IMPROVEMENT STRATEGIES MODEL:

ADJUSTMENT TO POPULATION HEALTH NEEDS: SURVEILLANCE

Led by: BILL & MELINDA GATES *foundation*   THE WORLD BANK IBRD • IDA | WORLD BANK GROUP   World Health Organization   In partnership with: ARIADNE LABS   RESULTS FOR DEVELOPMENT

SURVEILLANCE

Surveillance is the ongoing and systematic collection, analysis, and interpretation of health-related data essential to the planning, implementation, and evaluation of service delivery and public health. (1–3) Strong surveillance systems are dynamic and multimodal networks that combine monitoring and response activities to enable a country to identify and respond to emerging and existing threats and continuously assess and respond to communities' needs over time. (4,5) Effective surveillance systems consistently perform the four functions listed below: (3,6-8)

- Track health and burden of disease metrics (morbidity, mortality, incidence)
- Detect, report, and investigate notifiable disease, events, symptoms, and suspected outbreaks or extraordinary occurrences
- Continuously collect, collate, and analyze the resulting data
- Submit timely and complete reports from local to higher levels of the system and from higher levels of the system back to lower/community levels

In addition to collecting data on the incidence of communicable diseases of public health significance and subsequent notification of emergency response systems, effective surveillance systems should also collect comprehensive information on population health to inform service delivery. For example, an effective surveillance system would be designed to detect, report, and investigate an incident of viral meningitis, as well as flag a slow building increase in diabetes complications or seasonal increase in road traffic injuries.

WHAT IT IS: WHAT IS SURVEILLANCE AND WHY IS IT IMPORTANT?

WHAT IS THE ROLE OF PHC IN SURVEILLANCE?

High-quality primary health care can meet 90% of population health needs (9,10) and should be the first point of contact with the health system for most people for most health needs, most of the time. To be an effective first point of contact, primary health care must be able to consistently deliver services that users trust, value, and can easily access. (9,10, 11,12) As this first point of contact, PHC settings are critical sources of information and data for surveillance and response efforts, including maintaining routine service delivery and preventing disease outbreaks (13) through gathering of data, detecting and diagnosing conditions, alerting surveillance systems to trigger subsequent response, and providing case management at the primary care level. (14) A continuous feedback loop should be in place across all levels of the health system to ensure that information informs action and improves routine service delivery activities. The information generated from surveillance and response efforts at the primary care level, including lessons learned from past response to outbreaks, should be integrated into the broader surveillance system for continuous strengthening of the health system.

WHAT ARE THE DIFFERENT TYPES OF SURVEILLANCE?

Effective surveillance hinges on consistent access to reliable, real-time data that captures a comprehensive range of information on population health needs and events of public health significance (15, 16,17) As countries undergo epidemiological transitions,(18,19) surveillance systems must be equipped to track a broad spectrum of communicable and noncommunicable diseases to meet global targets and ensure comprehensive disease surveillance. (16) There are three types of surveillance that are essential for strong PHC: (20, 6,21)

- **Indicator-based surveillance:** Indicator-based surveillance is the systematic collection, monitoring, analysis, and interpretation of data (usually notifiable diseases) produced by formal or traditional information sources. Formal sources include official or authorized sources in direct contact with the event, such as primary care facilities and hospitals, clinicians, and local laboratories. (22) (Table 1)

- **Event-based surveillance:** Event-based surveillance refers to the organized and rapid collection, monitoring, assessment, and interpretation of mostly ad-hoc information about events that pose a potential risk to public health. These data typically come from informal sources, such as the media, social-network channels, and other crowd-sourced information. (22) Event-based systems are often designed to be complementary to traditional indicator-based surveillance systems to enhance the capacity of the national surveillance system to detect a more comprehensive set of public health threats, including rare and new events not included in indicator-based surveillance and events that occur in populations who access care through informal or non-traditional channels. (23) Strengthening event-based surveillance is discussed more in the WHO's Guide to Establishing Event-Based Surveillance and their report on early detection, assessment and response to acute public health events: implementation of early warning and response with a focus on event-based surveillance. (Table 1)

- **Syndromic surveillance:** Syndromic surveillance is a method of surveillance that aims to detect outbreaks earlier than traditional methods by focusing "on the early symptom period before clinical or laboratory confirmation of a particular disease" (24) and using both clinical and alternative data sources such as care-seeking rates, insurance claims, laboratory ordering volume, school and work absenteeism, over-the-counter drug sales, and internet-based health searches.

	Event-based surveillance	Indicator-based surveillance
Objectives	Detect Outbreaks	Detect outbreaks; define disease trends, seasonality, burden, risk factors
Information sources	Official and unofficial reports of potential disease events from a wide variety of sources including media, rumors, blogs, community members, etc.	Reports of cases of diseases from health care providers, including physicians and hospital laboratories
Information credibility	Reports need verification to ensure cases meet a specific case definition, and are most credible when supported by laboratory confirmation	Reports are usually credible because health care providers are instructed to only report cases that meet specific case definitions, but the most credible reports involve laboratory-confirmed cases
Timeliness	May be reported early, even before ill persons have sought medical attention	Reported by health care provider after ill persons have sought medical attention; may sometimes be delayed while awaiting laboratory confirmation or due to reporting requirements.
Where is it used?	Can be used anywhere	Where health infrastructure exists and health care providers and laboratories are willing to participate in public health surveillance
What diseases is it used for?	All public health events involving potential disease, including events caused by unknown disease	Usually known diseases

Table 1. Adapted from the Centers for Disease Control and Prevention webpage on global health protection and security: event-based surveillance. Available from:
https://www.cdc.gov/globalhealth/healthprotection/gddopscenter/how.html

HOW ARE SURVEILLANCE PRIORITIES DETERMINED?

An important component of surveillance is aligning with national and subnational priority setting processes to review disease control priorities and identify which health conditions and diseases should be closely monitored and how. These priorities should reflect population health needs and will subsequently inform how resources for surveillance should be utilized. (25) According to the WHO's Recommended Surveillance Standards, when considering what priority diseases to select, questions stakeholders might consider include:

- Does the disease have a significant impact on morbidity, mortality, and disability? (morbidity, disability, mortality)
- Does it have significant epidemic potential (e.g. cholera, meningitis, measles)
- Is the disease named as a target of a national, regional, or international control plan? (e.g. the WHO IHR)
- If the data were collected, would they lead to significant public health action? (e.g. immunization campaign or other specific control measures provided by the national health system)

Effective priority setting helps governments make the best use of limited human and financial resources and take advantage of new methods and techniques to strengthen surveillance. (26) Users can find more information on conducting prioritization exercises for surveillance in the WHO's Recommended Surveillance Standards and report on Setting Priorities in Communicable Disease Surveillance, the World Bank's Disease Control Priority Series, and in the Priority Setting module.

HOW IS SURVEILLANCE INTEGRATED INTO A NATIONAL PLAN?

After priority diseases have been selected, a plan of action should be developed.(25) Each country should regularly assess its national surveillance system and develop and implement national action plans to improve the core functions of surveillance.(27) National surveillance procedures, plans, and/or strategies should be regularly evaluated and tested (either through simulations or real health threats) to ensure continuous operational capacity. (27)

The national plan should include the following elements relevant to surveillance:

- **Plans for developing or enhancing event-based and syndromic surveillance:** Users can look to WHO guidance on implementation in national legislation for additional support in facilitating surveillance and response activities that meet International Health Regulation (IHR) obligations. Policy and legislation should also promote investment in infrastructure that support the functions of event-based and syndromic surveillance systems, such as electronic information systems and modernized laboratories and clinics. More information on *Information Systems* and *Facility Infrastructure* is coming soon.
- **Public health emergency response plan.** Procedures, plans, and/or strategies should be in place to activate responses to public health emergencies at the local level and elevate to higher levels as needed. Users can find more information in the Emergency Response Operations Indicator of the WHO's Joint External Evaluation Tool: International Health Regulations (2005).

- **System for sending and receiving medical countermeasures and health personnel during a public health emergency.** Medical countermeasures are products that can be used in a public health emergency including biological products, drugs, and devices. Users can find more information in the Medical Countermeasures and Personnel Deployment Indicator of the WHO's Joint External Evaluation Tool: International Health Regulations (2005).

To ensure the rapid response and systematic monitoring of a comprehensive spectrum of health threats and diseases, countries' surveillance strategies may differ between the local, regional, and national levels. Surveillance systems that engage multiple strategies will require coordination among the different health authorities at multiple levels of the health system. (28) Users can find more information on developing a detailed plan of action for surveillance and response systems in the WHO's guide to monitoring and evaluating communicable disease surveillance and response systems here and on the different types of surveillance strategies here.

HOW DO INFORMATION SYSTEMS SUPPORT SURVEILLANCE?

Effective surveillance systems use data to quickly and effectively identify emerging threats and continuously assess and respond to communities' needs over time. (5) However, collecting and recording data has little use without mechanisms in place to detect incidences or trends, specific communication channels for reporting, and trained staff with the necessary expertise to investigate and respond to these incidences or trends. The establishment of feedback loops for communication between the national and community level is particularly important for timely response to incidents as well as for overall integration of the surveillance system into service delivery at the facility and community level. (15), (29)

The most effective information systems are entirely electronic, interoperable, and interconnected. (30–32) Interoperability is the ability of different surveillance systems, processes, devices, or applications to connect, in a coordinated manner, within and across organizational or geographic boundaries to access, exchange, and cooperatively use data amongst stakeholders. This in turn allows stakeholders to respond to disease instances, with the goal of optimizing the health of individuals and populations. (33) Interconnectedness refers to the facilitated linkage or connection of all constituent parts of the surveillance system. This includes the connection of surveillance system components—data systems, detection, reporting and investigative activities, and feedback loops—within a sub-national health system network, and to the linkage between different sub-national health system networks. High-performing information systems enable:

- **The continuous collection of data on diseases and events of public health significance** (including burden of diseases data) from both traditional (indicator-based) sources and non-traditional sources, such as community-based or crowd-sourced data. (34), (15), (16), (17). More information on collecting data from non-traditional sources can be found in the WHO's guide for establishing community-based surveillance. This information should inform planning for future and ongoing community needs at the facility level and in the community, such as through proactive population outreach activities.
- **Systematic and timely reporting** from local to higher levels of the system and from higher levels of the system back to lower/community levels. Feedback loops between facilities, sub-national regions, and the centralized levels of the health system are critical to ensure that the data actually informs action. The flow of information from the national level back to facility is particularly important for response to incidents, as well as for overall integration of the surveillance system into population health and facility management.

- **Linkages** to laboratory and other information systems and coordination with actors in other relevant sectors to provide a complete surveillance picture. More information on strengthening health systems through coordination can be found in the WHO Framework for Action Toward Coordinated/Integrated Health Services Delivery and the World Bank report on Health Reform in China.
- **Timely analysis** of surveillance data by designated data analysis teams.
- **Timely reporting** of surveillance data by designated reporting teams.

Communication systems should promote feedback systems between facilities, sub-national regions, and the centralized levels of the health system. The flow of information from the national level back to facility is particularly important for response to incidents, as well as for overall integration of the surveillance system into population health and facility management. Relevant health workers must be appropriately trained and have a clear understanding of communication channels for reporting as well as the processes for investigating and responding to reports.

Users can access more information on improving the quality, availability, analysis, use, and accessibility of data in SCORE for health data, a technical package of essential interventions, actions, tools, and resources that aim to improve health information systems in countries. Additionally, users can find more information on developing well-functioning information systems in the WHO's handbook on Monitoring the Building Blocks of Health Systems: Information Systems and their Strategic Framework for Effective Communications as well as the Improvement Strategies module on *Information Systems*.

WHAT FACTORS ENABLE ROBUST SURVEILLANCE SYSTEMS?

Workforce development

Surveillance relies on the availability of a fully competent, coordinated, and multidisciplinary health workforce responsible for public health surveillance and response at all levels of the health system. (4), (15), (29-31) A detailed national workforce strategy that is tracked and reported on annually is a necessary prerequisite for training and sustaining a competent workforce. A national workforce strategy should delineate plans to provide continuous education and retain and promote qualified workforce within the national health system. (6) Strategies for developing and evaluating Workforce Development for sustainable and functional public health surveillance and response are discussed in the Workforce Development indicator in the WHO's Joint External Evaluation tool - Monitoring and Evaluation Framework.

Facility infrastructure

Health workers must also be supported by appropriate facility infrastructure and systems for effective population health management, such as empanelment and local priority setting, in order to be able to effectively and proactively detect, monitor, and respond to health threats and continuously monitor communities' needs over time. (29-31), (35) Users can find more information in the population health management Improvement Strategies module. Additionally, facilities should be equipped or in networks with laboratories with biosurveillance and laboratory-based diagnostic capacities (such as HIV genotyping) and clinics with point-of-care diagnostic capacities. For the timely and effective detection of public health threats, these laboratories must conform to international quality standards and adhere to standard operating procedures for transporting and collecting specimens that require advanced diagnostics at the national level. Users can find more information on building a sustainable capacity for testing and diagnostics at the point-of-care and in laboratories in the National Laboratory System Indicator of the

Joint External Evaluation tool - Monitoring and Evaluation Framework. More information on *Facility Infrastructure* is coming soon.

Communication and coordination

Effective, regular, and inclusive communication and coordination between stakeholders at all levels of the health system, including the community and the private sector is critical for ensuring that all relevant actors are included at the right time. To support a transparent and participatory engagement process, there should be established processes for engaging key national, regional, local, and international stakeholders with a clear definition of roles, sharing of resources, and joint action plans. Users can find more information in the Internal and Partner Communication and Coordination and Public Communication indicators of the WHO's Joint External Evaluation Tool: International Health Regulations (2005).

More information on strengthening health systems through coordination can be found in the WHO Framework for Action Toward Coordinated/Integrated Health Services Delivery and the World Bank report on Health Reform in China. More information on coordination activities and broad approaches to improve the delivery of care can be accessed in the Care Coordination Measures Atlas from the Agency for Healthcare Research and Quality.

Trust

Because many stakeholders are involved in surveillance, it's critical to facilitate trust among different levels of the health system, the public, the media, and non-health sectors. Communication systems might include partnerships between the government and diverse media outlets to provide health advice and address misinformation to the public in a factual and accessible manner. Users ca n find more information on building public communication, listening, and rumor management systems in the Risk Communication indicator of the WHO's Joint External Evaluation Tool: International Health Regulations (2005).

WHAT OTHERS HAVE DONE: WHAT HAS BEEN DONE ELSEWHERE TO IMPROVE SURVEILLANCE?

MULTIPLE COUNTRIES: COMMUNITY HEALTH WORKER-BASED SURVEILLANCE IN RESOURCE-CONSTRAINED CONTEXTS

Effective surveillance hinges on consistent access to reliable, real-time data that captures a comprehensive range of information on population health needs and events of public health significance (15, 16, 17) Collecting these data is particularly challenging in countries facing significant resource-constraints and a significant rural or isolated population. To address this challenge, a number of countries have used community-based or crowd-sourced data, such as InfluenzaNet and social media postings, to complement traditional facility-based data used in surveillance systems. (34)

Considering the rapid global expansion of community health worker (CHW) programs, CHWs offer a promising platform for strengthening surveillance systems in rural, resource-constrained settings. Several countries are already experimenting with CHW-based participatory-surveillance systems, often through the use of mobile phones. (34) In this model, CHWs collect data as a part of their routine course of care. Studies conducted on CHW-based surveillance in Nepal, Malawi, and Kenya have shown promise that CHW-collected data can supplement data collected at local facilities and support surveillance activities. (34,36,37) The efficacy of this model relies on factors that affect data validity, reliability, and quality such as local participation, presence of well-trained and supervised CHWs capable of conducting surveillance activities, (38) and ongoing support and quality improvement training. These CHW-based data collection strategies have the potential to improve surveillance capabilities in resource-constrained settings and aid real-time decision-making response to population health needs and resource allocation at the local and policy-making level. While these interventions have shown some success in tracking disease trends, it is important to note that individual, self-reported data can have limitations, including a lack of routine collection and should be supplemented with other sources.

AFRO REGION: INTEGRATED DISEASE SURVEILLANCE AND RESPONSE

In the 1990s, several countries across the WHO Africa Region (WHO-AFRO) experienced devastating outbreaks of largely preventable diseases including yellow fever, cholera, and ebola. These outbreaks had significant death tolls and affected biosecurity in the region. In response, ministries of health from the AFRO region partnered with the WHO to develop systems with a robust capacity to detect, confirm, and respond to public health events in a timely and reliable fashion and strengthen surveillance at every level of the health system.(21) In 1998, they adopted what is now known as the Integrated Disease Surveillance and Response (IDSR) strategy which aims to develop and implement integrated, comprehensive surveillance and response systems that meet African priorities and improve data collection and use at each level of the health system. (21,39)

The IDSR has since been adopted by 43 out of 46 African countries in the WHO-AFRO region. Each country's national IDSR strategy uses a priority setting process to define its disease priorities, administrative processes, and the roles and responsibilities of key partners and stakeholders at every level of the health system (in both the private and public sector). It also aligns with IHR requirements, priority health threats to include priority diseases, syndromes, conditions, and events of international concern and encourages the integration of both traditional indicator-based and event-based surveillance. The coordinated exchange of information, resources, and tools between the private and public sector and

sourcing of event-based data have served to enhance surveillance capacities, including more timely detection and response to priority communicable and noncommunicable diseases through community-based surveillance. (21,40)

While the IDSR focuses on priority diseases, syndromes, and other conditions that afflict the 43 African countries that have adopted the strategy, the model offers two considerations that countries outside the AFRO region can adapt to support more effective surveillance systems in their context. First, the IDRS strategy is adaptable to changing health system needs. (40) Every country adapts their IDRS strategy to meet the national context while ensuring that surveillance tools and processes comply with global recommendations for control and response (in alignment with the International Health Regulations). This targeted approach is vital for creating a sustainable and acceptable surveillance system that stakeholders will use across the health system. Secondly, the IDRS strategy is coordinated and comprehensive. The IDSR strategy coordinates multiple disease surveillance activities by tracking both indicator and event-based data reported by national disease reporting systems in the public and private sector. (40) This multisectoral, coordinated approach strengthens the ability of the surveillance system to capture a comprehensive range of information on population health needs and events of public health significance. However, various studies have revealed challenges in the implementation of the IDSR system. (41,42) For example, in Malawi, significant gaps existed between technical IDSR guidance and case identification and timely reporting in practice. Common challenges to IDSR implementation were related to resource and structural issues, such as the availability of a sufficient cadre of trained staff, laboratory capacities, and communication systems. (42) Users can read more about the experience of implementing IDSR in the WHO African region here, challenges and lessons learned here, and the study on Malawi here.

WHAT TO ASK: WHAT QUESTIONS SHOULD BE CONSIDERED TO BEGIN IMPROVEMENTS?

Effective surveillance systems perform the four core functions:

- Track health and burden of disease metrics (morbidity, mortality, incidence)
- Detect, report, and investigate notifiable disease, events, symptoms, and suspected outbreaks or extraordinary occurrences
- Continuously collect, collate, and analyze the resulting data
- Submit timely and complete reports from local to higher levels of the system and from higher levels of the system back to lower/community levels

The questions below may be a useful starting place for assessing performance across these functions and determining whether surveillance is an appropriate area of focus for a given context and how one might begin to plan and enact reforms.

HOW COMPREHENSIVE IS YOUR SURVEILLANCE SYSTEM?

Comprehensive surveillance systems detect and track a broad spectrum of data on communicable and noncommunicable diseases and events from both formal and informal reporting sources. To enable this, comprehensive surveillance systems integrate the following types of surveillance strategies:

- Indicator-based surveillance
- Event-based surveillance
- Syndromic surveillance

To understand how comprehensive your surveillance system may be, you might consider the strengths and weaknesses of the different types of surveillance strategies included in your surveillance system and the information collected and reported by these systems. How are the different surveillance strategies used? If not all types of surveillance are being fully utilized, are there plans in place to develop or enhance these strategies? What types of data sources are used (i.e. facility based or informal)? Are these systems interoperable and interconnected?

HOW ARE REPORTS MADE AND HOW RELIABLE ARE THESE REPORTS?

Surveillance systems must submit timely and complete reports from local to higher levels of the system and from higher levels of the system back to lower/community levels. To understand where gaps in your surveillance system may be, you might consider looking at recent examples of surveillance reporting. How were reports made? Are they reliably sent? If not, are gaps due to problems with information systems, workforce training, policies, or other factors?

HOW RELIABLY AND SUCCESSFULLY HAVE FOLLOW-UP INVESTIGATIONS BEEN MADE?

Effective surveillance systems should produce reliable, high-quality, and accessible data, reports, and analysis of trends in priority diseases. These outputs of surveillance should be continuously documented with proof of alerts being triggered, followed up, and validated. If follow-up investigations to alerts are

not being made, stakeholders should identify and seek to understand why there are gaps. Are interoperable, interconnected, and electronic communication channels and information systems in place to produce data and reports and analyze trends? Are these consistently functioning? If not, are gaps due to problems with workforce training, policies, or other factors?

WHAT FEEDBACK LOOPS ARE IN PLACE?

Closed feedback loops should be in place between facilities, sub-national regions and the centralized levels of the health system to ensure that the data actually informs action. To assess the reliability and quality of these feedback loops stakeholders should consider factors such as:

- Does information flow from the national level back to the facility level?
- Are interoperable, interconnected, and electronic communication channels and information systems in place and consistently functioning?
- Do staff have identified communication channels to report to? Are there trained staff with the necessary expertise and processes to investigate and respond to reports?

If there are gaps, stakeholders should identify and seek to understand why there are gaps, such as whether they are due to inputs (i.e. information systems and workforce), policies, or other factors.

HOW TO SUCCEED: WHAT ELEMENTS SHOULD BE IN PLACE TO SUPPORT EFFECTIVE IMPROVEMENTS?

INNOVATION AND LEARNING

Lessons learned from past health threats or simulations should be integrated into the review of national plans for continuous strengthening of the health system. (43, 6) Together, innovation and learning and surveillance enhance a country's ability to identify and respond to emerging and existing threats and continuously assess and respond to communities' needs over time. (4,5)

Find more information in the innovation and learning Improvement Strategies module.

INFORMATION SYSTEMS AND INFORMATION SYSTEMS USE

The coordinated collection and use of high-quality data at all levels of the health system relies on the presence and functionality of information systems with a built-in capacity for rapid detection and response, such as in-real-time alerts and predictive modeling. To be of optimal use, information systems must produce reliable, complete, and timely information that ensures interoperability from a wide range of data sources and interconnectedness across all levels of the health system. (30–32)

Find more information in the *information systems* and information systems use Improvement Strategies modules.

ACCESS, PROACTIVE POPULATION OUTREACH, AND COMMUNITY ENGAGEMENT

To capture relevant and up-to-date information on population health needs, surveillance systems must be able to continuously collect and track information from formal sources, such as health facilities as well as informal sources, such as community-based or crowd-sourced data. Collecting and tracking information on population health needs relies on public use and confidence in the health system. From the patient perspective, utilization of the health system is influenced by access (timely, geographic, and financial) and acceptability (including the trust and value placed in services). Surveillance systems that leverage approaches to enhance access and public trust in service delivery, including proactive population outreach and community engagement, gather more accurate data and strengthen the capacity of the health system to effectively monitor and respond to health needs in emergencies and over time.

Find more information in the access, proactive population outreach, and community engagement Improvement Strategies modules.

GOVERNANCE AND LEADERSHIP, HEALTH FINANCING, PRIORITY SETTING, AND PRIMARY HEALTH CARE POLICIES

Developing and strengthening surveillance response at all levels of the health system relies on the long-term financial and political commitment of human, financial, and material tools and resources and establishment of a strategic plan of action to monitor and respond to the most important population

health needs. Investment in surveillance should begin with a systematic review of national priorities for surveillance, including the prioritization of diseases and health events for public health surveillance, to ensure the broader surveillance system is high-functioning and reflects national disease control priorities. Effective priority setting for surveillance helps to make the best use of limited resources for surveillance and continually adapt to changing population health needs. (26) To support surveillance for PHC, priority diseases should capture information on a comprehensive range of diseases to enable PHC facilities to respond to the diverse and complex needs of communities.

Find more information in the *governance and leadership, health financing,* priority setting*, and primary health care policies* Improvement Strategies modules.

REFERENCES – SURVEILLANCE

1. information I. Indicator 3.d.1: International Health Regulations (IHR) capacity and health emergency preparedness.

2. World Health Organization. Joint External Evaluation Tool. 2005;

3. World Health Organization. International Health Regulations (2005), Third Edition. World Health Organization; 2016.

4. World Health Organization. Primary Health Care Transforming Vision into Action: Operational Framework. World Health Organization; 2018.

5. Bitton A, Veillard JH, Basu L, Ratcliffe HL, Schwarz D, Hirschhorn LR. The 5S-5M-5C schematic: transforming primary care inputs to outcomes in low-income and middle-income countries. BMJ Glob Health. 2018 Oct 2;3(Suppl 3):e001020.

6. World Health Organization. Joint External Evaluation Tool: International Health Regulations (2005). World Health Organization; 2016.

7. World Health Organization. International Health Regulations. 2005;

8. World Health Organization. WHO | Public health surveillance [Internet]. [cited 2019 Jan 3]. Available from: https://www.who.int/topics/public_health_surveillance/en/

9. Doherty J. The Cost-Effectiveness of Primary Care Services in Developing Countries: A.

10. Rao M, Pilot E. The missing link--the role of primary care in global health. Glob Health Action. 2014 Feb 13;7:23693.

11. Agency for Healthcare Research and Quality. Care Coordination [Internet]. [cited 2018 Dec 4]. Available from: https://www.ahrq.gov/professionals/prevention-chronic-care/improve/coordination/index.html

12. Thomas-Hemak L. Closing the loop with referral management. Group Health Research Institute; 2013.

13. Kruk ME, Ling EJ, Bitton A, Cammett M, Cavanaugh K, Chopra M, et al. Building resilient health systems: a proposal for a resilience index. BMJ. 2017 May 23;357:j2323.

14. World Health Organization. Primary health care and health emergencies. World Health Organization; 2018.

15. Kruk ME, Myers M, Varpilah ST, Dahn BT. What is a resilient health system? Lessons from Ebola. Lancet. 2015 May 9;385(9980):1910–2.

16. PAHO/WHO. Health promotion: achievements and lessons learned from Ottawa to Bangkok. Pan American Health Organization World Health Organization; 2006 Aug. Report No.: CD47/16.

17. Kroll M, Phalkey RK, Kraas F. Challenges to the surveillance of non-communicable diseases--a review of selected approaches. BMC Public Health. 2015 Dec 16;15:1243.

18. World Health Organization. WHO | Chapter 1: Global Health: today's challenges [Internet]. 2003 [cited 2019 Jun 3]. Available from: https://www.who.int/whr/2003/chapter1/en/index3.html

19. Mendoza W, Miranda JJ. Global shifts in cardiovascular disease, the epidemiologic transition, and other contributing factors: toward a new practice of global health cardiology. Cardiol Clin. 2017 Feb;35(1):1–12.

20. Centers for Disease Control and Prevention. Event-based Surveillance | Division of Global Health Protection | Global Health | CDC [Internet]. [cited 2019 Jun 12]. Available from: https://www.cdc.gov/globalhealth/healthprotection/gddopscenter/how.html

21. Kasolo F, Yoti Z, Bakyaita N, Gaturuku P, Katz R, Fischer JE, et al. IDSR as a platform for implementing IHR in African countries. Biosecur Bioterror. 2013 Sep;11(3):163–9.

22. World Health Organization. Early detection, assessment and response to acute public health events: implementation of early warning and response with a focus on event-based surveillance. World Health Organization; 2014.

23. World Health Organization. A guide to establishing event-based surveillance. World Health Organization; 2008.

24. Henning K. Overview of Syndromic Surveillance: What is Syndromic Surveillance? [Internet]. Centers for Disease Control and Prevention: MMR Supplement. 2004 [cited 2019 Jan 24]. Available from: https://www.cdc.gov/MMWR/preview/mmwrhtml/su5301a3.htm

25. WHO, UNAIDS. WHO Recommended Surveillance Standards. Second edition. World Health Organization;

26. World Health Organization. Setting priorities in communicable disease surveillance. World Health Organization; 2006.

27. World Health Organization. International Health Regulations (2005): Areas of work for implementation. World Health Organization; 2007 Jun.

28. World Health Organization. Chapter 9: Monitoring, surveillance, and investigation of health threats. World Health Organization; 2017.

29. Institute of Medicine (US) and National Research Council. Enhancing Surveillance to Detect and Characterize Infectious Disease Threats - Biowatch and Public Health Surveillance - NCBI Bookshelf. 2011;

30. CDC. Disease Surveillance and Monitoring | About | CDC [Internet]. [cited 2019 Jun 3]. Available from: https://www.cdc.gov/about/facts/cdcfastfacts/surveillance.html

31. Institute of Medicine (US) Forum on Emerging Infections. Managed care systems and emerging infections: challenges and opportunities for strengthening surveillance, research, and prevention: workshop summary. Davis JR, editor. Washington (DC): National Academies Press (US); 2000.

32. Haggerty JL, Reid RJ, Freeman GK, Starfield BH, Adair CE, McKendry R. Continuity of care: a multidisciplinary review. BMJ. 2003 Nov 22;327(7425):1219–21.

33. HIMSS. What is Interoperability? | HIMSS [Internet]. [cited 2019 Mar 15]. Available from: https://www.himss.org/library/interoperability-standards/what-is-interoperability

34. Meyers DJ, Ozonoff A, Baruwal A, Pande S, Harsha A, Sharma R, et al. Combining Healthcare-Based and Participatory Approaches to Surveillance: Trends in Diarrheal and Respiratory Conditions Collected by a Mobile Phone System by Community Health Workers in Rural Nepal. PLoS ONE. 2016 Apr 25;11(4):e0152738.

35. Raffler P, Posner D, Parkerson D. The Weakness of Bottom-Up Accountability: Experimental Evidence from the Ugandan Health Sector. Working Paper. 2019;

36. Amouzou A, Banda B, Kachaka W, Joos O, Kanyuka M, Hill K, et al. Monitoring child mortality through community health worker reporting of births and deaths in Malawi: validation against a household mortality survey. PLoS ONE. 2014 Feb 18;9(2):e88939.

37. Otieno CF, Kaseje D, Ochieng' BM, Githae MN. Reliability of community health worker collected data for planning and policy in a peri-urban area of Kisumu, Kenya. J Community Health. 2012 Feb;37(1):48–53.

38. Darmstadt GL, El Arifeen S, Choi Y, Bari S, Rahman SM, Mannan I, et al. Household surveillance of severe neonatal illness by community health workers in Mirzapur, Bangladesh: coverage and compliance with referral. Health Policy Plan. 2010 Mar;25(2):112–24.

39. World Health Organization. Integrated Disease Surveillance in the African Region: A Regional Strategy for Communicable Diseases 1999-2003. WHO Regional Office for Africa; 2001.

40. Perry HN, McDonnell SM, Alemu W, Nsubuga P, Chungong S, Otten MW, et al. Planning an integrated disease surveillance and response system: a matrix of skills and activities. BMC Med. 2007 Aug 15;5:24.

41. Joseph Wu T-S, Kagoli M, Kaasbøll JJ, Bjune GA. Integrated Disease Surveillance and Response (IDSR) in Malawi: Implementation gaps and challenges for timely alert. PLoS ONE. 2018 Nov 29;13(11):e0200858.

42. Phalkey RK, Yamamoto S, Awate P, Marx M. Challenges with the implementation of an Integrated Disease Surveillance and Response (IDSR) system: systematic review of the lessons learned. Health Policy Plan. 2015 Feb;30(1):131–43.

43. Short KR, Kedzierska K, van de Sandt CE. Back to the future: lessons learned from the 1918 influenza pandemic. Front Cell Infect Microbiol. 2018 Oct 8;8:343.