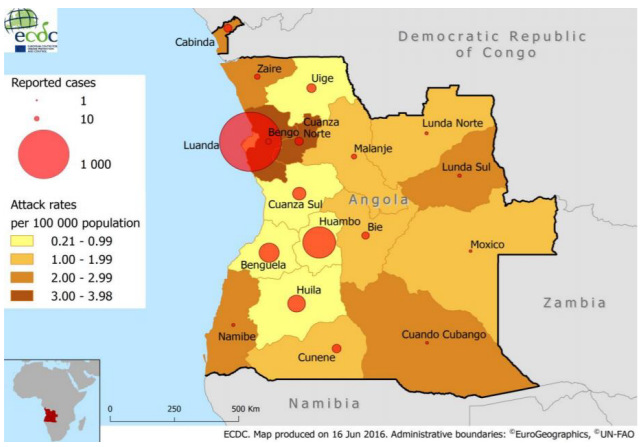


Sources: 50- The Global Fund, 2017; 51- Costing tools for cMYPs (v.8.3.4), 2018; 52- Setting priorities in CDS, WHO, 2006.

Surveillance data are critical to improve the timeliness and cost-effectiveness of outbreak responses.

In countries where public health surveillance is weak, several tools such as event-based surveillance (Global Public Health Intelligence Network (GPHIN)) and web-based surveillance (Google trends or HealthMap) can be leveraged *(53)*. However, these tools require follow-up investigation for confirmation.

Distribution of suspected/confirmed yellow fever cases and areas of local transmission *(54)*
Angola, 10 June 2016



By allowing rapid detection of suspected cases these tools are useful for detecting outbreaks earlier. In addition, responses can occur more promptly and will be shaped more precisely (e.g. budget, HRH, equipment, treatment), saving lives and avoiding cases and sequelae.

"In spite of the DRC having some of the global experts in Ebola, these experts could have responded even quicker if they had better tools and more resources to work with. One of the biggest lessons is that Congo needs to be digitized to have better surveillance systems and faster emergency response."

Trad Hatton, PATH on Likati (DRC) Ebola outbreak *(55)*

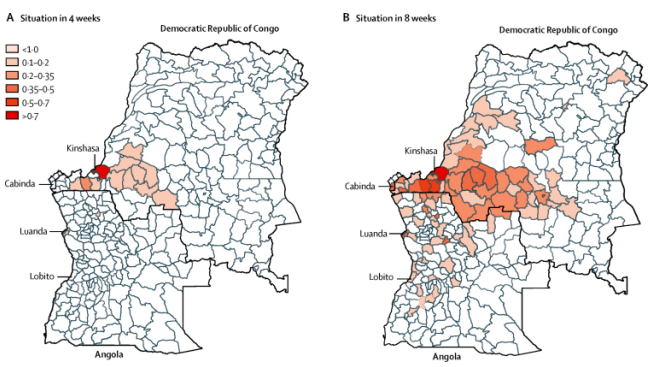
Level 4 Best practices

In the near future Member States should consider **real-time and community-based surveillance, propagation models, predictive simulations and cost/impact analysis.**

Propagation models enable and facilitate the shaping of **containment strategies and outbreak response scenarios**. By analyzing and simulating disease dynamics with complex mathematical models, propagation models can lead to the prediction of an outbreak, the identification of hotspots in terms of infectious diseases, or the probability of an emerging pathogen occurring.

Merging disease information with mobility patterns makes it possible to detect diffusion pattern scenarios for the disease. When additional information (e.g. vaccines, access to treatment, health behaviours and socio-economic variables) is added, high-risk areas can be identified for **targeted preventive actions**.

Prediction of yellow fever virus spread *(56)*
Angola, 2015–2016



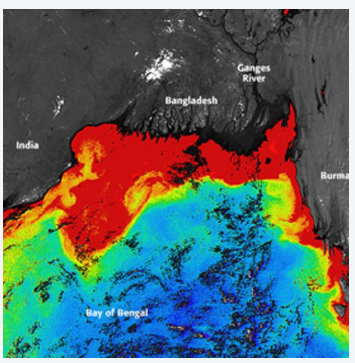
In addition, remote sensing technology can monitor environmental changes, which can be useful in predicting the spread of a disease. Satellite imagery can be used to monitor the activity of pathogenic species (e.g. anopheles mosquitoes) *(53)*.

Sources: 53- Christaki, Virulence, 2015; 54- Assessing the Yellow Fever Outbreak in Angola, ECDC, 2016; 55- PATH Website, 2016; 56- Kraemer et al., Lancet Infectious Diseases, 2017.

Satellite data aid in predicting cholera outbreaks

By using satellite imaging to collect information on sea-surface temperature, height and chlorophyll A levels, researchers were able to construct an environmental model that could accurately predict the actual incidence rate of a cholera outbreak in Bangladesh *(53)*.

Mohammad Ali, a senior scientist at the International Vaccine Institute in Seoul, found that increased air temperatures and rainfall are regularly followed by outbreaks. His study tracked seven years of data in Zanzibar, and the observed data were "very close to the prediction" *(57)*.

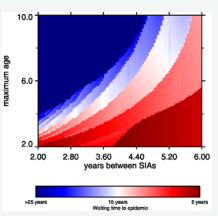


Measles epidemic in Burundi: mathematical model-based analysis and implications for vaccination timing

Using a mathematical model with realistic demography, Corey and Noymer (2016) *(58)* generated simulated epidemic curves and age × time epidemic surfaces.

Their findings suggest that SIAs should be used in places where routine vaccination cannot keep up with the increasing numbers of susceptible individuals resulting from population growth or from logistical problems such as cold chain maintenance.

They characterized the relationship between the SIA frequency and SIA age range necessary to suppress measles outbreaks.



Community-based surveillance monitors a wide range of information directly generated by community members. CBS has proven to be more sensitive and sustainable than most traditional surveillance systems *(49, 59)*.

Community informants are essential and sometimes unique relays for collecting and effectively communicating information about unusual events or changes in the health status of community residents to authorities.

CBS also raises population awareness of disease prevention and control measures, thus eradicating potential epidemics at source.

Key steps in CBS *(59)*

Detection	A community member detects a predefined trigger in the community and sends an alert.
Triage	The supervisor confirms the alert and forwards it to the local health authority.
Verification	Local health authorities investigate to verify whether the alert represents a health risk.
Risk assessment	Health authorities visit the community to investigate and determine the level of risk and put appropriate response measures in place.
Response	Timely and effective intervention takes place in the community with the appropriate level of resources.

Sources: 53- Christaki, Virulence, 2015; 57- Scientific American website, 2018; 58- Corey and Noymer, PeerJ, 2016; 49- Overview of VPD Surveillance Principles, WHO, 2018; 59- CBS: guiding principles, IFRC, 2017.

COORDINATION OF VPD SURVEILLANCE AT THE NATIONAL AND REGIONAL LEVELS*

Why do countries need to coordinate VPD surveillance activities?

Coordination of VPD surveillance activities is essential to develop evidence-based decisions and action plans, and optimize and pool available resources (human, financial, technical, material and logistical) while avoiding duplication of activities, address complex challenges (e.g. cross-border population movements), ensure fair and inclusive representation and coordinate the response to VPD outbreaks and other health emergencies.

What are the key outcomes and outputs of coordination?

Coordination of VPD surveillance activities leads to the development of:

- **Joint strategic plans** including a harmonized vision, alignment of policy formulation, funding and advocacy efforts,
- **Joint activities** including mechanisms for capacity building, data sharing, analysis and visualization, quality assurance and supervision, joint emergency responses, specimen transportation and joint communications,
- **Pooled resources** including laboratory networks, technical expertise, data management systems and financing, and
- **Norms and standards** including common case definitions, laboratory methodologies, standard operating procedures, etc.

Who are the stakeholders involved in surveillance coordination?

The **stakeholders** involved in coordination include the Ministries of Health (e.g. EPI, IDSR/IHR and other surveillance and disease control units), other Ministries (e.g. Finance, Homeland Security, Economy, Agriculture, etc.), political leaders, technical experts, development and humanitarian partners (e.g. WHO, CDC, Gavi, MSF, ICRC, IMC, Save the Children, UN agencies), CSOs, professional societies, policy makers at subnational and regional levels, laboratories (both public and private), IHR Technical Working Groups, emergency response organizations, national public health and research institutes as well as private academies.

Countries can **leverage existing platforms** such as national bodies (e.g. Inter-Agency Coordination Committees, NITAGs) and regional bodies (e.g. RITAG, African Union Commission), Gavi CSO constituency, Health Sector Coordination Committees, regional laboratory meetings, WHO regional committees and regional economic communities.

What best practices can the MoH use to coordinate VPD surveillance activities?

In terms of **governance**, high-performing countries designate focal points for each coordinating function, establish a multisectoral coordination group with representatives of major stakeholders, establish a legal framework, designate nodal agency to coordinate surveillance with the requisite mandate (e.g. Nigeria CDC), clearly define the roles, responsibilities and accountability of each stakeholder, create subgroups based on specific domains (e.g. laboratories, data, field surveillance, etc.), monitor activities and evaluate outcomes and impact, and streamline activities between different departments (e.g. IDSR and EPI departments).

In terms of **communications**, high-performing countries organize frequent coordination meetings, follow-up teleconference calls to monitor activities, joint trainings and workshops (e.g. for capacity building and strengthening) and develop regular communication among the right groups in the respective stakeholder organizations.

In terms of **missions**, high-performing countries organize joint evaluation missions, joint advocacy activities and joint resource mobilization processes.

What are the existing and potential new platforms for coordination of VPD surveillance activities?

Existing platforms include the IHR Technical Working Group, Surveillance Technical Working Group, Donor Meetings, JEEs, Africa Union Commission and WHO annual regional immunization stakeholders' consultation.

Examples of new potential platforms are combined data platforms, joint advocacy platforms and regional hubs (e.g. institutionalization of regular meetings between Ministries of Health and Finance).

Note: * Based on workshops held at the Africa VPD Surveillance Stakeholders' Consultation, Kigali, Rwanda, 21–23 November 2018.

SECTION 5:
NEW TECHNOLOGIES AND INNOVATIONS

New technologies and innovations have the potential to enhance VPD surveillance

This chapter presents, for illustrative purposes only, a non-exhaustive list of technologies and innovations that have had, so far, concrete impacts on the six components of VPD surveillance*.

Mobile technologies have been one of the first driver of change in VPD surveillance over the last years. In Africa 80% of the population is expected to have a mobile phone by 2020 *(60)*

From conventional surveillance to CBS, mobile phones allow surveillance officers to report cases in real-time, even in remote areas.

With applications like AVADAR *(61)* or Cell Preven, the use of mobile phones to detect suspected cases, locate and report them to the national surveillance system is increasing. This allows communities to report much more effectively and to interact directly with surveillance officers.

Mobile applications are used to track population movements to study the transmission dynamics and import routes of an infectious disease from one region to another.

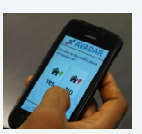
Technologies such as geographic information systems (GIS) make it easier to study trends, outbreaks and immunization

GIS enables immunized areas to be identified and mapped with high accuracy, thus allowing better identification of uncovered areas. When a case is detected the system allows accurate recording of the location (GPS coordinates), which is of major interest in countries where streets are not named. Information can be shared in real-time with regional or central monitoring centers for faster identification of possible outbreaks.

Use of GIS to map immunization resources *(62)*

The GPEI uses GIS to find non-immunized populations using satellite imagery and Arc d'Esri GIS *(63)*. In Nigeria vaccination teams are monitored remotely by telephone trackers who transmit their real-time position to satellites. This system increases team coverage and supervision while reducing errors and cases of fraud.

AVADAR *(61)*



Auto-Visual AFP Detection and Reporting (AVADAR) is a mobile application used for timely reporting and investigation of AFP cases.

It enhances traditional AFP surveillance by "widening the net" of disease reporters and by using SMS-based mobile technology to improve the completeness, timeliness and availability of AFP reports. When informants report suspected AFP cases automatic alerts are sent to the relevant disease surveillance officers. Data are automatically aggregated, visualized and made available to decision-makers.

5,198 community informants trained

8,794 AFP alerts investigated

580 cases (6.6%) confirmed

Sources: 60- Frost & Sullivan, 2015; 61- eHealth Africa website, 2018; 62- GIS Meeting Report, Unicef, 2017; 63- Information Week website, 2018.
Note: The elements presented in this chapter are for illustration purposes. They cannot be considered as official WHO recommendations.

New approaches such as Internet-based surveillance have emerged to harness the power of big data

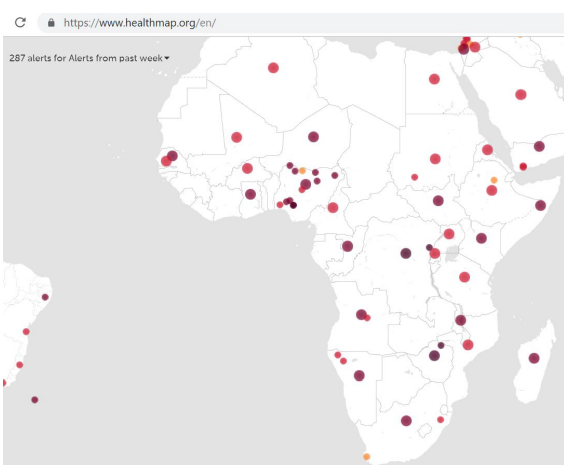
Development of the Internet and the multiplication of free online information sources available in real-time offer important reservoirs of data in general, and for health in particular. Analysis of data collected through social media applications presents new opportunities in emerging infectious diseases surveillance by allowing individuals to become disaggregated whistle-blowers on any potential case, therefore complementing somehow traditional surveillance systems*.

Following the West African Ebola outbreak Odlum and Yoon (2015) *(64)* investigated the trends in the geographical spread of EVD information on Twitter. The analysis captured progressive increases in the number of tweets discussing EVD case identification in Nigeria beginning on 24 July 2014, occurring 3 days prior to the news alert and 7 days before the official CDC update.

Using non-traditional digital disease surveillance data via HealthMap and Google Trends, Majumder et al (2016) *(65)* developed near real-time estimates of cases associated with the Zika virus in Colombia. The confidence intervals of their estimates from HealthMap and Google data were consistent with those estimated from the official number of Zika virus cases reported by the Ministry of Health.

Digital surveillance data could be a particularly effective means in low- and middle-income countries where surveillance systems are weak and detailed transmission studies are rare. In crisis situations these tools could help fast identification of important factors in the transmission of infectious diseases.

HealthMap *(66)*
African Region on 30 November 2018



Event-Based Surveillance systems combine high computing capabilities with real-time multi-channel analysis of data sources

Unlike classic surveillance, event-based surveillance (EBS) *(49, 67, 68)* is not based on the routine collection of data with automated thresholds for action. EBS is a more unstructured type of surveillance intended primarily to detect outbreaks.

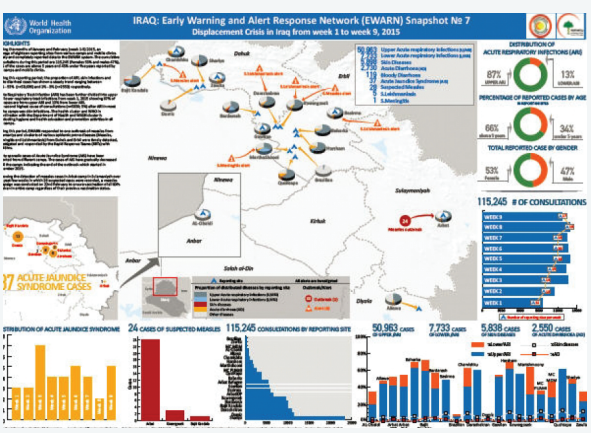
EBS can gather information from formal (routine surveillance systems) or informal channels (e.g. news, rumours, blogs, social media). It can account for events related to the occurrence of disease in humans or potential exposure for humans (e.g. dead animals, contaminated food, environmental hazards).

EBS is quite sensitive since it processes a large number of unformatted information in real-time allowing for rapid risk assessment and an immediate response. The system relies on statistical methods to detect changes in trends and events.

Early-warning alert and response networks *(69, 70)*

EWARN combines indicator and event-based methods in order to detect changes in event trends or alerts that could represent potential threats to public health.

In collaboration with several agencies, EWARN was launched in Southern Sudan in July 1999. Within 1 year the system had already significantly reduced both investigation time (from 4 months to 24 hours) and response time (from 6 months to 2 weeks).



Sources: 64- Odlum and Yoon, American Journal of Infection Control, 2015; 65- Majumder et al., JMIR Public Health Surveillance, 2016; 66- Health Map website, 2018; 49- Overview of VPD Surveillance Principles, WHO, 2018; 67- Meeting Report, WHO Technical consultation on EBS, 2013; 68- A Guide to Establishing Event-based Surveillance, WHO/WPRO, 2008; 69- Weekly epidemiological record, WHO, 2002; 70- United Nations Iraq website, 2015.
Note: * These tools only capture information shared by people and not when an event actually occurs, therefore requiring careful monitoring.

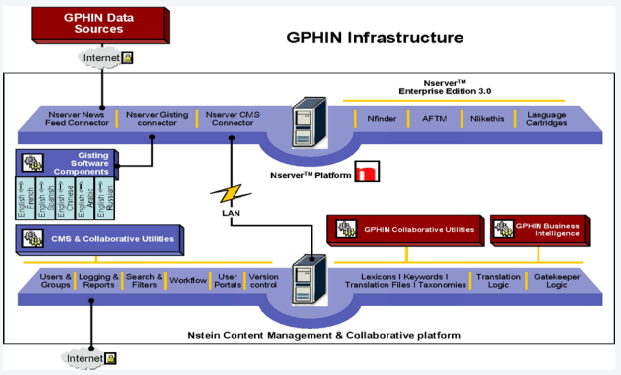
GPHIN *(53, 71, 72)*

GPHIN, a systematic event detection tool, analyzes more than 20,000 online news reports in nine languages worldwide every day.

A web-based program aggregates the data collected based on an algorithm providing potential signals of emerging public health events. These are then reviewed by a multilingual multidisciplinary team and an alert is sent if a potential risk is identified.

In April 2012 the GPHIN identified eight cases of an unknown respiratory illness and one death in Jordan. Following investigation, an outbreak of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) was confirmed.

GPHIN was credited with being the first to issue an alert about this new emerging illness.



Global Epidemic and Mobility *(53, 73)*

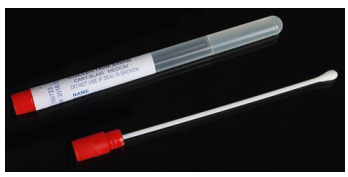
Global Epidemic and Mobility (GLEaM) is a stochastic model integrating global demographic data, air travel and short-range mobility data for the simulation of worldwide spread of influenza-like illnesses.

GLEaM was able to detect the H1N1 peak in advance, allowing immunization campaigns to start earlier, with better control of the epidemic and a reduction in the number of cases.

Once a case has been investigated a specimen is taken for laboratory confirmation. Several specimen transport techniques have been developed

Timely confirmation of disease-causing organism is essential, as a single case can rapidly turn into a deadly outbreak. Different types of specimens will require different transport methods in order to arrive at the laboratory in good quality. Stool specimens can be collected in **Cary-Blair transport medium** and transported at room temperature *(74)*.

Cary-Blair transport medium *(75)*



Blood specimens usually require a **reverse cold chain,** but for some diseases like measles, mumps, rubella and hepatitis B, a dried blood spot (DBS) is a reliable alternative, especially in resource-limited settings, since it offers several advantages.

Compared to conventional venipuncture, DBS is non-invasive, inexpensive, and does not require trained staff or a cold chain for transport and storage. Helfand et al. (2007) *(76)* performed separate tests on two immunoglobulin specimens (DBS and Sera) and the results for DBS were equivalent to those for Sera in about 99% of cases.

DBS specimen collection *(77)*

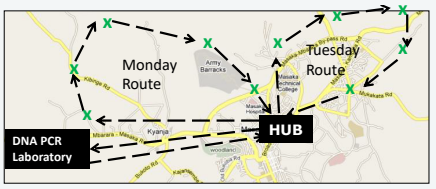
When a reverse cold chain or biosecurity is required it is even more important to establish a transport plan: budget, equipment (e.g. means of transport, collection kits, ice packs), routes, and so on. In the absence of adequate transport mechanisms specimens may be retained in health facilities or may be damaged, resulting in further costs and delays.

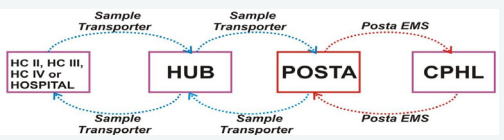
Sources: 53- Christaki, Virulence, 2015; 71- Dion et al. CCDR, 2015; 72- Mawudeku and Blench, 2005; 73- GLEaM website, 2018; 74- Thermofisher Scientific website, 2018; 75- Innovmed website, 2018; 76- Helfand et al., Clinical and Vaccine Immunology, 2007; 77- Devex website, 2018.

Specimen transportation network in Uganda *(78)*

Based on the results of a field investigation the Ugandan Ministry of Health and partners decided to invest in a specimen transport system to improve access to quality laboratory diagnostics.

This system involves the establishment of hubs which interconnect regional hospitals, district hospitals and health centers. Each hub has two motorcycles and drivers, which visit 30 health facilities within a 40 km radius of the center, bringing in all specimens from each facility and providing results on a weekly basis. The hub will use highly specialized tests such as DNA PCR tests looking at tuberculosis specimens, outbreak specimens, etc.





Using drones in hard to reach areas in Madagascar *(79)*

Drones are used to fly to villages that are not easily accessible by road, in order to deliver medicines or to take biological specimens for analysis at a central medical center.

For remote villages in Madagascar's Ifanadiana district, where there are no roads, drones can arrive in about an hour, while a trip on foot would take more than 10 hours.

The drone flies from the central research facility and lands in the village, where a health worker loads it with blood specimens. The drone then flies back to the facility.

The African Region has the opportunity to make a technological leap in laboratory techniques

Advances in high-speed sequencing methods have enabled the rapid acquisition of the data necessary for pathogen identification and analysis.

Genome-wide sequencing, multiplex PCR and micro-array technology are being used for syndromic surveillance, microbial discovery and disease susceptibility studies.

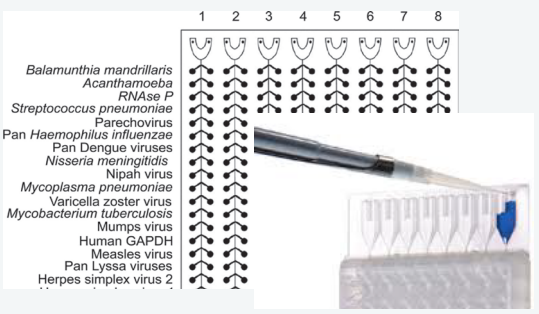
PCR *(80)* is a method used for amplifying DNA in vitro: one molecule of DNA can be increased to thousands of molecules within a few hours. Its principles date back to the early 1970s and it has been used in the laboratories since the 1990s.

More recently conventional **PCR has evolved to offer new techniques** such as reverse transcript, real-time or quantitative PCR (RT-PCR), and multiplex and even agglutination PCR (ADAP).

TaqMan Array Card *(81, 82)*

The TaqMan Array Card is a 384-well microfluidic card designed for performing 384 simultaneous real-time PCR reactions, allowing detection of multiple organisms in one experiment.

TaqMan Array Cards are preloaded with dried down high-quality TaqMan assays (TaqMan probes and PCR primer sets) ready for 1 to 8 specimens to be run in parallel against 12 to 384 Applied Biosystems™ TaqMan™ gene expression assay targets.



Sources: 78- Kiyaga et. al, PLoS One, 2018; 79- LifeScience website, 2018; 80- Highveld, 2018; 81- ThermoFisher Scientific website, 2018; 82- Onyango et al., Journal of Clinical Microbiology, 2017.

HOW TO OPTIMIZE LABORATORY CAPACITY AND LINKAGE TO VPD SURVEILLANCE*

What is the future of laboratory networks in the African Region?

Laboratory networks should evolve toward a network of national public health institutes with strategic and operational regional connections, backed-up by accreditation bodies and a comprehensive legislative framework to ensure standardization across different programmes and categories of laboratories (e.g. private, military, research, NGOs).

Laboratory capacity should be strengthened through the introduction of new technologies and innovation, both for diagnosis and data management, and through the development of regional centers of excellence that can ensure continuous capacity building of laboratory personnel.

What technologies can be used for routine surveillance?

Over the past few decades VPD diagnosis has evolved into two categories of tools and techniques:

- Testing multiple pathogens in the same experiment (e.g. TaqMan Array Cards), and
- Bringing the diagnosis closer to the patient (e.g. Point of Care Testing (PoCT) and rapid diagnostic tests (RDTs)).

Several tools (e.g. DHIS2 or WISE) and best practices (e.g. unique ID) allow for more efficient and timely data reconciliation between laboratories and surveillance systems.

Specimen transport has benefited from the development of diagnostic techniques, allowing accurate detection even when using specimens of lower quality. Similarly, methods of transport for specimens have been considerably extended through the development of autonomous devices such as drones.

How may we strengthen links between the laboratory network and surveillance?

In addition to integrated data management software and unique identifiers, several countries (such as Nigeria) have successfully organized joint weekly meetings of technical working groups.

The key success factor for these groups is the mix of those who are included: laboratory, vaccination and surveillance programme officers as well as focal persons from the partners such as WHO or CDC.

What are the opportunities for laboratory networks?

Governance and political engagement	• Establish National Public Health Institutes with strong regional linkages • Design a common and clear laboratory framework (e.g. legislation and regulations) • Establish a Memorandum of Understanding with private, military, research and NGOs' laboratories
Financing and advocacy	• Advocate for creation of a dedicated line for laboratories in the national budget • Estimate costs for sustainable laboratory capacity (e.g. staff, supplies, infrastructure, equipment) • Introduce performance-based financing with clear and laboratory-specific KPIs
Processes and coordination	• Create an online database with automated alerts • Systematic use of a unique identifier, barcodes or other tracking technologies • Weekly meeting of mixed technical working groups (e.g. EPI, other surveillance units, laboratory)
Laboratory network and capacity	• Develop centers of excellence capable of providing continuous training • Leverage existing capacities (e.g. private, military, research, NGOs' and non-VPD laboratories) • Leverage existing equipment and technologies (e.g. PCR, Elisa, country data management tools)
Equipment and procurement	• Set up a procurement pool for the purchase and supply of reagents • Establish a centralized procurement system at regional and country levels • Sign material transfer agreements and maintenance agreements

Note: * Based on workshops held at the Africa VPD Surveillance Stakeholders' Consultation, Kigali, Rwanda, 21–23 November 2018.

PoCT is helpful for rapid confirmation, management and containment of cases

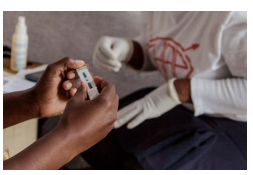
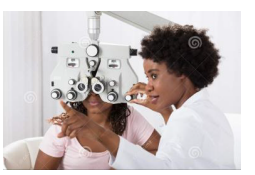
PoCT provides the opportunity to perform a test, get confirmation to guide clinical decisions and initiate follow-up actions in the same location.

However, while some techniques take seconds (e.g. for malaria), others only give a result after hours (e.g. for Ebola). Some will also require equipment and qualified personnel to collect and analyze the specimens. The most widely known PoCT technique is the rapid diagnostic test (RDT).

RDTs can be used in several settings in the absence of laboratory professionals, from home to communities and even hospitals, where they are critical in emergency rooms to rapidly identify infectious diseases and contain cases.

However, for most VPDs, subsequent laboratory confirmation will be required to confirm and document the case in a more comprehensive manner.

Diversity of target product profiles, users, and settings in PoCT *(83)*

HOME	COMMUNITY	CLINIC/HEALTH POST	PERIPHERAL LAB	HOSPITAL
Self-testing	**Testing in the community by health workers**	**Testing in the clinic by healthcare providers**	**Testing in the peripheral laboratory**	**Testing of inpatient in hospital**
Layperson	Minimally trained	Clinical staff	Laboratory technician	Hospital staff
RDT (pregnancy-type or dipstick)	RDT	RDT, handheld instruments	RDT, molecular tests, ELISA, microscopy, etc.	RDT, molecular, smears, etc.
Self-assessment, referral	Triage, referral	Diagnosis, treatment	Diagnosis, treatment, monitoring	Diagnosis treatment monitoring
				
• Malaria	• Malaria	• Cholera • Malaria • Dengue	• Cholera • Dengue • Ebola • Hepatitis B and C • Influenzae • Malaria • Tuberculosis	• Cholera • Dengue • Ebola • Hepatitis B and C • Influenzae • Malaria • Tuberculosis

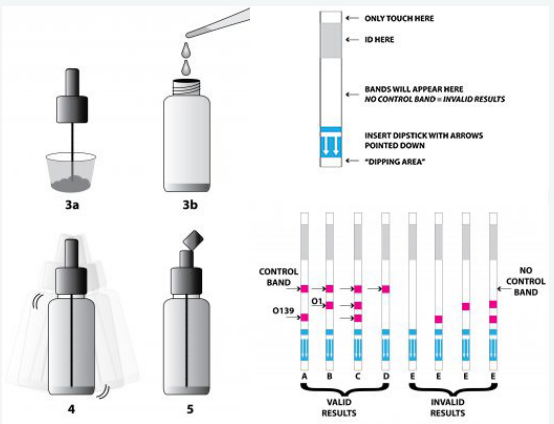
Sources: 83- Pai et al., PLoS Medicine, 2012.

RDT for cholera in Zimbabwe *(84, 85)*

On 5 September 2018, 25 patients were admitted to a hospital in Harare presenting with diarrhoea and vomiting.

The first case, a 25-year-old woman, presented to hospital and died on 5 September. A specimen from this case tested positive for Vibrio Cholerae serotype O1 Ogawa. The 25 patients had typical cholera symptoms including excessive vomiting, acute watery diarrhoea and dehydration.

Eleven cases were confirmed as cholera using RDT kits and clinical presentation, allowing the Ministry of Health and Child Care to declare a cholera outbreak by 6 September 2018.



RDT for Ebola in DRC *(86, 87)*

The DRC used RDTs to respond to an ongoing Ebola outbreak in a very remote area of the north east of the country.

One of the technologies being used to detect Ebola in DRC is GeneXpert, which was primarily developed to detect cases of tuberculosis but has been adapted to enable rapid testing of many pathogens (e.g. HIV, malaria, sexually transmitted infections and Ebola).

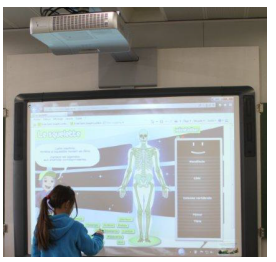
With support from partners, technicians can use GeneXpert at the INRB laboratory in Kinshasa to test for the Zaire strain of Ebola in just one hour.

Other tests developed during the West African outbreak are also being deployed, such as OraQuick – an RDT developed with the support of the CDC and Global Outbreak Alert and Response Network. OraQuick can test blood or saliva specimens for Ebola in just 30 minutes.

Capacity building is critical for the efficiency of surveillance networks, and e-learning could facilitate access to VPD surveillance training

There are several types of e-learning, from standalone massive open online courses (MOOCs), to enriched media and learning games, to webinars and virtual classrooms with live interactions between trainer and trainees.

Interactive whiteboards allow real-time feedback on the trainee's assignment



The main advantages of e-learning for health sector surveillance capacity building are outlined below *(88)*.

Scalability
E-learning enables educators to quickly create and communicate new policies, trainings and concepts.

Capacity and consistency
Using e-learning allows educators to achieve a great degree of coverage of their target audience, and ensures that the message is communicated in a consistent way.

High learning retention
Blended learning approaches result in a higher knowledge retention rate. It also helps that coursework can be refreshed and updated whenever necessary.

Time and money savings
E-learning reduces time away from the workplace, eliminates the need for travel, and removes the need for classroom-based training.

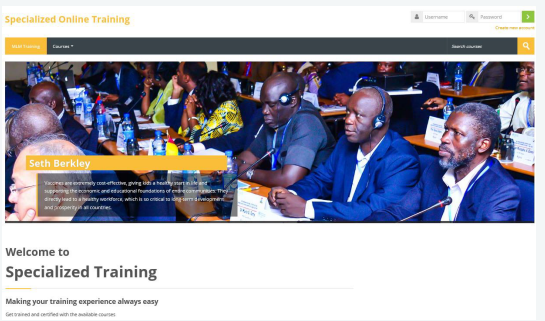
Flexibility
Using e-learning gives students the freedom to learn at their own convenience and pace. Staff can be trained in remote locations and in a consistent way. They can also receive online certification.

Sources: 84- Zimbabwe Cholera Outbreak, WHO, 2018; 85- Crystal® VC RDT Procedure, CDC, 2018; 86- New technology allows for rapid diagnosis of Ebola in DRC, WHO, 2018; 87- GeneXpert brochure, Cepheid, 2018; 88- Learning Pool website, 2018.

Mid-Level Managers training in Nigeria *(89)*

Mid-level managers (MLM) training provides on-site and online courses on IDSR, for which trainees receive certification.

The two-week course aims at training EPI trainers in MLM lesson design, updating facilitators and participants on the GVAP 2011–2020, cMYP 2016–2020 and Reach Every Ward (REW) approach and training EPI managers/professors in EPI management skills using AFRO MLM modules.



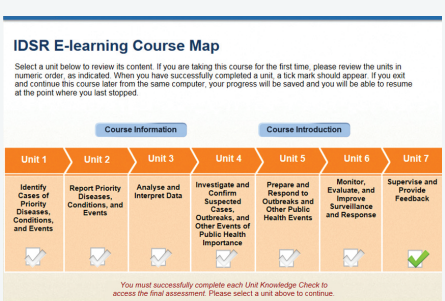
IDSR e-learning for a competent health workforce *(90)*

Considering the numerous public health events, the e-learning platform is an innovative approach to efficiently increase the availability of trained human resources for scaling up IDSR. This e-learning complements face-to-face training.

In order to contribute to the scale-up of the IDSR, WHO AFRO and the CDC finalized the IDSR e-learning course in English, French and Portuguese. It is accessible to a wide audience including preservice health personnel.

An electronic certificate is provided after successful completion of the course. So far all relevant WHO AFRO Country Office staff and at least one personnel member from the Ministry of Health in every country in the Region have completed the course and received certificates.

Since June 2017 200 public health officers have been enrolled on the course, of whom 99 have received their certificates.



Once sensitized the community is a valuable source of information able to fill gaps in surveillance

In hard to reach areas surveillance is weakened by low density of healthcare services, high HRH turnover rates, and time- and resource-consuming specimen transportation.

Community informants *(49, 59)* live or work in a community, and are leveraged to monitor and detect unusual events at community level which would often otherwise be missed by formal public health surveillance systems. They can be community health workers or CSO volunteers, traditional healers, midwives, pharmacists, village leaders, and the like.

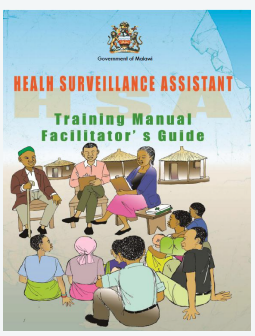
Since they do not have a medical background they need to be provided with a simplified definition of cases, trained and empowered with mobile phones, and means of travel in order to effectively improve the sensitivity of the system.

Health Surveillance Assistants for Community Case Management in Malawi *(91, 92)*

After several outbreaks in the 1970s Malawi identified individuals in the community to act as volunteers and support the Ministry of Health. When the EPI programme was set up these people were mobilized to provide basic promotive, preventive and curative care to those within the community, promote community participation in healthcare activities, and provide disease surveillance of health problems within the community.

Their routine job is to conduct home visits and community data collection through villages' health register, run and maintain community case management sites (village clinics), support and participate in the running of outreach immunization clinics, and conduct community feedback meetings. One such health surveillance assistant looks after about 1,000 people.

In 2014 a network of more than 10,450 people had been trained for 12 weeks on basic health care (60% theory, 40% practice) at a cost of $1,500 per person.



Sources: 89- MLM Training Website, 2018; 90- Performance Report - Q3 2017, WHO Afro, 2018; 49- Overview of VPD Surveillance Principles, WHO, 2018; 59- CBS: guiding principles, IFRC, 2017; 91- Has as Change agents for Community Case Management, MoH Malawi, 2014; 92- Training Manual Facilitator's Guide, MoH Malawi, 2009.

Performance-based financing can boost efficiency of surveillance systems by providing incentives

Performance-based financing (PBF) *(93, 94, 95)* is a mechanism through which health providers are, at least partially, funded by partners or government on the basis of their performance. PBF can be contrasted with the line-item approach, which finances a health facility through the provision of inputs (e.g. drugs or personnel). This mechanism also fits into the SDGs aid paradigm and global efforts for rapid progress on a few key indicators.

Growing evidence indicates that PBF reform packages can address problems of low responsiveness, poor efficiency and inequity in the public health system. PBF motivates health workers to perform well and deliver results.

PBF for health system strengthening *(93, 94, 95)*

As PBF builds on quantitative objectives, surveillance could easily be eligible for such an incentive scheme.

Outbreak insurance will help countries prevent pandemic risks during an outbreak through a fast-disbursing financial mechanism

Pandemics pose a serious threat not only to national and global security, but also to local economies. In most cases pandemics can be avoided if they are treated early. Timely provision of financial resources and support can save lives. However, there is often a critical gap between the limited funds available in the early stages of an outbreak and the assistance which is mobilized once the outbreak has reached critical proportions.

The Pandemic Emergency Financing Facility (PEF) *(95)* was developed by the World Bank Group in collaboration with WHO, and supported by Japan and Germany as well as private partners. It seeks to fill the gap by providing the much-needed surge funding for response efforts in order to help prevent rare, high-severity disease outbreaks from becoming more deadly and costly pandemics.

The World Bank Group announced creation of the PEF at the G7 Ministers of Finance Meeting in Sendai, Japan, on 20 and 21 May 2016. Japan and Germany came on board as donors, and allowed for the PEF's insurance window to be operational from July 2017. The cash window was operational as of summer 2018.

How the PEF works *(96)*

Sources: 93- PBF website, World Bank, 2018; 94- Sina Health Website, 2018; 95- Bertone et al., PLoS ONe, 2018; 96- PEF website, World Bank, 2018.

KEY MESSAGES

VPD surveillance is an essential function for the protection of populations. VPD surveillance provides an excellent ROI by significantly reducing the magnitude of outbreaks as well as the costs related to investigation and response to outbreaks.

Situation analysis of VPD surveillance
- VPDs kill over 500,000 children per year in Africa
- 30 million children suffer from VPDs every year
- Several disease-specific VPD laboratory networks have been set up across Africa (polio, measles, etc.)
- Countries' expenditure for surveillance are low
- The annual funding gap is estimated to be $16.7 million

Maturity grid and country categorization
- Six components for VPD surveillance and labs
- Each country is categorized by maturity
- Relevant milestones and governance are put in place
- This offers a tailor-made approach for countries

Ambition for 2030
- Aim, objectives, KPIs and targets defined
- Major decrease of mortality

Return on investment
- $470 million investments and additional costs
- 710 thousand lives saved
- 20.7 million cases averted
- $21 billion saved
- A 44.6 fold of estimated return on investment

Strategic importance and value-added activities
- Surveillance is critical for national security, local economies and health system sustainability
- Most countries in theAfrican Region could leverage the value of existing infrastructure better
- Advanced surveillance functions can be implemented at a reasonable cost

Innovations and new technologies
- Internet and event-based surveillance
- Propagation models
- Laboratory techniques and PoCT
- E-learning and innovative funding

NEXT STEPS

Following this work, the next steps are being considered:
- provide a standardized approach and toolkit to support countries in developing their own investment cases for VPD surveillance
- develop national investment cases with a number of selected countries, based on the maturity grid

The VPD investment case is a high-level framework applicable to all countries in the African region. It made it possible to create an overview of the situation on a continental scale, to understand the macroscopic challenges, to assess the maturity of African countries' VPD surveillance systems using standardized methodology, and to establish a first order of magnitude in terms of investments and benefits expected from the strengthening of these systems. Finally, it made it possible to define a shared vision for VPD surveillance in Africa for 2030.

This work at the regional level must be complemented by detailed analyses at the level of each country in order to adapt the high-level vision to the local context, to align with the existing situation and current country priorities, to adopt a more granular approach in terms of costing and investment, to integrate with the local IDSR strategy, and to build a pragmatic and actionable roadmap. It is essential that these processes and outcomes are owned by the local government and stakeholders.

WHO will develop a toolkit for supporting the creation and implementation of these "in-country investment cases". This toolkit will offer a structured approach, provide ready-to-use tools for the various stages of the analysis, accelerate and streamline the delivery, provide best practices, homogenize the outcomes between the different countries, benchmark the results, and set up a monitoring, evaluation and continuous improvement process. This toolkit will be built on the basis of work carried out in pilot countries within the region, representative of the variety and complexity of VPD surveillance situations.

With these concrete next steps at the regional and country levels across the continent, we will continue to move closer to achieving our shared ambition for VPD surveillance in the Africa Region.

REFERENCES

1. Addis Declaration on Immunization. In: Report of the Ministerial Conference on Immunization in Africa (MCIA); 2016 (http://immunizationinafrica2016.org/conference-report/, accessed 30 November 2018).
2. Roadmap for Implementing the Addis Declaration on Immunization: Advocacy, Action and Accountability. Brazzaville: WHO Regional Office for Africa; 2017 (https://www.afro.who.int/sites/default/files/2017-09/ADI%20Roadmap%20-%20English.pdf, accessed 30 November 2018).
3. Global Health Security Agenda (GHSA) Framework 2024. In: Global Health Security Agenda (GHSA) [website]; 2018 (https://www.ghsagenda.org/docs/default-source/default-document-library/ghsa-2024-files/ghsa-2024-framework.pdf, accessed 30 November 2018).
4. International Health Regulations 2005, Third edition. Geneva: World Health Organization; 2005 (https://www.who.int/ihr/publications/9789241580496/en/, accessed 30 November 2018).
5. World Health Organization and Centers for Disease Control and Prevention. IDSR Technical Guidelines 2010. Brazzaville: WHO Regional Office for Africa; 2010 (https://afro.who.int/publications/technical-guidelines-integrated-disease-surveillance-and-response-african-region-0, accessed November 2018).
6. Who we are. In: Global Polio Eradication Initiative (GPEI) [website]. Geneva: World Health Organization; 2018 (http://polioeradication.org/, accessed 30 November 2018).
7. Presentation to the Programme Budget and Administration Committee of the Executive Board. In: Polio Transition Planning, HR & Indemnity. Geneva: World Health Organization.; 2017 (http://apps.who.int/gb/ebwha/pdf_files/EB142/B142_11-en.pdf, accessed November 2018).
8. 2017 AFRO budget dashboard [internal database]. Brazzaville: WHO Regional Office for Africa; 2017.
9. About Gavi, the Vaccine Alliance. In: Gavi, the Vaccine Alliance [website]; 2018 (https://www.gavi.org/about/, accessed 30 November 2018).
10. Report of the Regional Immunization Technical Advisory Group (RITAG) meeting. In: RITAG, Brazzaville, 6–7 June 2017. (http://afro.who.int/sites/default/files/2017-09/RITAG%20Final%20Report%20Web.pdf, accessed 30 November 2018).
11. Business case for WHO immunization activities on the African continent, 2018–2030. Brazzaville: WHO Regional Office for Africa; 2018 (https://afro.who.int/fr/node/9873, accessed 30 November 2018).
12. Programme of meetings for Wednesday, 23 May 2018. In: 71st World Health Assembly [website]. Geneva: World Health Assembly; 2018 (http://apps.who.int/gb/ebwha/pdf_files/WHA71/A71_JOUR3-en.pdf, accessed 30 November 2018).
13. Global Vaccine Action Plan 2011–2020. Geneva: World Health Organization; 2013 (https://www.who.int/immunization/global_vaccine_action_plan/GVAP_doc_2011_2020/en/, accessed 30 November 2018).
14. Regional Strategic Plan for Immunization, 2014-2020. Brazzaville: WHO Regional Office for Africa; 2015 (https://www.afro.who.int/sites/default/files/2017-06/oms-ivb-rvap-afro-en-20150408_final_sent140317_0.pdf?ua=1, accessed 30 November 2018).
15. Maternal Child Epidemiology Estimation [online database]. Geneva: World Health Organization; 2016 (https://www.who.int/healthinfo/global_burden_disease/estimates_child_cod_2000_2015/en/, accessed 30 November 2018).
16. Model UNIVAC (v1.2.09) [economic model]. Geneva: World Health Organization; 2016.
17. World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. New York: United Nations, Department of Economic and Social Affairs, Population Division; 2017 (ESA/P/WP/248; https://esa.un.org/unpd/wpp/publications/files/wpp2017_keyfindings.pdf, accessed 30 November 2018).
18. Global Health Data Exchange [online database]. Seattle: Institute for Health Metrics and Evaluation (IHME); 2017 (http://ghdx.healthdata.org/, accessed 30 November 2018).
19. Ibinda F, Bauni E, Kariuki SM, Fegan G, Lewa J, Mwikamba M, et al. Incidence and risk factors for neo-natal tetanus in admissions to Kilifi County Hospital, Kenya. PLoS One. 2015;10(4). doi:10.1371/journal.pone.0122606.
20. Van Den Ent M, Strebel P, Cochi S, Reef S, Kezaala R. The promise of rubella vaccines and MR. In: Proceedings. GAVI Partners Forum, Dar es Salaam, Tanzania, 4–6 December 2012. Geneva: Gavi; 2012 (https://www.gavi.org/library/gavi-documents/events/partners-forum-2012/presentations/09---containing-vaccines-on-the-impact-of-rubella-and-measles-control/, accessed 30 November 2018).
21. Disease burden estimates [online database]. Geneva: World Health Organization; 2016 (https://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html, accessed 30 November 2018).
22. Martínez-Quintana E, Castillo-Solórzano C, Torner N, Rodríguez-González F. Congenital rubella syndrome: a matter of concern. Rev Panam Salud Publica. 2015;37(3):179-86. pmid:25988255.
23. Zhou F, Reef S, Massoudi M, Papania MJ, Yusuf HR, Bardenheier B, Zimmerman L, McCauley MM. An Economic Analysis of the Current Universal 2-dose measles-mumps-rubella Vaccination Program in the United States. The Journal of Infectious Diseases. 2004;189(1):S131–45. doi:10.1086/378987.
24. Child Causes of Death, 2000–2017 [online database]. Geneva: World Health Organization; 2016 (https://www.who.int/healthinfo/global_burden_disease/estimates/en/index2.html, accessed 30 November 2018).
25. GPEI Factsheet, May 2018. In: Global Polio Eradication Initiative [website]. Geneva: World Health Organization; 2018 (http://polioeradication.org/wp-content/uploads/2018/05/polio-vaccination-gpei-fact-sheet-may-2018-20180516.pdf, accessed 30 November 2018).
26. The Global Polio Laboratory Network (GPLN). In: Global Polio Eradication Initiative [website].

43

Geneva: World Health Organization; 2018 (http://polioeradication.org/polio-today/polio-now/surveillance-indicators/the-global-polio-laboratory-network-gpln/, accessed 30 November 2018).

27. Measles and Rubella laboratory network (MRLN). In: World Health Organization [website]. Geneva: World Health Organization; 2018 (https://www.who.int/immunization/monitoring_surveillance/burden/laboratory/measles/en/, accessed 30 November 2018).
28. Pediatric Bacterial Meningitis Surveillance - African Region, 2002-2008. In: Centers for Disease Control and Prevention [website]. Atlanta: Centers for Disease Control and Prevention; 2009 (https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5818a2.htm, accessed 30 November 2018).
29. Garske T, Van Kerkhove MD, Yactayo S, Ronveaux O, Lewis RF, Staples JE, Perea W, Ferguson NM. Yellow fever in Africa: estimating the burden of disease and impact of mass vaccination from outbreak and serological data. PLoS Med. 2014;11(5). doi:10.1371/journal.pmed.1001638.
30. Hossain A, Politi C, Mandalia N, Cohen AL. Expenditures on vaccine-preventable disease surveillance: Analysis and evaluation of comprehensive multi-year plans (cMYPs) for immunization. Vaccine. 2018;36(45):6850-6857. doi:10.1016/j.vaccine.2018.07.068.
31. Costing tools (v.8.3.4) for comprehensive multi-year plans (cMYPs) for Benin, Botswana, Cameroon, CAR (2016), Chad, Comoros, Côte d'Ivoire, DRC, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Malawi, Mali, Mauritania, Mozambique, Namibia (2016), Niger, Nigeria, Rwanda, Sao Tome e Principe, Senegal, Seychelles, Sierra Leone, South Sudan (2016), Togo, Uganda, Zimbabwe [online databases]. Brazzaville: WHO Regional Office for Africa; 2018 (https://www.who.int/immunization/programmes_systems/financing/countries/en/, accessed 30 November 2018).
32. Talisuna A, Use of the IHR monitoring and evaluation framework and IDSR strategy for strategic planning to secure health security in Africa. In: Proceedings. Africa VPD Surveillance Stakeholders' Consultation, Kigali, Rwanda, 21–23 November 2018. Brazzaville: WHO Regional Office for Africa; 2018.
33. Global Framework for Immunization Monitoring and Surveillance. Geneva: World Health Organization; 2007. (WHO/IVB/07.06; http://www.who.int/iris/handle/10665/69685, accessed November 2018).
34. Communicable disease surveillance and response systems, Guide to monitoring and evaluating. Geneva: World Health Organization; 2006. (WHO/CDS/EPR/LYO/2006.2; https://www.who.int/csr/resources/publications/surveillance/WHO_CDS_EPR_LYO_2006_2.pdf, accessed November 2018).
35. Deloitte health-economic impact calculator [economic model]. Brazzaville: Deloitte Congo; 2018.
36. Evans J. Pandemics and National Security. Global Security Studies. 2010; l(1).
37. Hampton L, Goel A. Gavi Support for Vaccine Preventable Disease Surveillance. In: Proceedings. Africa VPD Surveillance Stakeholders' Consultation, Kigali, Rwanda, 21–23 November 2018. Brazzaville: WHO Regional Office for Africa; 2018.
38. Socio-economic Impacts of Ebola on Africa. Addis Ababa: United Nations Economic Commission for Africa; 2015 (ISBN: 978-99944-61-49-3; https://www.uneca.org/publications/socio-economic-impacts-ebola-africa, accessed 30 November 2018).
39. Cost of the Ebola Epidemic. In: Centers for Disease Control and Prevention [website]. Atlanta: Centers for Disease Control and Prevention; 2016 (https://www.cdc.gov/vhf/ebola/history/2014-2016-outbreak/cost-of-ebola.html, accessed 30 November 2018).
40. Wallace AS, Masresha BG, Grant G, Goodson JL, Birhane H, Abraham M, Endailalu TB, Letamo Y, Petu A, Vijayaraghavan M. Evaluation of economic costs of a measles outbreak and outbreak response activities in Keffa Zone, Ethiopia. Vaccine. 2014;32(35):4505-14. doi:10.1016/j.vaccine.2014.06.035.
41. Colombini A, Badolo O, Gessner BD, Jaillard P, Seini E, Da Silva A. Costs and impact of meningitis epidemics for the public health system in Burkina Faso. Vaccine. 2011;29(33):5474-80. doi:10.1016/j.vaccine.2011.05.058.
42. Sierra Leone GDP growth (annual %) [online database]. Washington: World Bank; 2018 (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=SL, accessed 30 November 2018).
43. 2014-2015 West Africa Ebola Crisis: Impact Update. In: World Bank [website]. Washington: World Bank; 2016 (http://www.worldbank.org/en/topic/macroeconomics/publication/2014-2015-west-africa-ebola-crisis-impact-update, accessed 30 November 2018).
44. McKibbin W, Sidorenko A. Global Macroeconomic Consequences of Pandemic Influenza. In: Centre for Applied Macroeconomic Analysis Working Papers, Crawford School of Public Policy, The Australian National University. (https://www.brookings.edu/opinions/what-a-flu-pandemic-could-cost-the-world/, accessed 30 November 2018).
45. The Business Case for prevention, preparedness & response to pandemics, epidemics & outbreaks. Washington: USAID; 2017 (http://preparednessandresponse.org/wp-content/uploads/2017/06/business-brief.pdf, accessed 30 November 2018).
46. Torner N, Solano R, Rius C, Domínguez A. Surveillance Network of Catalonia Spain TM. Implication of health care personnel in measles transmission. Hum Vaccin Immunother. 2014;11(1):288-92. doi: 10.4161/hv.36166.
47. Cohen AL, Aliabadi N, Serhan F, Tate JE, ZuberP, Parashar UD. Using surveillance and economic data to make informed decisions about rotavirus vaccine introduction. Vaccine. 2018;36(51):7755-58. doi:10.1016/j.vaccine.2018.05.052.
48. Mwenda JM, Diagnostics & laboratory work strategy and coordination at WHO AFRO. In: Proceedings. Diagnostics & laboratory work strategy and coordination at WHO/AFRO, Brazzaville, Congo, 10–11 July 2018. Brazzaville: WHO Regional Office for Africa; 2018.
49. Overview of VPD Surveillance Principles. Geneva: World Health Organization; 2018. (https://www.who.int/immunization/monitoring_surveillance/burden/vpd/standards/en/, accessed 30 November 2018).
50. Funding Request for Grant. Geneva: The Global Fund to Fight AIDS, Tuberculosis and Malaria; 2017.

51. Simulation with costing tools (v.8.3.4) for comprehensive multi-year plans (cMYPs) template. Brazzaville: WHO Regional Office for Africa; 2018 (https://www.who.int/immunization/programmes_systems/financing/countries/en/, accessed 30 November 2018).
52. Setting priorities in communicable disease surveillance. Geneva: World Health Organization; 2006. (WHO/CDS/EPR/LYO/2006.3; https://www.who.int/csr/resources/publications/surveillance/WHO_CDS_EPR_LYO_2006_3.pdf, accessed 30 November 2018).
53. Christaki E. New technologies in predicting, preventing and controlling emerging infectious diseases. Virulence. 2015;6(6):558-65. doi:10.1080/21505594.2015.1040975.
54. Assessing the yellow fever outbreak in Angola: European Medical Corps mission undertaken in the framework of the European Union Civil Protection Mechanism. Stockholm: European Centre for Disease Prevention and Control; 2016 (https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/yellow-fever-angola-joint-ecdc-mission-report-2016.pdf, accessed in 30 November 2018).
55. Could the latest Ebola outbreak help avert future epidemics? In: PATH [website]; 2017 (https://www.path.org/articles/could-the-latest-ebola-outbreak-help-avert-future-epidemics/, accessed 30 November 2018).
56. Kraemer MUG, Faria NR, Reiner RC Jr, Golding N, Nikolay B, Stasse S, Johansson MA, Salje H, Faye O, Wint GRW, Niedrig M, Shearer FM, Hill SC, Thompson RN, Bisanzio D, Taveira N, Nax HH, Pradelski BSR, Nsoesie E, Murphy NR, Bogoch II, Khan K, Brownstein JS, Tatem AJ, de Oliveira T, Smith DL, Sall AA, Pybus OG, Hay SI, Cauchemez S. Spread of yellow fever virus out-break in Angola and the Democratic Republic of the Congo 2015-16: a modelling study. Lancet Infectious Diseases. 2017;17(3):330-338. doi:10.1016/S1473-3099(16)30513-8.
57. Satellite Data Aids in Predicting Cholera Outbreaks. In: Scientific American [website]; 2018 (https://www.ehealthafrica.org/avadar/, accessed 30 November 2018).
58. Corey CK, Noymer A. A 'post-honeymoon' measles epidemic in Burundi: mathematical model-based analysis and implications for vaccination timing. PeerJ. 2016;4. doi:10.7717/peerj.2476.
59. Community-Based Surveillance: guiding principles. Geneva: International Federation of Red Cross and Red Crescent Societies; 2017 (https://media.ifrc.org/ifrc/wp-content/uploads/sites/5/2018/03/CommunityBasedSurveillance_Global-LR.pdf, accessed 30 November 2018).
60. Sub-Saharan Africa to Witness Fastest Growth in Mobile Usage Rates Globally. Mountain View; 2015. (http://images.discover.frost.com/Web/FrostSullivan/AFR_PR_SJames_MA20-65_06Jan15.pdf, accessed 30 November 2018).
61. Auto-Visual AFP Detection and Reporting (AVADAR). In: eHealth Africa [website]; 2018 (https://www.ehealthafrica.org/avadar/, accessed 30 November 2018).
62. Meeting Technical Report. In: Proceedings. Improving Vaccination Coverage and Reducing Inequities: Use of GIS in Immunization Programs, New York, USA, 25–26 October 2016. New York: Unicef; 2017 (https://www.unicef.org/health/files/3._Final_Report_February_2017.pdf, accessed 30 November 2018).
63. GIS Technology Helps Eradicate Polio. In: Information Week [website]; 2018 (https://www.informationweek.com/healthcare/gis-technology-helps-eradicate-polio/d/d-id/1297265, accessed 30 November 2018).
64. Odlum M, Yoon S. What can we learn about the Ebola outbreak from tweets?. Am J Infect Control. 2015;43(6):563-71. doi:10.1016/j.ajic.2015.02.023.
65. Majumder MS, Santillana M, Mekaru SR, McGinnis DP, Khan K, Brownstein JS. Utilizing Nontraditional Data Sources for Near Real-Time Estimation of Transmission Dynamics During the 2015-2016 Colombian Zika Virus Disease Outbreak. JMIR Public Health Surveill. 2016;2(1). doi:10.2196/publichealth.5814.
66. Healthmap screenshot on 30 November for African Region. In: HealthMap [website]; 2018 (https://www.healthmap.org/en/, accessed 30 November 2018).
67. Meeting report. In: Proceedings. WHO Technical consultation on event-based surveillance, Lyon, France, on 19–21 March 2013. Geneva: World Health Organization; 2013 (http://www.episouthnetwork.org/sites/default/files/meeting_report_ebs_march_2013_final.pdf, accessed 30 November 2018).
68. A Guide to Establishing Event-based Surveillance. Manila: WHO Regional Office for the Western Pacific; 2008 (http://www.wpro.who.int/emerging_diseases/documents/docs/eventbasedsurv.pdf, accessed 30 November 2018).
69. Weekly epidemiological record, n°4, January 2002. Geneva: World Health Organization; 2002 (https://www.who.int/docstore/wer/pdf/2002/wer7704.pdf, accessed 30 November 2018).
70. IRAQ: Early Warning and Alert Response Network (EWARN) Snapshot #7 Displacement Crisis in Iraq from week 1 to week 9, 2015. In: United Nations Iraq; 2015 (http://www.uniraq.com/index.php?option=com_k2&view=item&id=3481:iraq-early-warning-and-alert-response-network-ewarn-snapshot-7-displacement-crisis-in-iraq-from-week-1-to-week-9-2015&Itemid=626&lang=en, accessed 30 November 2018).
71. Dion M, AbdelMalik P, Mawudeku A. Big Data and the Global Public Health Intelligence Network (GPHIN). Canada Communicable Disease Report. 2015;41(9):209-14. doi:10.14745/ccdr.v41i09a02.
72. Mawudeku A, Blench M, Global public health intelligence network (GPHIN). In: Proceedings. Eighth Conference of the Association for Machine Translation in the Americas, Cambridge, USA, 9–11 August 2006. Columbia: Association for Machine Translation in the Americas (AMTA); 2006 (https://amta2006.amtaweb.org/ or http://www.mt-archive.info/MTS-2007-Blench.pdf, accessed 30 November 2018).
73. Charting the next pandemic. In: Global Epidemic and Mobility [website]; 2018 (http://www.gleamviz.org/, accessed 30 November 2018).
74. Cary Blair Transport Medium notice. In: Thermofisher Scientific [website]. Waltham: Thermofisher Scientific; 2008 (https://assets.thermofisher.com/TFS-Assets/LSG/manuals/IFU60450.pdf, accessed 30 November 2018).
75. Transport Swab with Cary Blair medium. In: Innovmed [website]. WenZhou: Innovmed; 2018

(http://www.innovmed.com/product/Swab-03.html, accessed 30 November 2018).

76. Helfand R, Cabezas C, Abernathy E, Castillo-Solorzano C, Ortiz CA, Sun H, Osores F, de Oliveira LH, Whittembury A, Charles M, Andrus J, Icenogle J. Dried Blood Spots versus Sera for Detection of Rubella Virus-Specific Immunoglobulin M (IgM) and IgG in Samples Collected during a Rubella Outbreak in Peru. Clinical and Vaccine Immunology. 2007;14(11):1522-25. doi:10.1128/CVI.00144-07.
77. Early HIV diagnosis in infants works in Africa, but the technology must spread to save lives. In: Devex [website]; 2018 (https://www.devex.com/news/early-hiv-diagnosis-in-infants-works-in-africa-but-the-technology-must-spread-to-save-lives-91771, accessed 30 November 2018).
78. Kiyaga C, Sendagire H, Joseph E, McConnell I, Grosz J, Narayan V, Esiru G, Elyanu P, Akol Z, Kirungi W, Musinguzi J, Opio, A. Uganda's new national laboratory sample transport system: a successful model for improving access to diagnostic services for Early Infant HIV Diagnosis and other programs. PLoS One. 2013;8(11). doi:10.1371/journal.pone.0078609
79. In a First, Drone Used to Collect Medical Samples from Rural Village. In: LifeScience [website]; 2016 (https://www.livescience.com/55744-drone-collects-medical-samples-from-remote-village.html, accessed 30 November 2018).
80. What is PCR. In: Highveld [website]. Highveld; 2018 (http://www.highveld.com/pcr/what-is-pcr.html, accessed 30 November 2018).
81. TaqMan Array Cards Product Bulletin. In: Thermofisher Scientific [website]. Waltham: Thermofisher Scientific; 2008 (https://assets.thermofisher.com/TFS-Assets/GSD/Reference-Materials/taqman-array-cards-product-bulletin.pdf, accessed 30 November 2018).
82. Onyango CO, Loparev V, Lidechi S, Bhullar V, Schmid DS, Radford K, Lo MK, Rota P, Johnson BW, Munoz J, Oneko M, Burton D, Black CM, Neatherlin J, Montgomery JM, Fields B. Evaluation of a TaqMan Array Card for Detection of Central Nervous System Infections. Journal of Clinical Microbiology. 2017;55(7):2035-44. doi:55.10.1128/JCM.02469-16.
83. Pai NP, Vadnais C, Denkinger C, Engel N, Pai M. Point-of-care testing for infectious diseases: diversity, complexity, and barriers in low- and middle-income countries. PLoS Med. 2012;9(9). doi:10.1371/journal.pmed.1001306.
84. Cholera – Zimbabwe, Disease Outbreak News. In: World Health Organization. Geneva: World Health Organization; 2018 (https://www.who.int/csr/don/20-september-2018-cholera-zimbabwe/en/, accessed 30 November 2018).
85. Crystal® VC Rapid Diagnostic Test (RDT) Procedure. In: Centers for Disease Control and Prevention [website]. Atlanta: Centers for Disease Control and Prevention; 2018 (https://www.cdc.gov/cholera/pdf/crystal-vc-eng-p.pdf, accessed 30 November 2018).
86. New technology allows for rapid diagnosis of Ebola in Democratic Republic of the Congo. In World Health Organization [website]. Brazzaville: WHO Regional Office for Africa; 2018 (https://afro.who.int/fr/node/6187, accessed 30 November 2018).
87. The New GeneXpert® System, product brochure. Sunnyvale: Cepheid; 2018 (http://www.cepheid.com/us/component/phocadownload/category/1-about-us?download=12:gx-brochure, accessed 30 November 2018).
88. 7 advantages of e-learning. In: Learning Pool [website]. Belfast: Learning Pool; 2018 (https://www.learningpool.com/blog/advantages-e-learning-infographic/, accessed 30 November 2018).
89. Specialized Online Training. In: MLM Training Nigeria [website]. Abuja: MLM Training Nigeria; 2018 (https://mlmtrainingnigeria.com/course/index.php, accessed 30 November 2018).
90. Performance Report - Q3 2017. Brazzaville: WHO Regional Office for Africa; 2018 (ISBN: 978-929023367-1).
91. Ministry of Health Malawi, Health Surveillance Assistants as Change agents for Community Case Management. In: Proceedings. Integrated Community Case Management, Evidence Review Symposium, Accra, Ghana, 3–5 March 2014.
92. Training Manual Facilitator's Guide. Ministry of Health Malawi; 2009.
93. Mission. In: World Bank [website]. Washington: World Bank; 2018 (https://www.rbfhealth.org/mission, accessed 30 November 2018).
94. C'est quoi le PBF?. In: Sina Health [website]. La Haye: Sina Health; 2018 (http://www.sina-health.com/?page_id=80&lang=fr, accessed 30 November 2018).
95. Bertone MP, Falisse JB, Russo G, Witter S. Context matters (but how and why?) A hypothesis-led literature review of performance based financing in fragile and conflict-affected health systems. PLOS ONE. 2018;13(4). doi:10.1371/journal.pone.0195301.
96. Pandemic Emergency Financing Facility. In: World Bank [website]. Washington: World Bank; 2018 (http://www.worldbank.org/en/topic/pandemics/brief/pandemic-emergency-facility-frequently-asked-questions, accessed 30 November 2018).
97. Somda ZC, Perry H, Messonnier NR, Djingarey M, Ouedraogo KS, Meltzer MI. Modeling the Cost-Effectiveness of the Integrated Disease Surveillance and Response (IDSR) System: Meningitis in Burkina Faso. PloS one. 2010;5(9). doi: 10.1371/journal.pone.0013044.

ANNEXES

Annex A:
METHODOLOGY FOR COUNTRY CATEGORIZATION

Each country was assessed based on a four-step approach, using the surveillance maturity grid.

STEP 1: Define the components

- 6 key components have been identified and validated in collaboration with stakeholders
- 4 different levels of maturity have been considered
- Each component has been clearly defined for each of the 4 maturity levels

STEP 2: Collect individual assessment from key stakeholders

- Interviews were conducted to introduce participants to the maturity grid and objectives of the categorization work
- An excel document has been shared so that stakeholders could individually assess the country's components maturity levels

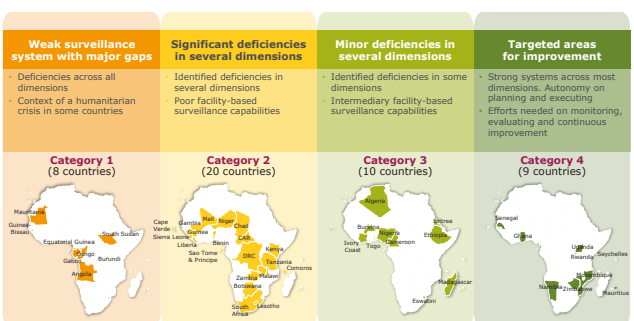
Countries	Governance and management	Standards setting for surveillance	Surveillance process and reporting	Average scoring	Country category
Eq. Guinea	1	1	1	1,1	1
Gambia	1,5	2	2	2,1	2
Iv. Coast	2,5	3	4	3,2	3
Rwanda	3,5	3	4	3,6	4
...					
47 countries					

STEP 3: Compile output

- Outputs were compiled together so that each of the 47 countries was assessed on its 6 components (from 1 to 4)
- Similarly to a segmentation exercise, a general scale was defined to generate homogeneous groups of countries
- Cross diseases components have been weighted with JEE results

STEP 4: Adjust and validate categories

- To avoid subjective bias, compilation outputs have been reviewed during a workshop involving a wide range of key stakeholders
- Adjustments were made collectively to take into account country specific context and recent events / data points



Annex B:
METHODOLOGY FOR ECONOMIC MODELING

The economic modeling quantifies the expected impact of VPD surveillance on cases, deaths, sequelae and economic benefits

STEP 1: Disease selection

- **High burden VPDs:**
  - Meningitis, measles, pneumococcal diseases and rotavirus,
- **Outbreak prone VPDs:**
  - Cholera and yellow fever

STEP 2: Costs estimation

- **Current costs** (baseline year)

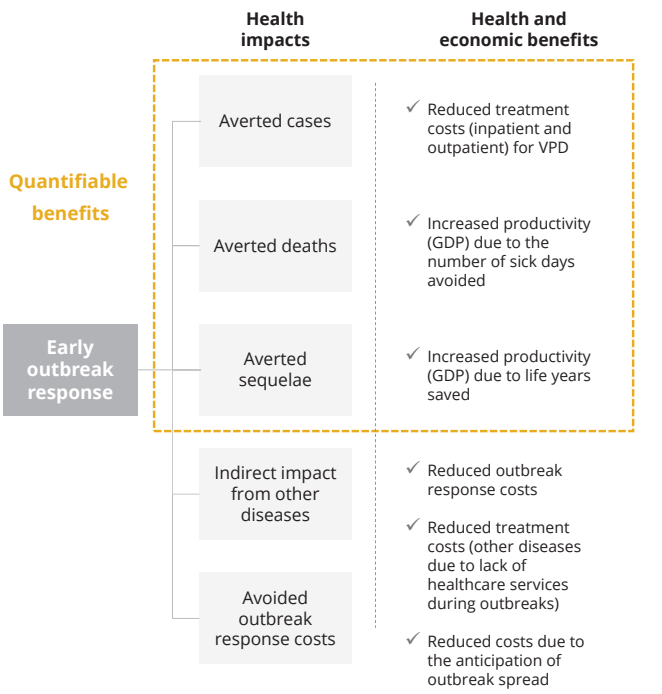
Cost	Description
Baseline	Baseline costs will be based on available cMYPs from countries in the African Region
Infrastructure costs	Sunk costs in capital investments already made, such as laboratories or sentinel sites
Operating costs	Annual current operating costs to maintain a surveillance system up and running (e.g. staff, reagents, sample transportation)

- **Future costs**

Cost	Description
Investment costs	One-off investment costs to meet the ambition for 2030 (e.g. surveillance and laboratory capacity building, data analysis, mobile technology, integrated system implementation, modelling tools)
Additional operating costs	Additional annual operating costs resulting from an increased scope of diseases and number of samples tested, and from an enhanced surveillance quality (case-based instead of aggregate surveillance)

- Note : Vaccine-preventable diseases surveillance activities must be coupled with a functional and responsive response system to have a positive impact

STEP 3: Quantifiable benefits identification



STEP 4: Health economic modelling

- **Best case scenario:**
  - Impact of reaching the ambition for 2030,
  - Main assumption: enhanced surveillance and response would reduce disease incidence by 15% and case fatality rate (CFR) by 26,8% *(97)*.
- **Worst case scenario:**
  - Impact of not funding and implementing VPD surveillance,
  - Assumption: revert back to 2000's situation regarding VPD outbreaks.

The limits of this model are the following:
- Reliance on cMYPs data reported by countries,
- Limited scope of diseases,
- Limited scope of quantifiable benefits,
- Limited number of available studies on VPD surveillance impact and benefits in the African Region

Source: 97- Somda et al., PLoS ONE, 2010
Note: *Among other benefits that could have been quantified are those derived from (i) optimization of immunization programmes, (ii) better information on genotypes, mutations and resistance and (iii) better availability and quality of data, allowing evidence-based decision-making.

ACRONYMS

ADAP: Antibody Detection by Agglutination-PCR
ADI: Addis Declaration on Immunization
AFP: Acute Flaccid Paralysis
AVADAR: Auto-Visual AFP Detection and Reporting
CAR: Central African Republic
CBS: Community-Based Surveillance
CDC: Centers for Disease Control and Prevention
CEBS: Community Event-Based Surveillance
cMYP: Comprehensive Multi-Year Plan
CRS: Congenital Rubella Syndrome
CSO: Civil Society Organizations
DBS: Dried Blood Spot
DHIS2: District Health Information Software 2
DNA: DeoxyriboNucleic Acid
DRC: Democratic Republic of Congo
EBS: Event-Based Surveillance
ECA: Economic Commission for Africa
ELISA: Enzyme-Linked Immunosorbent Assay
EoC: Emergency Operation Center
EPI: Expanded Programme on Immunization
EQA: External Quality Assessment
EVD: Ebola Virus Disease
EWARN: Early warning alert and response network
FETP: Field Epidemiology Training Program
G7: Group of Seven
Gavi: Global Alliance for Vaccines and Immunization
GDP: Gross Domestic Product
GFIMS: Global Framework for Immunization Monitoring and Surveillance
GHSA: Global Health Security Agenda
GIS: Geographic Information Systems
GLEaM: Global Epidemic and Mobility
GPEI: Global Polio Eradication Initiative
GPHIN: Global Public Health Intelligence Network
GPLN: Global Polio Laboratory Network
GVAP: Global Vaccine Action Plan
HIV: Human Immunodeficiency Virus
HPV: Human Papilloma Virus
HRH: Human Resources for Health
ICRC: International Committee of the Red Cross
IDSR: Integrated Disease Surveillance and Response
IFRC: International Federation of Red Cross and Red Crescent Societies
IHME: Institute for Health Metrics and Evaluation
IHR: International Health Regulations
IMC: International Medical Clinic
INRB: Institut National de Recherche Biomédicale
JEE: Joint External Evaluation
KPI: Key Performance Indicators
MCEE: Maternal Child Epidemiology Estimation
MERS-CoV: Middle East Respiratory Syndrome Coronavirus
MLM: Mid-Level Managers
MRI: Measles and Rubella Initiative
MSF: Médecins Sans Frontières
NAPHS: National Action Plans on Health Security
NCDC: Nigeria Center for Disease Control and Prevention
NGO: Non-Governmental Organization
NITAG: National Immunization Technical Advisory Group
PBF: Performance-Based Financing
PCR: Polymerase Chain Reaction
PEF: Pandemic Emergency Facility
PoCT: Point-of-Care Testing
RDT: Rapid Diagnostic Test
REW: Reach Every Ward
RFID: Radio Frequency Identification
RI: Routine Immunization
RITAG: Regional Immunization Technical Advisory Group
ROI: Return on investment
RSPI: Regional Strategic Plan for Immunization
RT-PCR: Real Time Polymerase Chain Reaction
SDG: Sustainable Development Goals
SIA: Supplementary Immunization Activities
SLRC: Sierra Leone Red Cross
SMS: Short Message Service
TEPHINET: Training Programs in Epidemiology and Public Health Interventions Network
UHC: Universal Health Coverage
Unicef: United Nations International Children's Emergency Fund
VPD: Vaccine Preventable Diseases
WHA: World Health Assembly
WHE: World Health Emergency
WHO: World Health Organization
WISE: WHO Immunization Information System

World Health Organization

ACT'VISION Communication