Public Health Institutes of the World

IANPHI

Integrated Disease Surveillance Project Summary Report

Awarded by: Bill & Melinda Gates Foundation
Grant ID: INV-037877
Duration: April-November 2022

Authors:
Andrew Lee, UK Health Security Agency/University of Sheffield, UK
Bjørn Gunnar Iversen, Norwegian Institute of Public Health, Norway
Sadaf Lynes, International Association of National Public Health Institutes
Jean-Claude Desenclos, International Association of National Public Health Institutes/Santé Publique France
Janine Bezuidenhoudt, National Institute for Communicable Diseases, South Africa
Gerd Monika Flodgren, Norwegian Institute of Public Health, Norway

Design and layout: Eszter Saródy

Version control
Version 3.3 Date 03/22/2022

This report is based on research funded by the Bill & Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect the positions or policies of the Bill & Melinda Gates Foundation.

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Abbreviations

API	Application Programming Interface
BMGF	Bill & Melinda Gates Foundation
CDC	Centre for Disease Control
COVID-19	Coronavirus disease 2019
CRVS	Civil Registration and Vital Statistics
FETP	Field Epidemiology Training Programs
FIF	Financial Intermediary Fund
HIC	High Income Country (World Bank classification)
IANPHI	International Association of National Public Health Institutes
IDS	Integrated Disease Surveillance
IDSP	Integrated Disease Surveillance Program
IDSR	Integrated Disease Surveillance and Response
IHR	International Health Regulations
IT	Information Technology
LIC	Low Income Country (World Bank classification)
LMIC	Lower Middle-Income Country (World Bank classification)
MOH	Ministry of Health
NCD	Noncommunicable disease
NPHI	National Public Health Institute
OH	One Health
PPR	Pandemic Preparedness and Response
RKI	Robert Koch Institute
UMIC	Upper Middle-Income Country
WHO	World Health Organization

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Abstract

The International Association of National Public Health Institutes (IANPHI) was funded by the Bill & Melinda Gates Foundation (BMGF) to examine the status of national surveillance systems, if and how integrated disease surveillance (IDS) systems have been developed and operationalized, and the evidence base for the effectiveness of IDS.

IDS can be summarized as "a combination of active and passive systems using a single infrastructure that gathers information about multiple diseases or behaviors of interest."[1] It has been advocated as an approach to enable countries to improve their disease surveillance and response capabilities so that they can detect and respond to communicable disease threats in a timely way. Global surveillance systems were not well-prepared to identify and manage the emerging threat COVID-19 posed to health and well-being.

The aims of this study of IDS systems were to document the current state of knowledge, understanding and implementation of IDS worldwide. The assessment also aimed to identify key barriers, enablers, and opportunities revealed by responses to the COVID-19 pandemic. To achieve these objectives the project conducted a scoping review of published evidence, a multi-country survey of IANPHI members, and qualitative "deep dive" case studies of seven countries. This report brings together results and collective analysis from these three individual workstreams.

Some of the key findings and reflections from the project include:

- Integration of IDS systems should be driven by a clear purpose; set within the national context; and account for local constraints, resources, needs, priorities, legal frameworks, and system enablers in which the surveillance system operates.

- To be effective, coherent, and well-integrated, IDS systems need an "all-of-government" approach characterized by a broad commitment with, and from, the entire political system. Effective IDS systems need a clear and coordinated legal framework, and a governance structure that defines roles and responsibilities of all influencing stakeholders.

1 Nsubuga P, White ME, Thacker SB, et al. Public Health Surveillance: A Tool for Targeting and Monitoring Interventions. In: Jamison DT, Breman JG, Measham AR, et al., editors. Disease Control Priorities in Developing Countries. 2nd edition. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2006. Chapter 53. Available from: https://www.ncbi.nlm.nih.gov/books/NBK11770/ Co-published by Oxford University Press, New York.

- Effective, multi-sectoral IDS systems require a trained, skilled workforce linked to one another through high-trust professional networks to work collaboratively. These relationships and networks require resources to establish, nurture and sustain, which could be a key role for entities such as NPHIs, using their convening power to bring together the key actors across sectors and systems.

- The complexity and significant infrastructural requirements of implementing a multi-sectoral surveillance system should not be underestimated. Implementation planning for an IDS system should consider that multiple structures that communicate and collaborate well with each other may be a better, more feasible option than a single infrastructure for disease surveillance.

- Building networks and communities of practice for shared learning, knowledge exchange and dissemination of best practice through norms is a key enabler of effective IDS systems. This requires multi-sectoral and multi-disciplinary engagement.

- Fostering multi-sectoral collaborative research and innovation is important to generating new evidence for strengthening and optimizing functions related to IDS, and for identifying innovative practices.

- Donors, ministries of health (MOHs) and national public health institutes (NPHIs), need to coordinate their efforts and resources to ensure alignment of purpose and strengthen IDS systems.

IANPHI has developed three primary recommendations based on these findings, as well as consideration for current context and future funding opportunities for strengthening national and global surveillance. Contextual considerations include the revision of the International Health Regulations (IHR), the developing International Treaty for Pandemic Prevention, Preparedness, and Response, and the strong commitment to building the public health workforce contained in the statement of the Inter-governmental Negotiating Body (INB) on the Pandemic Treaty.

IANPHI's three key recommendations detailed in this report are:

1. **Clarify the definition, scope, and purpose of IDS.** To be operationalized at national and subnational level, IDS needs to have its purpose, scope and operational systems thoroughly articulated.

2. **Adopt a strategic planning approach to IDS implementation.** IDS requires a strategic approach to planning for implementation. With support from global and regional partners (WHO, other UN organizations, regional CDCs, etc.) countries should review and evaluate their existing surveillance systems and determine if IDS is the best approach and, if so, how best IDS can be implemented.

3. **Implementation plans should consider key enablers.** Because of the amount and complexity of data, the implementation of an IDS system should consider the possibility that multiple collaborative structures or organizations that are interconnected and communicate well may be a better choice for some countries than a single infrastructure for disease surveillance.

Finally, this report proposes several actions for different key stakeholders to facilitate the implementation of IDS.

Introduction

Disease surveillance is an essential public health function needed to inform the response to diverse health threats and for planning public health programs. It is often led by ministries of health (MOHs), usually with input from national public health institutes (NPHIs) or equivalent public health departments in MOHs that are technically responsible for surveillance. Effective surveillance requires a One Health (OH) approach, built on good multisectoral links between human health as well as animal and environmental health. It also benefits from enhanced functional integration across different disease surveillance systems to maximize the utility of the data collected.

Integrated disease surveillance (IDS) has been defined as "a combination of active and passive systems using a single infrastructure that gathers information about multiple diseases or behaviors of interest."[1] The World Health Organization's (WHO) Integrated Disease Surveillance and Response (IDSR)[2] strategy describes it further as an approach that aims at collecting health data for multiple diseases, using standardized tools. IDSR is also described as the provision of comprehensive public health surveillance and response systems for priority diseases, conditions, and events at all levels of the health system.[2,3] IDSR aims to make surveillance and laboratory data more usable and to help public health managers and decision-makers improve detection and response to the leading causes of illness, death, disability, and emerging threats. The strategy makes explicit the skills, activities and resources needed at each level of the health system to operate all functions of a surveillance system. However, there is currently limited information available on the status of IDS systems in countries and the enablers or challenges encountered in the development and implementation of IDS systems.

The COVID-19 pandemic highlighted the importance of disease surveillance and the role of public health entities for supporting decision making for disease control. It also revealed challenges and limitations of disease surveillance. The pandemic motivated many global public health leaders to create a better, interconnected global system for public health surveillance and intelligence that is based on strong, standardized, and interoperable national capacity.[4] This ambition is mirrored by the newly established WHO Hub for Pandemic and Epidemic Intelligence in Berlin, whose role is to engage countries on collaborative surveillance, connecting information and concepts to make relationships in data more visible and increase analytical power that will result in deeper insights.

2 For the purposes of this report, the related concepts of IDS and IDSR are used interchangeably and interpreted as synonymous.

The massive costs resulting from the failure to be adequately prepared for major health events has also intensified efforts to secure investments in pandemic preparedness. The Financial Intermediary Fund (FIF) for pandemic prevention, preparedness, and response was established in September 2022 to provide a dedicated stream of additional, long-term financing to strengthen pandemic preparedness and response (PPR) capabilities in low- and middle-income countries (LMICs)[5]. The FIF was officially launched as the Pandemic Fund at the G20 meeting in Bali, Indonesia on November 13, 2022. This initiative as well as other concurrent external donor funding streams provide a window of opportunity for the establishment or enhancement of IDS in countries.

In many countries NPHIs play a key role in the organization of national disease surveillance. The International Association of National Public Health Institutes (IANPHI) works with NPHIs, MOHs, national laboratories, as well as public health academic and research institutes, to strengthen their functions through collective intelligence, peer-to-peer learning, and multilateral collaboration. IANPHI was funded by the Bill & Melinda Gates Foundation (BMGF) to examine the status of national surveillance systems, the extent to which IDS systems have been developed and operationalized, and the evidence base for the effectiveness of IDS.

The aims of this work are:

- To document the current state of knowledge, evidence for, and understanding of IDS
- To describe the state of IDS across the IANPHI network, mapping variations in definitions, approach to, and implementation of IDS
- To identify the barriers, enablers, and opportunities for IDS development and implementation, considering some of the lessons learned from the COVID-19 pandemic

To address these aims, the project carried out a scoping review of the published evidence, a multi-country survey of IANPHI members, and qualitative "deep dive" case studies of seven countries. This report brings together the results from the project and presents the collective analysis from across the three individual workstreams.

Methodology

This project seeks to understand and characterize the state of IDS globally and identify the key enablers and opportunities for IDS systems. The insights from this work could help inform areas for investment that would help build and strengthen surveillance systems. This project may help public health leaders and stakeholders better understand how greater integration of disease surveillance can increase the effectiveness and efficiency of national surveillance systems. The findings may help identify priority actions that could enhance collaboration across sectors for the integration of data, and better articulate the role of NPHIs and key actors involved in surveillance and response to human health threats. This study aims to offer insights that advance ambitions to create an interconnected global system for public health intelligence, based on strong, standardized, and interoperable national capacity, as well as focusing attention on the role that NPHIs can play in this process.

The project covers three distinct workstreams (Table 1):

1. A systematic scoping review of the literature on IDS
2. A survey of 110 IANPHI member NPHIs in 95 countries
3. "Deep dive" case studies in three high-income countries (HIC) [Canada, England, and Sweden] and four lower middle-income countries (LMIC) [Malawi, Mozambique, Pakistan, and Uganda]

This report brings together the results from the three workstreams and presents the analysis, identified themes, reflections, and recommendations emerging from them. Full details of the separate workstreams, including methodology and findings, are published in separate reports elsewhere. [7,8,9]

Table 1: The Three Workstreams of the IDS Project

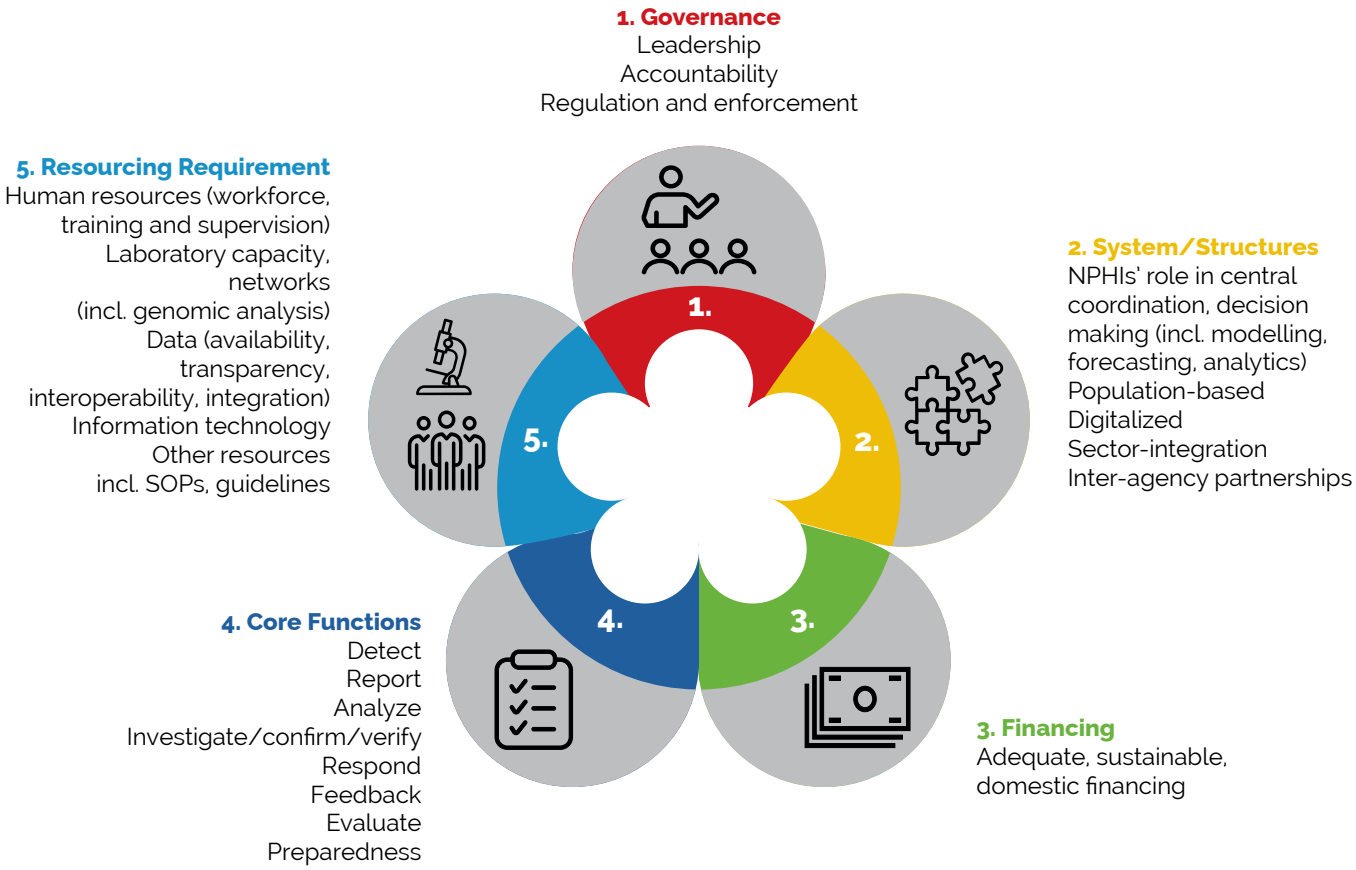
Projects	Objectives	Methods	Sources of Information
Project 1: Systematic Scoping Review	To document the current state of knowledge, conceptualization, and implementation of IDS	Systematic review of the literature	Medline, Embase, Epistemonikos, and web portals of three key organizations
Project 2: Multi-Country survey of IANPHIs membership	To understand how IDS is conceptualized by NPHIs and explore existing surveillance systems and maturity models in terms of linkages between surveillance systems, roles, opportunities availed and challenges to integration across systems, sectors, infrastructure, and professionals	Online survey with IANPHI members	65 respondents who were senior NPHI focal persons from IANPHI's membership
Project 3: Country 'deep dive' case studies	To explore the current barriers, challenges, and enablers of an 'IDS' system; what is meant by IDS according to country context; how IDS is delivered including enablers; and opportunities and innovations for implementation	Multi-sectoral focus group discussions and key informant interviews	Qualitative studies conducted in 7 countries (3 HIC and 4 LMIC)

The project devised a bespoke conceptual framework (Figure 1) designed for the study. It incorporated the WHO IDSR framework and the five principles for integrated disease surveillance (Table 2), as proposed by Morgan et al. in 2021.[10] The conceptual framework adopted by this project identifies five key domains for IDS (governance, system/structure, financing, core functions, and resourcing requirement) that were used to guide the project's framework, methodology formulation and analytical approach to frame the emerging themes and priorities identified.

Table 2: Core Principles for Integrated Disease Surveillance, Morgan et al. (2021)

	Benefits	Implementation requirement
Population-based	Denominators for mortality rates and disease burden	Civil registration and vital statistics (CRVS) or sample registration system
Laboratory Confirmation	Cases accurately tracked	Capacity to scale testing and sequence pathogens
Digital Data	Systems interconnected and privacy protected	Unique health identifies, standard metadata, web accessible
Data Transparency	Visibility of all national threats by NPHIs and by WHO for transnational threats	Automated reporting to NPHI with a subset to WHO and regional bodies
Adequate Financing	Sustainable country-owned systems	Invest US$1-4 per capita annually
Country 'Deep Dive' Case Studies	To explore the current barriers, challenges, and enablers of an 'IDS' system; what is meant by IDS according to country context; how IDS is delivered including enablers; and opportunities and innovations for implementation	Multi-sectoral focus group discussions and key informant interviews

Figure 1. Conceptual Framework of the Study



In addition to the three workstreams, the project's final analysis also considered other reports and reviews on the subject, such as Resolve to Save Lives' report *Integrated Public Health Architecture: An assessment of national public health institutes and proposed framework to improve surveillance effectiveness and efficiency*. This involved a review of the report to identify common findings and variance, as well as discussions with the RTSL report authors. Triangulation of findings were also carried out with complementary work being undertaken by the Robert Koch Institute (RKI) on disease surveillance through knowledge sharing workshops hosted by RKI in Berlin on October 12 and 13, 2022. Initial findings were presented to BMGF and the WHO Hub for Pandemic and Epidemic Surveillance on October 13, 2022, and the World Health Summit in Berlin on October 16, 2022.

What we Found

3.1 Summary of Scoping Review Findings

Eight reviews and five primary studies published between 2009 and 2021 were included in the scoping review. They included a mix of qualitative, quantitative, and mixed methods studies. **The quality of the body of evidence included was judged to be low to critically low.** The existing evidence for IDS conceptualization and operationalization in published articles is fragmented and incomplete. For example, there was no common IDS definition or articulation of the parts that constitute an IDS system or definition of disease surveillance integration. The review found articles mostly focused on the adequacy of core functions, resources, and system structure of IDS. Only a few articles mentioned governance and financing. Articles described the provision of core functions and resourcing requirements as generally inadequate, especially at the health facility and regional levels. When mentioned, financing was described as non-sustainable and a major challenge.

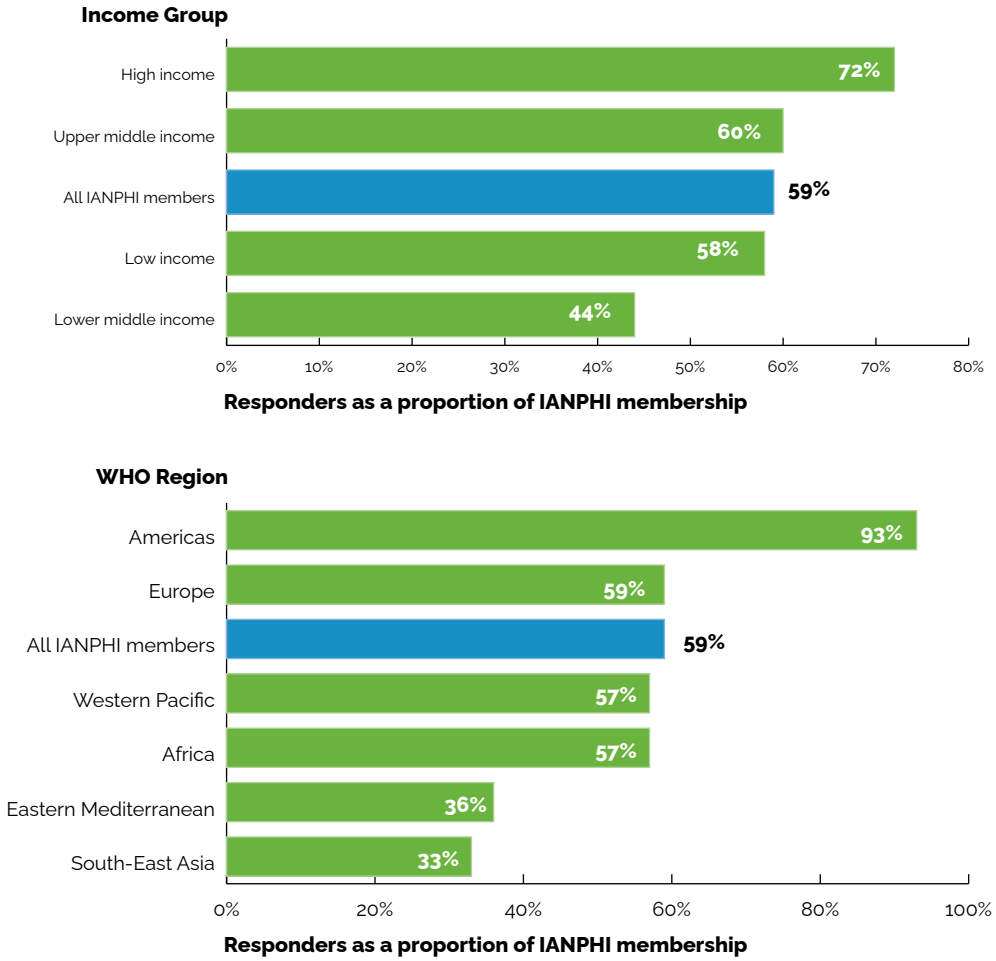
It should be noted that the main search was restricted to articles in English and only conducted in two major databases and three selected gray literature sources. The review also mainly focused on evidence summaries, therefore relying on the specific aims and quality of the reported outcomes within these articles. The articles reviewed for this report do not outline the effect of IDS systems on disease control outcomes.

Findings from the review appear to support the five key elements and linked sub-functions that are proposed in the conceptual framework shown in Figure 1. **The enablers and opportunities identified for IDS included: active sharing of data; close cooperation between agencies or different elements of the system (governance); clear reporting channels; integration of categorical disease control programs; increased staff training; and electronic/mobile reporting adoption (resourcing requirements).** The review highlighted the need for sufficient staffing with an appropriate mix of skills and training, as well as standardized case definitions, protocols, and guidance. Integration requires consistent processes and interconnectivity. Electronic solutions can enhance surveillance activities and regulatory enablers may help, but dysfunctional technology can be a barrier.

3.2 Summary of the Multi-Country NPHI Survey Findings

Of the 110 IANPHI member institutions surveyed, 65 (59%) provided a complete response. Many responses (35%; n=23) were from respondents in countries classified as high income (HIC) by the World Bank, followed by upper middle income (UMIC) (23%; n=15), lower middle income (LMIC) (23%; n=15) and low income (LIC) (17%; n=11) countries. Most responses were from countries in the WHO European region (34%; n=22), followed by the African region (26%; n=17) and the Americas (23%, n=15) (Figure 2). Most respondents reported having a partially developed IDS system (55%; n=36), using the definition of IDS provided by Nsubuga et al (2006)[3]. 25% of respondents (n=16) reported having a developed IDS system and 20% (n=13) reported no IDS system in place.

Figure 2. Complete Survey Responses by World Bank Income Group and WHO Region (n=65)



3 *Integrated surveillance:* a combination of active and passive systems using a single infrastructure that gathers information about multiple diseases or behaviors of interest to several intervention programs. (Nsubuga et al., 2006)

The understanding of IDS differed from country to country and there was a lack of a universally agreed and understood definition of IDS. Respondents interpreted "integration" as a complex process involving multiple stakeholders and sectors and occurring at all levels of the health system; respondents adopted what can be described as a "whole systems" perspective. The purpose of integration of disease surveillance, how the system enables better decision making and response to health threats were a key consideration, for which the system needed to be agile, responsive, and resilient.

The importance of governance was highlighted by respondents, including the need for adequate legislative and regulatory frameworks, good governance and political engagement, appropriate control, and monitoring and evaluation. While most surveillance systems were often led by the MOH (45%), in many countries NPHIs played a major part in surveillance either jointly with the MOH (11%) or as the sole lead agency (32%). This was especially true for high income countries, and those with more developed IDS systems. Respondents also indicated that there is a need for improved data management and regulation to ensure data integrity, confidentiality, interoperability, and multi-sectorality. Data protection was recognized to be an issue that needs attention to enhance public trust in public health surveillance. Equity and guaranteed access to surveillance outputs were also mentioned as important in supporting strong, well-functioning integrated surveillance systems, as well as flexibility, simplicity, and acceptability of surveillance systems. Resilience and capacity building were also key factors.

While a lack of adequate resources was reported in all country income groups, it was more pronounced in LICs. **Finance, including inadequate investment and the lack of a multi-year budget, was identified as a challenge in setting up and running IDS systems** by the majority (73%, n=37/51) of respondent countries with either a full or partial IDS system. For some respondents, particularly in LICs, the reliance on international aid funding was deemed to be unsustainable. External donor financing of programs creates vertical data surveillance systems to meet disease specific needs but fails to strengthen system capability and limits national control over system development and design. Other challenges identified were workforce capacity, skills and supporting technology to enable robust multi-sectoral data analysis and interpretation. Workforce gaps were reported in the areas of data science, analytics, and information technology (IT), followed by epidemiology, administration/data entry, laboratory, and public health generalist professionals. While LICs and LMICs may invest in workforce similarly to UMICs and HICs to maintain indicator-based surveillance systems, the survey indicated a lack of resources to invest similar capacity to maintain event-based surveillance systems.

Respondents reported integration challenges at the interfaces of technological systems. Systems often tended to be vertical be it between different organizations, levels, or sectors. There were also deficiencies reported in integrating data from the private and pharmaceutical sectors, laboratories, and genomic data, which was more acute in LICs and LMICs. Integration challenges were more common for non-human health sectors such as environmental health and animal health sectors, as well as non-infectious disease sectors, such as non-communicable diseases, surveys and research, and occupational health. Other reported barriers included data ownership, agreement and permissions, the absence of mandatory enforcement for reporting, and a lack of funding for information technology systems development, infrastructure, and maintenance. Data integration was better for national public health laboratories, followed by sub-national public laboratories, than other public health, or private sector laboratories.

The impact of the COVID-19 pandemic on IDS systems varied by country. **The COVID-19 pandemic has totally or partially strengthened most surveillance systems**, according to respondents. COVID-19 surveillance has been made possible by leveraging existing surveillance systems, primarily components of viral respiratory surveillance systems. The development of surveillance data streams was key to having a robust COVID-19 surveillance system. For example, a functional weekly disease notification system facilitated COVID-19 notification and contributed to rapid response, early and appropriate detection, and data sharing. However, for some countries, the surveillance system was only improved for COVID-19-related data. **Some countries in sub-Saharan Africa reported that COVID-19 destabilized their surveillance systems or failed to strengthen existing surveillance systems.** Moreover, most of the system changes that happened during the pandemic did not last long.

Case studies and exemplars of good practice provided by respondents included: the enabling role of technology such as greater automation, electronic reporting systems, algorithms, and data platforms.

3.3 Summary of Findings from the Deep Dives

3.3.1 Key Findings from Deep Dives in the Four LMICs

In the four LMICs (Malawi, Mozambique, Pakistan, and Uganda), most of IDS's elements are in place, but there is room for improvement in areas such as governance, human resources, funding, data quality, and digitization. Where IDSR has been implemented, it is often seen to be synonymous with IDS and involve synchronization or better coordination of communicable disease surveillance systems with vertical, donor-driven programs. Improving data integration from health facilities with laboratory data, and better collaboration between human and animal health is challenging.

Good quality civil registration and vital statistics (CRVS) are often lacking. The quality of the data in disease surveillance registries are often poor, and laboratory confirmation of cases is frequently missing. There is a need to strengthen laboratories and to improve laboratory and surveillance data collection, validation, analysis, interpretation, and reporting at all levels. Digitization may help. Most patient records are still on paper due to the slow introduction of electronic medical records. Most of the respondent countries aim to have one electronic surveillance system where data can be transferred from various sources, but there are challenges with data transfer, leading to duplications in sending both electronic and paper reports.

In several countries the legal framework for IDS was reported to be deficient, lacking a clear purpose and clear assignments of responsibility. This resulted in fragmented ownership of surveillance. There was also varying political commitment to IDS, although this improved with the COVID-19 pandemic due to the demand for good surveillance data. Another emerging theme was the need for guidelines (such as the WHO IDSR technical guidelines) to be better adapted to national settings and for national implementation.

Most disease surveillance systems lack sufficient resources for staffing, technical systems, IT, software development, and microbiological laboratories. External support from international donors was crucial for developing and maintaining such systems, but external support may fragment and duplicate national surveillance and divert human resources from NPHIs. There is a lack of trained staff, especially at the district and local levels where data collectors at facility sites are a critical factor. Training programs such as the Field Epidemiology Training Program (FETP) are important for capacity building, and there is a need to develop local knowledge, networks, relationships, and trust between professionals, agencies, and between sectors at all levels.

3.3.2 Key Findings from Deep Dives in the Three HICs

For the three HICs (Canada, England, and Sweden), there was no consensus on what integration means, and unfamiliarity with IDS/IDSR concepts. Respondents were concerned IDS could create a single "unwieldy" system. Respondents also expressed concern that creating such a system would be too costly and difficult to achieve because of the variety of current systems and lack of sufficient standardization. Multiple, compatible infrastructures may be preferable to a single IDS infrastructure. There is also a need for clarity of the intended outcomes sought through integration and to distinguish between data summation and integration. None of the HICs had an IDS system, but all had examples of highly developed, well-functioning surveillance systems that were widely used. There were varying degrees of system integration; for most, they were integrated enough to respond. The agencies involved could deliver joint analysis and response, but this was dependent on well-established collaborations and data sharing mechanisms. High levels of trust between colleagues, good relationships, goodwill are important enablers of collaboration. Collaboration takes place in these existing networks, and to an extent replaces the advantages a common infrastructure might have.

The core functions of existing surveillance systems tend to work well, have some flexibility, and can be scaled up. There is room for improvement through increasing automation, clarifying data protection and confidentiality concerns, and improving standardization. Inconsistencies in reporting still occur due to a lack of awareness of reporting requirements. There is a considerable amount of data but limited analytical capacity. Improved prioritization of disease areas and surveillance activity is often needed, but priorities and timelines differ between national and local levels. Data is collected for various purposes because different users of surveillance outputs have different needs. In federated systems, surveillance is supported through established national survey systems, dedicated networks such as laboratory networks, and with support from NPHI senior management and federal experts.

NPHIs play a leading role in disease surveillance and the coordination of disease control responses. Organizational and national boundaries can make integration difficult due to different access to data assets, IT systems, procedures, definitions, and denominators. NPHI mandates, independence from government, and authority also varied considerably. Multi-sectoral integration varies, and public involvement tends to be limited. There is also a need for more collaboration with different actors, and especially in the private sector. There are a wide range of surveillance systems with diverse data infrastructures. The data from different sectors are not standardized, resulting in heavier processes and non-comparable data. Where there are no formal linkages, informal data sharing may exist.

Significant changes to systems require strong political support and clarity of governance structures. Supportive legal and regulatory frameworks and mandates help clarify roles and responsibilities, which facilitates data sharing. Legal mandates can enable NPHIs to drive integration of surveillance systems, facilitate surveillance by mandating reporting, and providing a legal instrument for sharing data. However, legal requirements can also delay timely data sharing, and make system changes and adaptations difficult.

Financing and resources were problematic but generally considered adequate. However, there is a lack of sufficient, sustained, and stable funding for modernization and integration. It is difficult to demonstrate cost-effectiveness of disease surveillance activities and evaluations of the surveillance system are rarely done. Expert analytical input is required to ensure appropriate interpretation of surveillance data, but there is also a shortage of trained public health professionals with necessary skills and competencies. Enhanced training is therefore needed as well as workforce planning.

3.4 Cross Cutting Themes Across the Three Workstreams

Based on the key findings collected through the three workstreams, we identified seven major cross-cutting themes. More details about the evidence can be found in Appendix 2.

1. **IDS: What it means in different country settings**
   Integration must be thought of as more than simply the integration of data and IT infrastructure, or the summation of data. Integration must be conceptualized across a spectrum of systems, capacities and activities. Enhancements to the core principles from the Morgan, et al. paper as well as additional core principles are needed such as governance, legislation, human resources, effective system attributes, and a multi-sectoral approach. Data systems should include One Health data, data from the public and private sectors, and include both laboratory and clinical information.

2. **The role of NPHIs and Public health entities/ departments**
   The role of NPHIs in IDS is not well defined. NPHIs are not established in all countries. In several countries there are departments at the national level under MOHs that provide the functions of public health. In some countries, NPHIs play a major role, either jointly with the MOH or as the sole lead agency, particularly for the core functions of surveillance. This includes ownership of surveillance systems. NPHIs in both LMICs and HICs play a role in IDS, the extent of which is dependent on the scope of their mandate and powers.

3. **Levels of maturity of IDS functions across countries**
   Countries are at differing levels of IDS system development, and this is not necessarily linked to country income levels. LICs lag in digitization and system integration compared to HICs due to poorer technological development. Disease surveillance system integration most commonly occurs in the human sector, with the existence of case-based, disease-specific, vaccine coverage, and laboratory-based surveillance systems. Multiple barriers exist that affect data availability, interoperability, coverage, capacity and coordination. Digitization, including the potential use of unique health identifiers and electronic records and documentation may help. Other enablers for IDS development include supporting IT infrastructure, supportive legislation, sustainable funding, together with workforce training and capacity building. Integration of vertical, and externally donor-funded programs were also less common.

4. **Roles and responsibilities in fragmented and integrated systems**
   Governance and charters defining roles and responsibilities of IDS systems (i.e., health facility/data collection level, region, district, or national level) were typically neither described nor discussed in the literature. The literature focused almost entirely on core functions and resourcing requirements of IDS systems. Technology, professional and laboratory networks, as well as supportive legislation, may help overcome some of these issues. Improved governance and clear organizational mandates are also needed at all levels of the IDS system.

5. **Multi-sectoral integration**
   Fragmentation and the lack of integration between sectors was evident, particularly in areas related to One Health. Integration issues exist where fragmented systems interface with one another. These systems tend to be poorly integrated between different organizations, levels of government, or sectors. Vertical, disease-specific systems are particularly problematic in LMICs where they inhibit data linkages and accessibility, and partly due to donor requirements. Integration also tended to be particularly weak for the private and pharmaceutical sectors, and to a lesser extent the non-health sectors. There is a need to improve active collaboration between health and non-health sectors, ensure that data collected in different sectors can be used and integrated for public health surveillance, as well as promote data collection standards and protocols across sectors.

6. **Core Functions: *Detect, Report, Analyze, Investigate/Confirm/Verify, Respond, Feedback, Evaluate, and Preparedness***
   The reported performance of the core functions varied by country, but tended to be weaker in LICs, particularly for the "*report*", "evaluate" and "feedback" elements. Weak "*evaluation*" function was common to both LICs and HICs. IDS systems need to be monitored and evaluated on a routine basis, and they require enhanced feedback mechanisms at all levels of the system. There is a clear need to strengthen the evaluation function, as well as to conduct a systematic assessment to identify gaps and weaknesses in the core functions for improvement, with consideration too of surveillance functions performed by humans.

7. **Resourcing requirements (*Governance, Human Resources, Infrastructure and tools, Financing, Data protection*)**

   Different systems organized by different authorities make coordination and cooperation difficult. Making significant changes to existing surveillance systems would require political will and support, funding, and clarity of organizational governance structures. Not all NPHI have sufficient authority to mandate the integration of systems in other organizations. The presence of an enabling legal and regulatory framework would help facilitate surveillance. There is a major need for active and sustained national policies that invest in workforce capacity, development, and retention. Having the right skills and expertise are essential, with data science and analytics, and information technology being common priority areas. Laboratory and IT infrastructure are essential building blocks for IDS systems. These must maintain, integrated, and developed, across various levels and sectors. Sufficient, sustained, multi-year funding is required to establish, maintain, and integrate disease surveillance systems. LICs and LMICs are heavily reliant on external funding for their systems, which can exacerbate fragmentation of surveillance systems. Donors and funding agencies are therefore key actors in these settings and have a critical role to play in fostering and maintaining IDS systems. It is also important to consider the ethical dimension and privacy protection of surveillance systems.

Lessons from the COVID-19 Pandemic

The response by some countries to the pandemic has shown that there is potential to improve surveillance effectiveness through leveraging existing surveillance systems and cross-sector collaboration. The pandemic legacy of good practice and innovative COVID-19 surveillance initiatives could be embedded into current systems. Sustaining these developments will require appropriate funding, resources, workforce development and infrastructure, and alignment to priority needs. The increased investment seen during the pandemic is likely to be short-lived. Consequently, there is an urgent need to not only learn lessons from the pandemic but also identify sustainable levels of investment needed to strengthen existing surveillance systems, while maximizing the efficient and effective use of limited resources.

3.5 Alignment with Complementary Projects

There were two other parallel projects funded by Bill & Melinda Gates Foundation on IDS, led by Resolve to Save Lives (RTSL) and by Robert Koch Institute (RKI). We were asked by the funder to compare findings and identify common themes.

- **RTSL** conducted a two-part evaluation to collect data on how integrated surveillance is currently operating and what opportunities exist in the space. They performed in-depth assessments in Gambia, Liberia, and Nigeria. Many of their findings are like those IANPHI identified, such as the lack of organizational maturity, unstable funding sources, unclear governance, lack of staff training, software and data management challenges and lack of big-picture thinking. They recommended that NPHIs change how they build and evolve surveillance systems by applying a new integrated public health architecture framework. This includes architecture for systems, data, software, standards, guidelines, and tools. **There are no contradictions between RTSL and IANPHI reports, and they both support a common set of recommendations for strengthening IDS in countries.**

- **Robert Koch Institute (RKI)** carried out a similar study to the IANPHI project, including scoping interviews, scoping literature review and deep dives in Namibia, Côte D'Ivoire, Madagascar and Saudi Arabia. Their project had focused on workforce and laboratory development. Their preliminary findings and recommendations are aligned with the findings of the IANPHI project and include improving integration between epidemiology and laboratory surveillance, improving data quality and management systems, increasing lab capacity and organization, data sharing, improving the quantity, quality and coordination of workforce development and training, and a much better implementation of One Health in surveillance. **The findings from the RKI and IANPHI studies complement each other. Both support the case for investing more in the skills and competencies of the surveillance workforce.**

Discussion: Strategic Priorities

An IDS system's value and effectiveness should be judged by its contribution to public health decision-making and public health outcomes. The consolidated findings of this report should be used to inform planning for the development, implementation and strengthening of IDS systems. Insights from the project span both strategic as well as operational level considerations. National, regional, and global health security policies and priorities, agreements, strategies, and frameworks, need to be considered at the strategic level. This section outlines a set of key strategic priorities identified in this project (purpose, governance, people, infrastructure, finance and learning) that span all three workstreams.

4.1 Purpose

Integration of surveillance systems or data should be driven by a clear purpose that is linked to specific outcomes and impact sought. Integration should be focused on functions and activities that deliver outcomes, for example surveillance outputs that can be used in detection and response, policy decisions and for directing investment and funding. The purpose of surveillance needs to transcend disease specific systems to include other indicators necessary for a collaborative public health response. It should have a One Health approach and include outcomes beyond disease-specific ones. Surveillance outputs and their intended use should drive the design of a system. Surveillance systems should be developed with the ability to increase the utilization and effectiveness of data and should be conceptualized within the specific context for the country. Development and strengthening of surveillance systems should consider local constraints, resources, needs and priorities, as well as legal frameworks and system enablers in the places where the system will operate. It should also consider the role of public and private health systems as well as non-health sectors.

4.2 Governance

Political commitment across all of government needs to be in place for surveillance systems to be coherent and well-integrated. A clear and coordinated legal framework and governance structure that defines the roles and responsibilities of all stakeholders are essential. NPHIs or their functional equivalents, should have a central, coordinating role and hold independent scientific authority to make evidence-based recommendations for decision makers. An appropriate supporting legal framework is needed to provide stability, but it should be flexible enough to adapt to new challenges. Since the legal roles and responsibilities for various surveillance systems, health and non-health databases are often split between various ministries and subordinate agencies within the governmental structure, coordination and communication between agencies and departments need to be defined. Sharing of data should be made explicit through formalized data sharing agreements, within the ethical remits of privacy protection. In countries where externally funded disease programs play a significant role in national databases (including registries), external funders should be mandated to work closely with MOHs and the national disease surveillance system leads to ensure alignment with national systems, priorities and needs.

4.3 People

A skilled, dedicated workforce linked through high-trust professional networks, working in partnership to deliver collaborative outputs are essential for effective multi-sectoral systems to function effectively. These skills and competencies span professions and disciplines and are needed to comprehend and build evidence. Creating and interpreting evidence into impactful action require interaction between professionals, which is maximized through establishing interprofessional, multi-disciplinary teams, professional communities and networks that can work across departments, sectors, and organizational boundaries. In addition to explicit skills, there are tacit skills required in communication and relationship building across sectors and professions. These professional relationships and networks require input to create, nurture and sustain. NPHIs can use their convening power to bring together the key actors. The community is also a key stakeholder and meaningful community engagement can help IDS systems achieve their public health goals. This requires effective communication channels between communities and government.

4.4 Infrastructure

There is a need to invest in the infrastructure and institutional structures which support surveillance and its integration for improved response and policy. **The complexity of implementing a surveillance system should not be underestimated,** especially the infrastructural requirements, the amount and complexity of data, as well as multidisciplinary expertise needed to analyze, interpret, and respond across human, animal, and environmental sectors.

Multiple collaborative structures that communicate well may be more feasible to create than a single infrastructure for disease surveillance. The design of surveillance systems needs to be based on developing existing structures. Complete re-design may not be feasible or desirable. Data system infrastructure needs to be developed with a specific focus on interoperability and application programming interface (API) that communicate with each other, which allows exporting and importing of data, data validation, and data manipulation. Data from multiple sources and sectors should be shared, merged, or integrated. This can improve data quality and representativeness, make it more easily available to decision-makers, and support timely responses to health threats. Data sharing agreements are key to enabling the operational aspects of such a multi-sectoral system.

4.5 Finance

Sufficient, long-term funding is required to build and sustain surveillance systems to generate intelligence and evidence that informs policy and supports prevention, preparedness, and response to health threats. Additional investments will be needed to drive integration efforts. Donors and governments need to coordinate and harmonize funding streams to ensure national surveillance systems are strengthened while avoiding creating siloed systems. International donors should align efforts to create models of funding supporting sustainable platforms and enablers to develop systems that integrate and build sources across capacity and capabilities.

4.6 Collaborative and Shared Learning

Building communities of practice for sharing knowledge and best practice is important at local, national, and global levels, and within and between sectors. At the local and national level, this is a role NPHIs or their equivalents can perform. Establishing international norms for knowledge exchange, learning and inter-country comparisons is an important function that can be performed by WHO or IANPHI through its peer-to-peer support model. Fostering multi-sectoral collaborative research, evaluation and innovation is also important to generate new evidence on strengthening and optimizing IDS functions and for identifying innovative practices. Catalysts are needed to accelerate the translation of evidence into practice that can support learning between countries. Evaluation practice must be strengthened further, which would add to the knowledge base, and support quality improvements in public health systems. Further work is also needed to develop generic tools and protocols to assess the effectiveness and cost-effectiveness of IDS. Evaluations could be coordinated to enable comparisons between different health systems and countries, including different income groups. Other research opportunities include wider elements such as public behavior, communication and understanding. Other examples are the growing infodemiology and infoveillance fields where internet activity can be analyzed for disease intelligence and surveillance. Another potential area is social media and its potential role in surveillance.

Recommendations

In this section IANPHI proposes recommendations for aiding the implementation of IDS. The key strategic priorities outlined in Section 4 should be considered and addressed at the relevant levels of government and the public health systems. The approach to IDS implementation must be collaborative, multi-disciplinary and multi-sectoral so that interdependencies can be identified and addressed. Skilled planners and implementors are needed for successful implementation of systems that are effective and meet relevant objectives.

Recommendation 1: Clarify the Definition, Scope, and Purpose of IDS

Countries should properly define IDS. Its purpose, scope, and organization should be clearly articulated at the national and subnational levels. This work should be undertaken through multi-sectoral consultation by governments. In the survey and deep dive case studies, the need for clarification and understanding of the purpose of IDS to guide the organization and functioning of the IDS system was highlighted. Clearly defining IDS will help guide technical integration of the system to ensure that it is effective, durable, and able to deliver its intended outcomes. Integration is not a solution across all topic areas but should be prioritized by topic area to inform public health action according to need.

Integration must be conceptualized across a spectrum of functions, systems, capacities and activities. This conceptualization phase needs to occur in countries when implementing, reviewing, or enhancing IDS.

Recommendation 2: Adopt a Strategic Approach to Planning IDS Implementation

A strategic approach to planning for the implementation of IDS is needed. With support from partners such as WHO, other United Nation organizations and regional CDCs, countries should review and evaluate existing surveillance systems, identify gaps and development needs, and determine how best to implement IDS if it's deemed the best approach for the country context. Countries should identify their priority diseases, conditions, events, or indicators to be included under IDS by considering the local epidemiological profile, national, regional, and international perspectives, as well as the resources available and health system needs.

During the conceptualization phase, knowledge, expertise, training and skills-building, and communication strategies should be addressed. Reporting structures and roles and responsibilities of all stakeholders also need to be clarified. IDS plans must be developed which can be financed and operationalized for all levels of the health system. Depending on the level of maturity of the system, there will also be a need to adopt an additive and incremental approach that increases multi-sectoral integration-building from its existing state of integration. For example, assuring the quality of existing communicable disease data, then sequentially linking it with laboratory data, animal health data, data from CRVS, and other data platforms as required. Consideration is needed regarding what data is integrated for defined public health purposes.

Recommendation 3: Implementation Plans Should Factor In Key Enablers

Multiple enablers have been identified that will help facilitate both the functioning and effectiveness of IDS systems such as system leadership, political commitment, IT infrastructure and staff, digitization of data, laboratory networks, data sharing agreements, additional investments for integration, and training staff to build their skills. The project findings affirm the five key principles for IDS shown in the conceptual framework in Figure 1. These should all be considered when creating implementation and financial plans for IDS. These enablers operate at various levels of the surveillance system, including both national and subnational levels, so action is required at all levels of the system.

NPHIs are key enabling actors for IDS. They are uniquely positioned at the interface of different sectors and can forge links and partnerships for shared intelligence, finding consensus, and avoiding duplication. NPHIs can be innovative and trusted partners to bring health and non-health sectors together. They act as catalysts for evidence-based decisions that are needed to effectively tackle multifaceted threats to human health. They can also build tacit and explicit collaboration and partnerships across sectors.

Call for Action

A further output of this project is a call for action (see Appendix 1) that includes an extensive range of operational proposals. These proposed actions span community, subnational, national, regional, and global levels, covering health security policies and priorities, agreements, and strategies. Every country is different, so activities need to be tailored to country context and IDS system maturity. Country "maturity models" need to be developed to establish common descriptors for IDS system maturity, and related recommendations for each maturity level. Peer-to-peer support and evaluation should be used to help create, review and update tools used for establishing and operating IDS systems. Working with implementors to maximize efficiency and effectiveness would reduce implementation challenges.

There are several actors who play key roles in ensuring countries are well equipped to tackle health threats through integrated disease surveillance to support early detection, preparedness, response, and recovery. Some of the key actions these actors can take to support IDS are also outlined in the Appendix 1. These include the following:

6.1 International Partners

At the international level there are other organizations who provide platforms for collaboration, development of tools and shared learning. This includes IANPHI, which engages national public health institutes and related public health entities. IANPHI members and partners should provide support through peer-to-peer or multi-lateral engagement. The trust and credibility of its network, which has deep, hands-on experience of public health, promotes understanding and sharing of solutions.

International and national non-governmental organizations (NGOs), donors and funders support the investment and implementation of regional and country level surveillance, utilizing them to drive programs of impact and outcomes in priority diseases. With the shift in funding as well as further investment in building structures and functions to tackle future epidemics, there is a need to consolidate focus and efforts to enable establishment and operational capabilities of systems for early detection, preparedness, response, and recovery. Donors and funders should seek to align investments to support and strengthen national systems, including allowing the integration of vertical systems where doing so can increase the efficiency and effectiveness of the overall national surveillance system. This requires close collaboration and dialogue with MOHs and leaders of national surveillance systems.

Research funding agencies should increase investment in research, monitoring and evaluations of the effectiveness and impact of surveillance, so that there is stronger evidence to support investment in surveillance. Philanthropic donors should identify areas of catalytic investment in disease surveillance, including mobilizing peer-to-peer support between NPHIs, to strengthen surveillance systems based on nationally identified need, drawing on expertise from agencies in other countries who have experience addressing similar issues. Research should focus on learning how to optimize public health outcomes of surveillance and the response to health threats.

6.2 WHO and the Supranational (Regional) CDCs

WHO and the WHO Berlin Hub should work closely with NPHIs and MOH public health entities to promote and strengthen their role in support of IDS. They can facilitate the development of new ideas and piloting innovative practice, as well as support national and sub-national operationalization within countries through the sharing of best and innovative practice. The WHO Berlin Hub could act as an incubator and accelerator of innovation through sharing and making accessible best practice over a greater cross-regional geographical footprint by engaging with international, regional, and national actors involved in IDSR. Additionally, supranational (regional) CDCs are key organizations representing the needs of its member states who can collate collective intelligence and advice, bring support, as well as advocate for enhanced capacity and capabilities to optimize essential public health functions for disease surveillance and response actions.

6.3 NPHIs or MOHs

NPHIs or MOHs need to critically appraise their current approach to surveillance and clarify its purpose. Starting with an agreed global definition of IDS and framework, current national surveillance systems should be mapped, and their surveillance components reviewed to ensure that financing, governance, core functions, surveillance infrastructure and resourcing are suitable for their missions. MOHs and NPHIs should review governance and data sharing agreements so that a single agency, ideally an NPHI, has the authority to manage the collection, collation, and analysis of data from various sources and sectors. Coordination mechanisms between governments, MOHs, NPHIs, donors and funding organizations should strengthen alignment of all surveillance funding behind a newly developed plan for IDS. NPHIs should actively engage global peers to learn with and from others, becoming be part of a global community of practice. They should work with WHO and Regional CDCs to determine the extent to which data and metrics can be standardized and shared between countries to allow for reliable inter-country comparisons and exchange of data. NPHIs also need to increase their understanding and engagement with private sector actors that gather surveillance data and develop strategies for increasing data collection with and from the private sector as well as the non-human health sector.

6.4 National and Sub-national

Interfaces need to be strengthened through sustained investment to build functions related to IDS. These need to encompass the domains described in this report and should take place at all levels of government to ensure interconnectivity and that collective intelligence and evidence can be gathered and shared to enable timely response to health threats. At the operational level, the implementation of IDS will require careful multi-sectoral, multi-year planning processes. Local context, needs, constraints, and priorities, as well as health and non-health sectors at all levels of the system need to be considered. IDS action planning will need alignment and integration with the country's national public health and healthcare strategic plans and complement other existing programs and infrastructure to minimize duplication and conflicting activities.

Next Steps and Further Opportunities

Every country is different; therefore activities need to be tailored to the specific country context and level of IDS system maturity. Country specific plans for IDS implementation need to take an incremental approach that establish descriptors for various levels of IDS system maturity and recommend a suite of developmental actions and resources that are relevant to the specific maturity levels. The sustainability of the actions and maturity levels also must be considered. There is also benefit from peer-to-peer support and evaluation.

There is an evidence gap regarding the mechanisms that enable effective inter-sectoral and multi-disciplinary collaboration to take place. It is also unclear precisely how variations in system integration, simplicity, stability, or representativeness of data impact outcomes. More evaluation is needed because past studies did not quantify the effect of system integration and the governance of surveillance systems is rarely studied. There is also a specific evidence gap in terms of how surveillance impacts responses and outcomes, and how this pathway can be further optimized.

A health economics approach to decision making is another area for further research. Demonstrating how IDS can bolster a national economy by aiding prevention, early detection, preparedness, response, and recovery; while also providing direct health benefits such as reducing mortality, morbidity. Health economic can build a case for national and international investment in IDS and its supporting functions.

Another area for further work is the formulation of tools and guidance for NPHIs and public health entities on data integration for surveillance that have responsibility to collate, analyze and disseminate evidence for decision and action. It is recommended that co-design and co-production principles are used when these tools are created as this will best reflect and draw on collective and individual experience and expertise. Peer-to-peer and multi-lateral evaluation processes can also ensure that guidelines and assessments are realistic and implementable by the people and organizations tasked.

Conclusion

Across all three sub-studies, a common issue was the lack of a collective understanding of IDS. In addition, there were debates regarding the IDSR strategy and the entire disease surveillance ecosystem, including aspects of policy, culture, systems, infrastructure, processes, and wider determinants of surveillance efficacy. Another question that arose was whether it is advisable to push countries to have IDS. It can be expensive to set up, maintain and may only be of marginal value if desired outcomes could be achieved through other methods, such as more efficient data collection and linkages of existing surveillance systems. The risk of pursuing a route to IDS could mean setting up a separate IT system that countries cannot afford. It may also create a vulnerability by concentrating all surveillance into a single IT system.

The pursuit of integration of disease surveillance is complex and carries with it risks. The design and implementation of the building block and domains needed for the functions of an IDS system require skilled planning and implementation and should be guided by its intended purpose. Countries should integrate what needs to be integrated, when it needs to be integrated, for a specific aim, and with full knowledge of the relevant national context. IDS implementation will require that key strategic priorities and building blocks to be addressed, at every level of the public health system, to create a stable and sustainable surveillance system. Improvements in data systems and increasing the levels of integration need to be approached in a deliberate, incremental manner that are likely to be more sustainable and affordable. This integration endeavor must be collaborative and involve all the key stakeholders. Finally, for impact, the systems must be effective and durable, with surveillance activities and outputs linked to decision making and responses that are aligned with achieving intended aims.

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Acknowledgements

Project Management

Project Director: Sadaf Lynes, IANPHI
Project Officer: Jehan Gandamra, IANPHI
Technical Lead: Andrew Lee, UK Health Security Agency (UKHSA) and University of Sheffield
Executive Committee Chair: Quentin Sandifer, IANPHI
Technical Committee Chair and Advisor: Neil Squires, UKHSA

We are grateful to the following members of IANPHI and their respective organizations for their commitment in joining us in this project, for sharing their generous time and valued expertise, and for their active support and valuable feedback and editorial support in completing this work:

Executive Committee

Dr. Quentin Sandifer (Chair)	IANPHI
Dr. Kip Baggett	U.S. Centers for Disease Control and Prevention (U.S. CDC)
Professor Geneviève Chêne	Santé Publique France (SPF)
Dr. Scott Dowell	Bill & Melinda Gates Foundation (BMGF)
Dr. Angela Fehr	Robert Koch Institute (RKI)
Dr. Meerjady Sabrina Flora	IANPHI and Ministry of Health, Bangladesh
Dr. Eleni Galanis	Public Health Agency (PHA), Canada
Engr. Pierre Grand	WHO Hub for Pandemic and Epidemic Intelligence, Berlin
Professor Laetitia Huiart	SPF, France
Dr. Bjorn Iversen	Norwegian Institute of Public Health (NIPH)
Dr. Maarit Kokki	European Center for Disease Control and Prevention
Professor Andrew Lee	UKHSA and University of Sheffield
Sadaf Lynes	IANPHI
Dr. Natalie Mayet	National Institute for Communicable Diseases (NICD), South Africa
Dr. Lenka Korner Nahodilova	Robert Koch Institute (RKI)
Dr. Patrick O'Carroll	Taskforce for Global Health
Professor Neil Squires	UKHSA
Dr. Joy St. John	Caribbean Public Health Agency (CARPHA)
Dr. Raji Tajuddin	Africa Centres for Disease Control and Prevention (Africa CDC)
Dr. Anne-Catherine Viso	IANPHI
Ellen Whitney	IANPHI

Technical Committee

Professor Neil Squires (Chair)	UKHSA
Malin Ahrne	Public Health Agency, Sweden
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Dr. Alex Riolexus Ario	Uganda National Institute of Public Health (NPHI)
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Dr. Osman Dar	UKHSA
Dr. Jean-Claude Desenclos	Santé Publique France
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Dr. Bjorn Iversen	NIPH, Norway
Dr. Ilesh Jani	INS, Mozambique
Dr. Muhammad Khan	National Institute of Health (NIH), Pakistan
Professor Andrew Lee	UKHSA and University of Sheffield
Sadaf Lynes	IANPHI
Dr. Carlos Martinez	RKI, Germany
Dr. Dana Paquette	Public Health Agency Canada
Dr. Claudia Perandones	Unidad de Educación Superior ANLIS Malbrán, Argentina
Dr. Carl Reddy	Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET)
Daniel Stewart	UKHSA
Dr. Anders Tegnell	Public Health Agency (PHA), Sweden
Kyeng Mercy Tetuh	Africa CDC
Dr. Sabrina Weiss	RKI, Germany
Scott Teesdale	Resolve To Save Lives

Scoping Review Working Group

Dr. Gerd Flodgren (Lead)	NIPH, Norway
Norah Hamad Alkanhal	Public Health Authority, KSA
Janine Bezuidenhoudt	NICD, South Africa
Simon Brinkwirth	RKI, Germany
Professor Andrew Lee	UKHSA and University of Sheffield
James Ross	U.S. CDC

Survey Working Group

Dr. Jean-Claude Desenclos (Lead)	Santé Publique France
Janine Bezuidenhoudt	NICD, South Africa
Emily Carter	U.S. CDC
Professor Andrew Lee	UKHSA and University of Sheffield
Sadaf Lynes	IANPHI
Dr. Victoria Ng	PHA Canada
Daniel Stewart	UKHSA
Dr. Erin Rees	PHA Canada
James Ross	U.S. CDC
George Odongo	U.S. CDC

Deep Dive Core Working Group

Professor Andrew Lee (Lead)	UKHSA and University of Sheffield
Dr. Trude Arnesen	NIPH, Norway
Angela Hinds	CARPHA
Maryam Ibrahim	Africa CDC
Dr. Lisa Indar	CARPHA
Dr. Bjorn Iversen	NIPH, Norway
Sadaf Lynes	IANPHI
Dr. Celine Nadon	PHA Canada
Dr. Victoria Ng	PHA Canada
Dr. Stephanie Salyer	Africa CDC
Dr. Muhammad Sartaj	UKHSA
Dr. Anders Tegnell	PHA Sweden
Maddie Weir	UKHSA
Dr. Anne Wilson	UKHSA

Report Writing Team

Professor Andrew Lee (Lead)	UKHSA and University of Sheffield
Dr. Bjorn Iversen	NIPH, Norway
Dr. Jean-Claude Desenclos	SPF, France
Sadaf Lynes	IANPHI
Janine Bezuidenhoudt	NICD, South Africa
Dr. Gerd Flodgren	NIPH, Norway

Editorial Panel

Dr. Quentin Sandifer (Chair)	IANPHI
Dr. Kip Baggett	U.S. CDC
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Dr. Thidar Pyone	WHO
Professor Neil Squires	UKHSA
Dr. Joy St. John	CARPHA
Dr. Anders Tegnell	PHA Sweden
Ellen Whitney	IANPHI

Likewise, we are immensely thankful to the the following members of the Country Deep Dives and the twinned NPHIs, and all other contributors for organizing, delivering, and evaluating the deep dive consultations in their countries through both in person and remote participation:

Malawi working group: Public Health Institute of Malawi

- Dr. Benson Chilima (Lead)
- Mtisunge Yelewa (Co-Lead)
- Noel Khunga
- Dr. Annie Chauma
- Dr. Dzinkambane Kambalame
- Edward Chado

Partner NPHI: Norwegian Institute of Public Health

- Dr. Bjorn Iversen (Lead)
- Dr. Trude Arnesen
- Emily MacDonald
- Dr. Karine Nordstrand

Mozambique working group: National Institute of Health - Ministry of Health, Mozambique

- Dr. Eduardo Samo Gudo (Lead)
- Dr. Liliana Baloi,
- Dr. Americo Barata, National Institute of Health – Nampula
- Dr. Sergio Chicumbe
- Dr. Lutero Cuamba
- Dr. Janet Dula
- Dr. Thandie Harris
- Dr. Ivalda Macicame
- Dr. Naisa Manafo
- Dr. Tatiana Marufo
- Dr. Etelvina Mbalane
- Dr. Didier Mugabe
- Dr. Nilsa Nascimento
- Dr. Jose Paulo
- Dr. Acacio Sabonete
- Dr. Edna Viegas, National Institute of Health – Maputo City

Partner NPHI: Public Health Agency of Sweden

- Dr. Anders Tegnell
- Dr. Charlotte Larsson Sandén
- Dr. Maria Axelsson

Pakistan working group: National Institute of Health of Pakistan

- Muhammad Adeel Khan (Lead)
- Muhammad Ans Shams
- Mustafa Chaudry

Partner NPHI: United Kingdom Health Security Agency

- Dr. Muhammad Sartaj (Lead)
- Dr. Najma Javed Awan
- Dr. Muhammad Asif Khan
- Nadia Nisar
- Dr. Syed Wasif Shah
- Dr. Anne Wilson

Uganda working group: Uganda National Institute of Public Health

- Dr. Alex Ario Riolexus (Lead)
- Dr. Felix Ocom (Co-Lead)
- Dr. Alice Asio
- Dr. Vento Auma
- Dr. Immaculate Atuhaire
- Dr. Petranilla Nakamya
- Dr. Brenda Simbwa Nakafero
- Dr. Mercy Wendy Wanyana
- Dr. Hilda Wesonga
- Dr. Jane Frances Zalwango
- Dr. Maria Gorreti Zalwango
- Dr. Robert Zavuga

Partner NPHI: U.S. Centers for Disease Control and Prevention

- Briana Lucido (Lead)
- Erika Meyer (Lead)

Canada working group: Public Health Agency of Canada

- Dr. Dana Paquette (Lead)
- Jessica Deming
- Delane Boakye
- Emily-Ann Butler
- Janis Ellis-Claypool
- Dr. Eleni Galanis
- Orsolya Gyorgy
- Dr. Jean-Claude Mutabazi
- Dr. Celine A. Nadon
- Dr. Victoria Ng
- Dr. Erin Rees
- Dr. Ayesha Siddiqua
- Ranu Sharma

Partner NPHI: UK Health Security Agency

- Dr. Sally MacVinish (Lead)

Sweden working group: Public Health Agency of Sweden

- Dr. Anders Tegnell (Lead)
- Dr. Thomas Åkerlund
- Dr. Maria Axelsson
- Dr. Karolina Fischerström
- Dr. Emmy Johdet
- Dr. Sonja Löfmark
- Dr. Annelie Sandén
- Dr. Charlotte Larsson Sandén
- Dr. Amanda Ternstedt

Partner NPHI: Norwegian Institute of Public Health

- Dr. Astrid Louise Løvlie (Lead)
- Dr. Karine Nordstrand
- Dr. Elina Marjukka Seppälä

UK – England working group: University of Sheffield and UK Health Security Agency

- Professor Andrew Lee (Lead)
- Dr. Sally MacVinish
- Hannah Watson
- Jennifer Willburn

Partner NPHI: Public Health Agency of Canada

- Dr. Celine Nadon (Lead)

Last but not the least, this is to acknowledge the proposal development team including the UK Health Security Agency, Norwegian Institute of Public Health, Santé Publique France, Sadaf Lynes (consultant), and the IANPHI Secretariat (Paris) and office (Atlanta).

Additionally, our deepest appreciation to the IANPHI Executive Board, the PMO, Sadaf Lynes (Director), Jehan Gandamra (Manager), Dr. Quentin Sandifer, and Professor Neil Squires, and the project's technical leads, Professor Andrew Lee and Dr. Thidar Pyone. A very special thank you to Juliette Fugier (IANPHI Secretariat) for her consistent support in completing this project.

Appendix 1: Call for Action

Every country is different, both in terms of public health context and the level of IDS system maturity. There will likely never be a one-size-fits-all, universal IDS model to fit every context. Country context models for IDS need to be developed from adaptive frameworks and toolboxes to create maturity model for collaborative and integrated disease surveillance. Planning for country context models should be driven through peer-to-peer and multi-lateral peer collaborations. This will help ensure maturity models are based on realistic and inter-related plans and help achieve effective and optimized functions for IDS and required outcomes.

Several actors can play critical roles to ensure countries are well-equipped to tackle health threats through IDS to support early detection, preparedness, response and recovery.

In the call for action table below, we identify areas for action to advance IDS implementation. Each action is linked to one or more strategic priorities for implementing IDS shown in the areas for action column and identified by the following:

Purpose =1
Governance = 2
People = 3
Infrastructure = 4
Finance = 5
Collaboration and Shared learning = 6

In the table we have taken the approach to identify the levels at which these actions should be implemented and reflect the findings and working group discussions from the project. These include:

1. International Level (i.e., NGOs, Major Donors, Funders, Associations (IANPHI))
2. WHO Hub for pandemic and epidemic surveillance (WHO)
3. Supranational Level (i.e., Regional CDCs)
4. National Level (i.e., Central government, NPHIs/public health entities, Ministries, private/public sector)
5. Subnational Level (i.e., local authorities, providers, NGOs, academia)
6. Community Level (i.e., healthcare, community-based organizations)

In the lead/responsibility column we have indicated which of the actors have responsibility for leading on the implementation of these actions.

1. International Level (Partnerships, NGOs, Donors)

Purpose =1 Governance = 2 People = 3 Infrastructure = 4 Finance = 5 Collaboration and Shared learning = 6

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Strengthen surveillance functions through knowledge sharing [3,6]	Strengthen the surveillance functions (capacity and capabilities) of public health institutes, countries and entities through shared learning and best practice	WHO, INGOs, NGOs NPHIs and networks, major donors, international and national faculties/ schools of public health, MOH, government (groups)	Twinning of public health institutes and/or MOH public health entities to facilitate bi-directional learning (South to South, North to South, and North to North) and action to implementation Peer-to-peer and multi-lateral support to co-create a country context overview (through the evaluation of existing systems) and implementation plan to strengthen functions within organizations involved in public health intelligence, surveillance, and preparedness	IANPHI, The Task Force for Global Health, I/NGOs, WHO hub for epidemic and pandemic surveillance	Country driven evaluation and implementation plans that are built to reflect context and priorities Identification of country context levers, enablers, gaps, and opportunities	Efficient, focused, and optimized IDS plans, and improved preparedness and responses to emerging threats

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Investment [5]	Enable countries to build sustainable IDS surveillance systems that are agile, as well as improve the capacity and capabilities of those systems Align funding objectives with domestic goals, needs and priorities Enable IDS planners and implementers to bring together the technical knowledge, practical action, & implementation skills, to enable SMART models of implementation Leverage funding processes to strengthen & improve IDS or IT Systems	The pandemic fund (FIF), NGOs, major donors (World Bank, USAID, UN, UNICEF, BMGF, Global Fund, Rockefeller foundation, Chan Zuckerberg Initiative, etc), MOH, NPHIs	Building bi-directional paths of action from "top-down" to "bottom-up" implementation that converge to create multi-sectoral capabilities to collate, analyse and generate early warning, advice, and policies for a rapid response within a resilient system Enhanced dialogue and agreement between donors, government, NPHI/public health entities seeking to harmonize funding aims with domestic needs and priorities Programmatic monitoring and evaluation of systems applied to enable systematic improvement	The pandemic fund (FIF), i/NGOs, major donors (World Bank, USAID, BMGF, Global Health, Rockefeller foundation, Chan Zuckerberg initiative etc.	Customized surveillance systems that build a bi-directional approach to measurable impact Change through targeted actions (capacity and infrastructure building, data sharing) leading to impact	A sustainable responsive prevention and response system Investments are value for money and address key needs and priorities Sustainable systems created Investments support continuous quality improvement practice/operational research

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Advocacy [6]	Acceleration of policy into action through adoption, ownership, and evaluation Integrate wider issues that impact pandemics and epidemics (e.g., climate change, zoonosis/vectors, food insecurity)	Governments and international sector partnerships	Advocate and influence governments through international platforms such as G20, G7	NGOs, NPHIs, IANPHI.	Prioritization of systems building through strengthening the building blocks for epidemic prevention, preparedness/ response Acceleration of policy adoption & implementation	Prevention of epidemics and early response to emerging threats
Workforce [2,3,4,5,6]	Competency based training for Public Health – as set out in the Roadmap for the PH and Emergency workforce	WHO, INGOs, NGOs NPHIs/MOH, major donors, international and national faculties/ schools of public health, government	MOH, NPHIs with Schools of public health to develop competency-based training to deliver the essential public health functions for surveillance & response.	WHO	Skilled public health workforce to deliver the essential public health functions for surveillance and response.	Evidence-based decisions on early warning, prevention and response
Research and innovation [3,5,6]	Generate knowledge and evidence on IDS models	NPHIs; academic institutions, research organizations; multi-sectoral researchers; research funding bodies; governments	Identification of research priorities and needs, to inform the creation of an international research agenda Multi-sectoral funding for collaborative, implementation research on public health, and health systems research on IDS functions and building blocks	NPHIs, research funding bodies, Government, INGOs, NGOs, non-commercial research organizations	Generation of evidence, dissemination and sharing of best practice	Customized adoption of best practice models, translating evidence into practice

2. WHO Hub for Pandemic and Epidemic Surveillance Building on the mission for the Hub (Connect, Innovate, Strengthen)

Purpose =1 Governance = 2 People = 3 Infrastructure = 4 Finance = 5 Collaboration and Shared learning = 6

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Connect [3,6]	Provide collaborative space for shared learning on strengthening the building blocks for IDS	WHO Hub and partners	Host of collaborative engagement and learning driven through need and priority areas (challenges and opportunities). These activities to occur at various levels from national, supra-national through to international levels, as well as across sectors and disciplines.	WHO Hub for pandemic and epidemic surveillance	Collaborative networks (multi-sectoral and cross professional) established and sustained Repository of case studies, lessons learnt and guidance	Communities of practice and learning to improve surveillance and achieve outcomes to ensure response to health threats
Innovate [3,4,6]	Promote and disseminate cross-cutting innovation in IDS	WHO Hub stakeholders (public and private sector)	Information technology development, analytical capacity, laboratory and genomic support to surveillance, inter-sectoral collaboration, applied research. Building multi-professional and multi-sectoral consortia with geographical spread as an incubator for ideas: design, development, testing and exchange. Development of tools and implementation guides that can be adapted to different country contexts, and based of stages of IDS maturity Proof of concept/piloting and adoption into operational practice of innovations	WHO Hub for pandemic and epidemic intelligence	Sharing of innovative practice with measurable outcomes Acceleration of adoption into practice Impact of proven models with deliverable outcomes Development of IDS implementation strategy that fully integrates effective innovations and best practices	A vibrant IDS system that is progressive, innovative, and seeking to continually improve. A modernized IDS that fully integrates effective innovations and best practices

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Strengthen [2,4,6]	Build skills and surveillance capacities and capabilities across different sectors that contribute, lead and deliver functions related to IDS Advocate and lobby for investment in functions for IDS surveillance, capacity and capability building	WHO, regional CDCs	Develop WHO multi-sectoral toolkits and training modules for IDS/R Co-create a country context plan and implementation to strengthen functions within organizations leading on public health intelligence, surveillance, and preparedness	WHO Hub for pandemic and epidemic intelligence	Validated multi-sectoral toolkits and training modules for IDS/R	A more responsive and agile public health system able to respond quickly and flexibly to emerging threats Improved national capacities and capabilities to deliver high quality surveillance activities that positively impact on disease control policies/activities

3. Supranational (Regional) CDCs

Purpose =1 Governance = 2 People = 3 Infrastructure = 4 Finance = 5 Collaboration and Shared learning = 6

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Purpose [1]	Define the aim, scope, and purpose of IDS, to drive its design and implementation Develop IDS plans that are appropriate for the setting and country context, with specific relevance and application	NPHI/public health organizations; multi-sectoral lead organizations (health and non-health)	Define targeted outputs and outcomes Map systems, partnerships, infrastructure, data types, sharing capabilities and interfaces between health (communicable and non-communicable diseases) and non-health sectors	Government and ministries, NPHIs	Clarified aims, scope, and purpose of IDS Coherent IDS plans, based on country context, for the integration and enhanced interconnectivity of systems, networks, and intelligence Clarified roles and responsibilities of IDS actors Established systems and processes where the delivery system is defined by the ability to create early warning, preparedness, and response capabilities	Maximized efficiencies and effectiveness of surveillance systems from different sectors that are fit for purpose Roadmap and costed action plan for implementation
Regional coordination [3,6]	Strengthen regional coordination and learning through collective intelligence for regional impact	Regional CDCs, WHO regional offices, NPHIs/MOH, ministries, agencies, NGOs	Creating regional communities of practice where knowledge and intelligence is shared, and collective action is coordinated Alignment of priorities based on regional and country needs to strengthen functions for IDS	Regional CDCs, regional organizations e.g., European Union and African Union, WHO Regional Offices	Dissemination and sharing of evidence, collective intelligence, and best practice for IDS functions Country level capacity and capability building	Improved coordinated epidemic intelligence, surveillance, preparedness, and response for countries at regional level.

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Donor financing, implementation support [6]	Improve the coherence and sustainability of financing of IDS in LIC and LMIC countries	Donors, governmental organizations, not-for-profit organizations	Providing opportunities of collaborative practice based on collective priorities. Reduction of duplication of effort through targeted training across member states Rationalization and harmonization of funding streams and programmes to strengthen overall national surveillance systems and not just disease specific areas	Donors, regional CDCs	Building capacity and capabilities Knowledge repositories on cross-cutting themes (legal, data security and ethics, data analytics, communications, policy development) Complementarity between different donor funded surveillance systems with reduced duplications and strengthened national systems.	Coordinated donor funding and funded programmes that contribute to strengthened functions and support to drive decisions related to early detection, prevention, preparedness of epidemics
Implementation support and expertise [2,3,4,5]	Bring together IDS expertise to drive implementation, monitoring and evaluation	Member states (multi-professional), other regional CDC, twinned NPHIs/ public health organizations); donors, governmental organizations, not-for-profit organizations; private sector	Reducing failure of implementation from shared lessons. Providing opportunities to create collective learning from implementation Embedding monitoring and evaluation systems through a continuous learning mechanism Providing accessibility to countries of innovation, technology tools and platforms that can support an effective IDS	Regional CDC	Implementation through an agile shared learning approach. Strengthened capabilities and support to drive evidence and decisions Harnessing technologies that can facilitate analysis of multi-sectoral data into evidence	Rapid synthesis into decisions and action

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Collaborative learning and knowledge [3,6]	Share IDS best practices, innovations, and tools	Regional CDCs, WHO regional offices, FETP	Fellowships, secondments, research and innovation, evidence dissemination, technology sharing Creating inter-professional knowledge exchange and sharing of practice	Regional CDCs WHO regional offices	Effective sharing of best practice, innovation, and expertise, which strengthens IDS networks and capacities	Improved regional capacity, networks and mutual understanding with expertise applied to IDS
Advocacy [1,2,3,4,5,6]	Advocate for sufficient and sustained resource allocation to address public health IDS surveillance, preparedness, and response, for country priority needs	Regional CDCs; governments (member states); international development organizations	Build collective intelligence through regional surveillance and evidence Highlight priority areas for investment and focus to strengthen capacity and capabilities in member states	Regional CDCs	Shared strategic views for priority investment	Governmental and donor commitment to sustained resourcing of IDS

4. National (Country specific context)

Purpose =1 Governance = 2 People = 3 Infrastructure = 4 Finance = 5 Collaboration and Shared learning = 6

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Public health in all [1,2]	Strategic ownership for epidemic and pandemic preparedness through policies and strategic plans	Governmental sectors including non-health sectors, NPHIs	Explicit goals and objectives to be developed into ministerial level strategies that are adopted by departments and agencies reporting to those Ministries.	Government/MOH	Commitment across the sectors to engage in public health agenda Capacity and capability investment to create responsive organizations Development of multi-sectoral policies	Collective multi-sectoral effort, activities and policies to address public health threats

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
System governance [2,4,5]	Enhance and ensure appropriate governance of the IDS system	Government, NPHIs	To identify governance requirements and gaps in existing national systems and put in place development plans to address deficiencies. To clarify roles and responsibilities of key stakeholders in the system To provide effective leadership with clarity of goals and purpose of the system To promote adherence to legislation/regulatory frameworks and processes to protect data subjects	Government/ MOH	Clearly defined roles and responsibilities of stakeholders Clear and effective leadership, reporting and accountability structures Regulatory frameworks to protect the rights of data subjects Development plans to address system governance deficiencies	Surveillance system that is led and governed effectively in the pursuit of surveillance goals, with appropriate accountability mechanisms in place
System interoperability [1,3,4]	Optimize the interoperability of surveillance functions and systems	Government, NPHI/ public health organizations, multi-sectoral lead organizations (health and non-health)	Identify key drivers that support the building blocks and infrastructure necessary to establish an interoperable IDS system Adoption of a consolidated approach to devise and implement the various parts of the system so that it is operationally functional	Government/MOH	Functionality of platforms that create a collaborative and connected system across sectors Timely epidemic intelligence and reporting	Timely provision of multi-sectoral and multi-disciplinary surveillance outputs that inform decisions and responses to public health threats

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Collaboration [4,6]	Promote, develop and sustain collaborations and partnerships	All agencies	Inter-sectoral and multi-agency collaborations and networks, working to a common purpose to address public health threats Greater engagement of private providers and laboratories	All agencies	Commitment across sectors to collaborate More integrated data flows embedded in clear purpose and decision paths Timely sharing of data and reports	Effective multi-sectoral collaborations
Legal [1,3,4]	Advocate for the enactment of legal mandates that support collaborative surveillance (based on a One Health approach)	NPHI or public health entities (MOH) at the interface of sectors/ government	Legal mandates and agreements that enable data gathering, access, sharing and privacy protection across different organizations	Government	Clarity of multi-agency roles and responsibilities. Legal enablement of access and sharing of data from different health and non-health systems	Timely intelligence sharing between agencies

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Data interface [3,4]	Match purpose and planned outcomes to data source and surveillance systems, and improve both the inter-connectivity, interoperability as well as functional integration of these systems	NPHI/public health entity, multi-sectoral lead organizations (health and non-health)	Creating networks and pathways of national level data reporting Create standardized reporting tools, timelines and channels Identify predictive analytical tools and models to support synthesis of data Create capacity for data analysis and predictive models Data regulations ensuring mandatory reporting, data quality and privacy protection) Activities to improve the interconnectivity and interoperability of different surveillance systems	Government and national agencies in charge of databases and systems	Fit-for-purpose data warehouses Interconnected complementary data bases from health and non-health sectors. Multi-source analytical capacity Timely and efficient analysis and reporting	Timely intelligence, decisions, and responses to public health threats Improved data completeness, quality and data protection
Ethics and data security [1,3,4]	Ensure ethical functioning of surveillance systems Build an approach to the moral duty and legal obligation to fulfil with regards to population expectations and rights.	All agencies	To ensure that good ethical practices are followed by all agencies involved in IDS, thereby protecting the rights of citizens Creating accountability systems to beneficiaries and the public (i.e. accountability and oversight committees)	Government	Strict adherence to ethical principles and legislative measures for public health data use, intelligence, and evidence for the benefit of society, health and well-being in the fields of prevention and protection.	Analyse and use of personal data within the bounds of ethical principles to deliver evidence to protect public health from harm. Improved population trust in surveillance systems and adherence to regulations

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Financial models [1,4,5]	Financial commitment and realistic costed plans for IDS implementation Invest in and obtain sustainable funding for IDS systems Ensure coherence and complementarity of external and governmental financing	External donors, government	Scale to build, grow and sustain an operational budget that is ring-fenced for public health capacity in across surveillance. External donors to build transition and transfer funding models as part of vertical integration plans	Donors, government. NPHIs	Costed IDS implementation plans that are sustainable, with long term perspectives and sustainability built in. Financing of surveillance systems that is coordinated between donors/ funders	Improve targeting of external financing that supports a more sustainable and coherent development of IDS systems Less fragmented and more coherent resourcing of IDS
Applied research [3,6]	Promote and support innovative developments in applied research to support surveillance capacity and response	Research funders, governments, academia, NGOs, civil society, research organizations	Investment/additional funding to incentivize, support and drive research on IDS National governments/ NPHIs to devise IDS research strategy and priorities based on country needs and priorities Strengthening of research and epidemiology departments in national governments to identify needs and priorities.	NPHIs, MOH, Academia	More funding for applied research Developed applied models, framework and tool kits based on evidence Clear IDS research strategy and agenda Greater dissemination of IDS research outputs Catalysts and channels to facilitate adoption into practice	Improve integration through evidence-based knowledge and evaluation Epidemic and pandemic surveillance research translated into policy and practice

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Workforce requirements [1,3,4]	Develop workforce capacity and capabilities, across professions and sectors (health and non-health) to facilitate relevant data capture, detection, investigation, analysis, acceleration of evidence into recommendations, communication, and implementation	International and national faculty/ schools of public health/academic and educational organizations; public health, healthcare providers, laboratories; government departments	Building academic and professional/practical skills across the diversity of professionals across sectors needed for epidemic and pandemic prevention and response Internships, partnerships, on the job training Investing in dedicated workforce for IDS	Government, MOH, ministry of higher education	Sufficient and dedicated skilled workforce to deliver and maintain high performance surveillance systems	Improved system capacity, capability, and sustainability of the surveillance system to respond to health threats Improved timeliness and sustainability of surveillance functions (including data analysis and report dissemination)
National laboratories [3,4]	Build and improve laboratory capacity and capabilities, and sub-national laboratories infrastructure (including interoperable laboratory information systems, as well as genomic sequencing capabilities for both human and non-human health sectors)	Laboratories; MOH	Development of interlinked networks of national and subnational laboratories, with the required skills, capacity and capabilities, to provide the required laboratory support to disease control initiatives Map laboratory services coverage and development plans for gaps Building partnerships with regional laboratories	Governments/MOH	National coverage of key laboratory services Linkages between laboratory data systems allowing for integration and effective networks	Improved detection response and monitoring of emerging infectious threats through timely provision of laboratory services (including drug resistance and genomic sequencing)

5. Subnational

Purpose =1 Governance = 2 People = 3 Infrastructure = 4 Finance = 5 Collaboration and Shared learning = 6

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Local networks [3,6]	Build, strengthen and maintain local inter-professional and multi-sectoral networks and partnerships	Public health departments; national and sub-national government (country/provincial municipal/local authorities); healthcare providers; laboratories	Creating local working groups and networks that are multi-sectoral and inter-professional Create systems for bi-directional feedback between national and local levels	Public health departments, local authorities/ lunicipalities, healthcare providers, laboratories	Mature local networks and communities of practice able to problem solve, innovate, and learn collaboratively, as well as exchange knowledge. Better account of the local and community context in analysis and surveillance outputs.	Strengthened and improved capacity and response at all levels of the country from national to community levels, through creation of vigorous networks that are action oriented and solution focused.
Local engagement [2,3,4]	Strengthen local stakeholder engagement (e.g., with local providers and communities), linking into national IDS structures	Stakeholders to be identified through stakeholder engagement	As above	Public health departments, local authorities/ municipalities,	Empowerment of local stakeholders and community leaders	Improved and shared capacity Increased trust and confidence in MOH to respond to public health threats
Funding [4,5]	Developing and sustain surveillance systems, and enabling integration linked to purpose	National and sub-national government (Country/ Provincial Municipal/ local authorities); Donors	Ring-fenced funding to build and sustain multi-sectoral surveillance systems and IDS	National and sub-national government	Multi-sectoral surveillance system and collaborative interface and platforms for IDS Escalation systems based on multi-sectoral IDS intelligence and evidence	Early warning and local actions for prevention and control of epidemics Evidence based decisions for multi-sectoral response.

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Workforce [3,4,5]	Ensure capacity and capabilities are built through ring-fenced sustainable funding across stakeholders	Country/ provincial/ municipal/local authorities; healthcare providers; local laboratories; public health organizations	Build multi-sectoral capabilities and capacity through robust workforce needs assessment and planning, workforce budgeting, training, and skills development	Central government and local budgets	Adequate workforce staffing, with staff with the right skills and expertise, to deliver on data collation, quality assurance and analysis required for national and local decisions	Resilient and skilled workforce able to deliver core surveillance functions linked to early warning and local actions for the prevention and control of diseases, outbreaks, and epidemics
Translation into practice [1,3,4]	Efficiently operationalize national IDS policy and ambitions at the local level	Local IDS actors and stakeholders	Operationalization of IDS Local sectors assist with interpretation of data and translation of data to fit local context and setting	Public health departments, local authorities/ municipalities, healthcare providers, laboratories	Shared plan of action adapted to the local context Functional IDS system at the subnational level	Improved response that considers subnational context
Linking non-health surveillance to IDS [1,2,4,5]	Link or establish NCDs, non-health surveillance, e.g., wastewater surveillance to indicator and event-based surveillance as well as strengthening One Health to early warning and interventions to optimize the functions associated with IDS	Healthcare providers; municipalities/local authorities; agriculture, environmental, chemical, and occupational health sectors; NPHI and other public health organizations	Operationalization of IDS and the One Health approach with multi-sectoral engagement with key subnational actors, including non-health & NCD systems Further development work to incorporate systems currently yet to be integrated, including work around identifying key triggers and trends from non-health data, as well as exploring the potential utility of new opportunities around wastewater and genomic surveillance for example Alignment with social determinants of health including statistical information and real time data (e.g., demographics, geographical, environmental)	NPHI and other public health organizations	More multi-sectoral surveillance outputs, allowing greater depth and scope of analysis Better understanding of the potential scope and utility of new technologies/ developments/ opportunities, e.g., around wastewater and genomic surveillance More timely early warning through optimization of available data from other non-health sectors	Enhanced early warning and surveillance More comprehensive and insightful outputs from surveillance analysis to inform and guide system responses and decisions

6. Community Level

Purpose =1 Governance = 2 People = 3 Infrastructure = 4 Finance = 5 Collaboration and Shared learning = 6

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Primary care (PHC) and public health interface [2,3,4,6]	Strengthen the link and collaboration between primary care, public health, and other community/ local sectors	Primary care, hospital providers, local laboratories, public health, local authorities, and community sectors	Feedback loops between public health, healthcare, and laboratory providers in primary and community care (both public and private sector) Feedback from higher levels to PHC Establish primary care and public health networks	MOH, NPHI	Sustained networks of collaborative practice	Better collaboration with primary health care sector for early detection of disease of concerns and response.
Workforce	Support competency-based training of front-line PH workforce	MOH, local authorities with primary care and hospital providers	FETP fellow integration into multi-sectoral networks Strengthen capabilities and capacity of community healthcare and primary care professionals	MOH, NPHIs	Investigation and analytical competencies for rapid detection of health threats Escalation and dissemination of evidence for decision making.	Accelerated reporting and response of health threats

Areas for Action	Aim	Stakeholders	Activity	Lead/ Responsibility	Expected Output	Expected Outcome
Foster research and iInnovation [2,3,6]	Explore applied research aspects / practice	Research / academic sector	Multidisciplinary, multi-sectoral and teams approach at the local level to research/investigative studies, e.g., through point prevalence studies. Involvement of communities, local primary care, and public health, in IDS research and research agenda setting Identification of local IDS issues where further applied/practice-based research is required, local research questions, and community-level research priorities	NPHI; academic institutions	Creation of a local IDS research agenda that provides a snapshot overview of any areas that warrant further exploratory work Generation of robust IDS studies at the community level, addressing local community issues and priorities, and involves the community (e.g., prevalence studies)	Research system and culture that promotes applied research in IDS, as well as engagement of key local stakeholders in the research Research outputs incorporate a comprehensive analysis and interpretation that is informed by good understanding of local population context. In turn, generating innovative local solutions to local issues
Local engagement [3,6]	Increase community participation and engagement in surveillance, response, and recovery Learn from community experience in facing emerging threats.	Population and community-based organizations (e.g., civil society organizations, businesses, religious entities)	Dialogue with community representatives and NGOs. Exploration of avenues to boost communication from IDS providers to IDS users, especially local audiences, including the public Develop IDS systems that build in community involvement with a view to enhancing community-based surveillance.	NPHI, community representatives and stakeholders (e.g., civil society organizations/ non-governmental organizations)	Greater community participation and involvement in surveillance Enhanced communication with the community	Improved trust with the community, representatives, and stakeholders, established community-based surveillance Donors, governmental organizations, not-for-profit organizations, private sector

Appendix 2: Cross-Cutting Thematic Findings from the Workstreams

1. What IDS Means in Different Country Settings

In several of the articles included in the scoping review, the term IDSR was used instead of IDS. In many of the African countries included in the deep dives, IDS is perceived to be synonymous with IDSR and definitions were not discussed in detail. Only one of the articles in the scoping review used the definition of IDS provided by Nsubuga et al[1]., (which was used as a comparator in the survey). IDS is understood differently by survey respondents. Most respondents agreed to an extent with the IDS definition provided by Nsubuga et al. Agreement was stronger for respondents with no IDS than for respondents with a fully or partially developed IDS system. Respondents in the deep dives tended to give a more practical rather than theoretical definition of IDS.

Articles included in the scoping review provided various descriptions of the intent, aims, scope, or goals of IDS as a strategy, framework, platform, health unit, or means to improve surveillance. They also highlighted various aspects of the system that were important (e.g., usability of data, use of single infrastructure, coverage). Both the described target of integration (e.g., active and passive systems, vertical systems, animal sector, etc.), as well as the stated purpose/goal of the IDS system (e.g., improving surveillance and response, supporting decision making, alleviating disease and mortality) varied across studies.

Survey respondents indicated that the concept of IDS as a single infrastructure was challenging because it is a complex system to implement and manage. It was suggested that multiple, collaborative infrastructures could be used, based on greater data exploitation through appropriate and effective data sharing and better coordination between different systems and jurisdictions. Respondents also identified several aspects of an effective IDS system that were not covered in the provided IDS definition, such as the various levels of the surveillance system; the collaboration between sectors, agencies, and organizations required for the control

1 Nsubuga P, White M, Thacker SB et al. 2006. Chapter 53: Public health surveillance: a tool for targeting and monitoring interventions. In: Jamison DT, Breman JG, Measham AR et al.(eds). Disease Control Priorities Project. 2nd edition. Washington (DC):World Bank, http://files.dcp2.org/pdf/DCP/DCP53.pdf

and prevention of diseases and response to health threats; as well as the purpose of having a surveillance system to function as an early warning system to optimize public health responses. Several respondents suggested enhancements to the core principles proposed by Morgan et al. (2021)[2], such as effective system attributes and a multi-sectoral approach.

From the deep dives, IDS was seen as multiple activities that reduced the duplication of data collection and improved data sharing between vertical surveillance programs. For some, this could be achieved through the establishment of one common electronic platform, enabling the sharing of data between systems or having joint data analysis. Data systems should include One Health data, data from the public and private sectors, and include both laboratory and clinical information. It should also improve feedback loops across the different levels through data sharing and involve better linkages with disease control response, and whether information reaches end-users.

Summary

It was evident from the project that integration must be thought of as more than simply the integration of data and IT infrastructure, or the summation of data. Some questioned the need for integration and were concerned that it might imply a single system leading to "unwieldy" IT infrastructure that could "paralyze our ability to respond." Integration must be conceptualized across a spectrum of systems, capacities and activities. Respondents interpreted "integration" to be a complex process involving multiple stakeholders and sectors, occurring at all levels of the health system, and adopted what can be described as a "whole systems" perspective. There were also concerns that integration cannot be easily realized due to the plurality of systems and lack of sufficient standardization in the system. "Compatible infrastructures" instead of a "single infrastructure" may be needed. Integration should also not be seen as a solution across all topic areas, but should be prioritized by topic area to inform public health action.

2 Morgan OW, Aguilera X, Ammon A, Amuasi J, Fall IS, Frieden T, Heymann D, Ihekweazu C, Jeong EK, Leung GM, Mahon B, Nkengasong J, Qamar FN, Schuchat A, Wieler LH, Dowell SF. Disease surveillance for the COVID-19 era: time for bold changes. Lancet. 2021 Jun 19;397(10292):2317-2319. doi: 10.1016/S0140-6736(21)01096-5. Epub 2021 May 14. PMID: 34000258; PMCID: PMC8121493.

2. The Role of National Public Health Institutes and Public Health Agencies

The role of NPHIs in IDS is not well defined in the published evidence. NPHIs are not established in all countries, and in several countries, there are national departments under the MOH that provide the functions of public health. While most surveillance systems involved the MOH, in many countries where there were NPHIs. In those countries, NPHIs played a major role, either jointly with the MOH or as the sole lead agency, particularly for the core functions of surveillance. This includes ownership of surveillance systems. This was especially true for countries in higher income groups, and those with more developed IDS systems (including some LICs), where NPHIs were found to be key to the development and functioning of the IDS systems[3]. Countries with developed IDS systems also reported that the reporting of surveillance outputs was led by NPHIs, and the feedback function was shared by the MOH and NPHIs. On the other hand, the response function tended to be primarily led by the MOH rather than the NPHI. The NPHIs' dominant role in leading on the core functions of IDS systems is strongest for the HIC respondents and decreases with income group where the MOH more frequently leads on the core functions.

In all four LMIC deep dives, the NPHIs were either responsible for IDSR, or have a significant role working jointly with the MOH that had the lead responsibility for disease surveillance. In all LMICs there were other actors responsible for other parts of health surveillance. For the HIC deep dives, all the NPHIs involved had a role in data gathering through surveillance systems, providing expert technical advice and analysis, and coordinating communicable disease control and prevention, especially where more than one region is involved. All had significant crossovers in functions as well as interfaces with other government departments and agencies. Their levels of autonomy ranged from being independent of government to being part of the MOH. The authority and powers of NPHIs also varied, from having a legal mandate to having more limited powers. They were likely to hold unique roles too, such as acting as the country's IHR National Focal Point, or as the national statistical authority responsible for statistics within infection control and public health development.

Summary

It was evident that NPHIs in both LMIC and HIC settings play a significant role in the development, delivery and maintenance of IDS, either as the sole lead agency or in conjunction with the MOH. The extent of the NPHI's autonomy, authority and roles varies. These are dependent on the scope of their legal mandate and powers. It is important for NPHIs to retain independent scientific integrity to make evidence-based recommendations and decisions.

3 IANPHI Integrated Disease Surveillance Project, Multi-Country Survey, 2022

3. Differing Levels of IDS System Maturity

Evidence from the scoping review suggests there are varying levels of IDS or IDSR system maturity across different WHO Africa member states, as well as weak surveillance systems in India. Due to poorer technological development, LICs may lag in digitization and system integration compared to HICs. In HICs there is also a continuum of surveillance system maturity and varying levels of integration, with systems set up to provide some degree of functionality. The perceived level of IDS maturity does not necessarily mirror the country's income level. Some LICs, mostly in Africa, were more likely to report having developed IDS systems. One reason for the higher perceived level of IDS system maturity in LICs may be due to a greater familiarity with the WHO's IDSR strategy in African countries. It may also be due to differing interpretations of the definition of integration. As one deep dive country reported, their system was "integrated enough to respond, but not if it is about integrated systems and data analytics." The highest form of integration, convergent integration, was more frequently reported in LICs than in HICs.

Disease surveillance system integration was reported in the survey to occur most commonly in the human sector. More than half of respondents who reported the existence of case-based, disease-specific, vaccine coverage, and laboratory-based surveillance systems stated these were integrated. Less common were integrated One Health systems (~25%), and the least integrated was the animal sector. Integration of vertical, and externally donor-funded programs were also less common. From the scoping review, IDS data in LMICs appear to consist mostly of syndromic data, with little laboratory confirmation, and with little or no reporting from the private sector, or use of non-healthcare data (e.g., CRVS data). In most countries there is a wide range of surveillance systems with varying levels of data collection, data availability, and integration of data. Data from notifiable disease systems were most often collected and integrated, while data on behavioral, surveys/research, community-based and wastewater surveillance less often so.

Current systems in many countries allow for the integration of data from various sources. Approximately 20% of respondents, mostly from LMICs, reported having systems that were not fully capable of meeting their requirements. Most IDS systems in LMICs are not fully digitized. Hand-written patient records and reporting forms remain common, particularly at the health facility level. Data is transferred to an electronic format at various levels. HICs all reported having multiple, highly developed disease surveillance systems that were widely used, but with varying degrees of integration and data sharing, despite none of them fitting WHO IDSR's description of an integrated disease surveillance system. These systems were not perfect and had issues, such as a lack of consistency in coverage and multiplicity of actors. For example, Sweden's system was described as a "distributed network with many actors taking care of their part of the system". It may be neither feasible, affordable, nor even desirable to integrate these developed systems into a single system.

Summary

IDS system maturity varies by country and is not necessarily linked to country income levels. Countries need to start their integration journey from where they are. Integration varies and is better for some sectors such as human health and infectious diseases. Multiple barriers to integration exist that affect data availability, interoperability, coverage, capacity and coordination. Digitization such as the potential use of unique health identifiers and electronic records/documentation may help. Other enablers for IDS development include supporting IT infrastructure, supportive legislation, sustainable funding, together with workforce training and capacity building.

Multiple challenges to surveillance system integration were identified including the disparity of data and systems, a lack of unique health identifiers or updated ID registries, unstable and poor web-access, lack of quality assurance systems, poor IT system capacity and interoperability, lack of financing and workforce capacity, lack of coordination and collaboration between sectors, legal limitations for data collection and sharing, and concerns with governance including the lack of clear definition of roles and of understanding between sectors.

4. Roles and Responsibilities in Fragmented and Integrated Systems

The charter, governance, roles and responsibilities of IDS at different levels of the system, such as health facilities and the data collection level, region, district, or national level. They were usually neither described nor discussed in literature, which is focused almost entirely on core functions and the resourcing requirements of IDS systems. Paradoxically, fragmentation and integration issues were commonly reported in the survey and deep dives.

Fragmentation and the lack of integration between sectors was evident, particularly regarding the One Health strategy. There was a high degree of fragmentation of disease surveillance reported by the participating LMICs. For example, governmental responsibility for surveillance of human health lies with MOHs, but animal and environmental health are the domains of other ministries such as agriculture. There were some attempts at One Health integration, mainly within NPHIs. Externally funded disease programs, mostly funded by international donor organizations, tended to set up their own surveillance systems for their selected diseases, and seldom shared their data with governmental surveillance systems.

For most respondents, public sector health providers and laboratories were involved in their country's surveillance systems, but there was low integration of surveillance systems with private and pharmaceutical sector, especially in LICs and LMICs. This was the same for non-health sectors, although animal health and environmental health demonstrated a higher level of integration compared to other sectors such as agriculture. Biosafety and biosecurity related surveillance were also variable with better integration with food security surveillance as compared to the chemical and poison sector.

Multi-sectoral surveillance involvement was more commonly reported in settings with a developed or partially developed IDS system. Various case studies and exemplars of good practice were also cited that point to the enabling role of technology including greater automation, electronic reporting systems, algorithms, and data platforms. While the capacity of LICs and LMICs to maintain and develop indicator-based surveillance systems appeared similar to UMICs and HICs, LIC and LMIC respondents reported that they lacked the resources to invest to a similar extent for capacity to maintain event-based surveillance systems. This consequently affects their detection functions and inhibits their ability to deliver a rapid response.

For HICs, organizational boundaries and national boundaries make integration difficult. Each has different access to data assets, IT systems, procedures, different definitions, and denominators. Surveillance tends to be a shared responsibility between federal, provincial, and administrative levels. Boundary issues can be partially overcome through national-level surveillance support such having established longstanding national survey systems, support from NPHI senior management, federal public health experts, and dedicated networks for integration (e.g., laboratory networks), as well as supportive legislation that regulates the surveillance role and defines which communicable diseases are under surveillance. Public involvement tends to be limited and there is room for greater public engagement.

Summary

Integration issues exist especially at the interfaces of fragmented systems. Often these systems are too vertical; divided between different organizations, local versus national levels, or sectors. Integration tended to be particularly weak for the private and pharmaceutical sectors, and to a lesser extent the non-health sectors. Public engagement is weak. Technology, professional and laboratory networks, as well as supportive legislation, may help overcome some of these issues. Improved governance and clear organizational mandates are also needed at all levels of the IDS system.

5. Multi-sectoral Integration

Disease surveillance integration is usually better for human infectious disease surveillance, specifically for notifiable infectious diseases, and disease specific programs. An example of collaborative multi-sectoral integration is the One Health approach to surveillance where efforts have been directed to improving linkages between human, animal, and environmental health sectors. The rationale for this is the expected improvements in effectiveness and efficiency of disease control, from prevention to detection, preparedness, response, and management of infections. For example, the use of animal data as a predictive model for human cases, or the combination of existing information in an integrated One Health surveillance system to better assess the magnitude and spread of zoonotic agents. Multiple barriers to the adoption of an integrated One Health approach have been encountered such as the diversity of data and surveillance systems, as well as prohibitive costs.

Although many sectors are involved in the collection of surveillance data, the data are not necessarily accessible and rarely integrated into human public health surveillance systems. This is particularly true for data from other sectors than health, such as animal, agricultural and environmental health, as well as the private and pharmaceutical sectors. Even health sector data may be problematic, usually for non-infectious disease sectors such as Noncommunicable disease (NCD) programs, occupational health, surveys, research, health and demographic data, and behavioral surveillance, as well as laboratory and genomic data.

The reasons for these integration issues include poor data systems integration, lack of IT interoperability or data sharing, lack of equipment and supplies, and limited staff. Data from other sectors tend not to be standardized and are not always collected in the same way or same time periods. This results in heavier data processing requirements and generation of data outputs that are not easily compared or interpreted. Other barriers include governance requirements related to data ownership, data sharing agreements and permissions, as well as a lack of enforcement for reporting. A lack of funding hinders the development, implementation and maintenance of IT and laboratory infrastructure for IDS infrastructure. This can lead to patchy accessibility and availability of genomic testing and sequencing for example, or limited coverage of national public health laboratories.

These issues affect all countries, but especially LMICs where there is limited integration of surveillance systems across and within sectors, and weak integration between the health sector and non-health sector. Siloed, vertical disease-specific systems create further barriers to integration because of information governance restrictions and protectionist unwillingness to share data. For the HICs, it was reported that there is a wide range of active and passive surveillance systems across different sectors that make use of diverse data platforms and infrastructures. However, there are limited formal linkages or shared governance mechanisms between animal health and human health sectors, although some informal data sharing does exist at both local and national levels.

What is also not known is the effect of system integration on cost-effectiveness, simplicity, and reliability of the system, or the representativeness of data. There is a lack of evaluation studies as most studies did not quantify the effect of system integration. Multi-sectoral integration clearly relies on good intersectoral collaboration between different actors and access to a plurality of data sources, including from the private sector. While the barriers to integration are well-recognized, there is an evidence gap regarding the mechanisms that enable effective inter-sectoral and multi-disciplinary collaboration to take place.

ne suggested approach is to adopt a stepwise, or incremental approach to increase multi-sectoral integration. The first step is to assure the quality of existing communicable disease data, then to sequentially link-in laboratory data, animal health data, data from civil registries and vital statistics (CRVS), and other data as required. Which data are integrated should be carefully considered and technological innovations may help facilitate multi-sectoral integration. There are four levels of integration mechanisms that should be considered: interconnectivity [19], interoperability [33], semantic consistency [21] and convergent integration [27]. [Box 1- **Definitions of integration mechanisms**[4]]

Box 1. Definitions of integration mechanisms

- Interconnectivity: Interconnectivity includes the sharing of external devices or transfer of data files with little or no integration in terms of function. An example is the exchange of information between two systems to alert the authorities of any unusual disease event.
- Interoperability: This is the ability of the system or its component to work with another system without special effort required from the users. It allows the different systems to communicate and exchange data.
- Semantic consistency: This refers to the implementation of database management and reporting systems that enable access to data while reducing the potential for errors in human interpretation through the creation of standard data definitions and formats.
- Convergent integration: This involves the merging of technology with business processes, knowledge, and human performance, and represents the highest and most sophisticated form of the integration state. An example is the current integration activities for One Health and IDSR.

Summary

Multi-sectoral integration of disease surveillance such as One Health is less common even though it is desirable. The anticipated benefits include improving the sensitivity of disease surveillance systems and enhancing the quality and timeliness of surveillance data. There is less integration with non-health sectors and non-infectious disease sectors within the health sector. Vertical, disease-specific systems are particularly problematic in LICs and LMICs in terms of data linkages and accessibility. There is a need to improve active collaboration between health and non-health sectors, ensure that data collected in different sectors can be used and/or integrated for public health surveillance, as well as promote data collection standards and protocols across sectors.

4 Nsubuga P, White M, Thacker SB et al. 2006. Chapter 53: Public health surveillance: a tool for targeting and monitoring interventions. In: Jamison DT, Breman JG, Measham AR et al.(eds). Disease Control Priorities Project. 2nd edition. Washington (DC):World Bank, http://files.dcp2.org/pdf/DCP/DCP53.pdf

6. Core Functions (Activities)

There are several ways of listing and grouping the core functions and activities of disease surveillance. For the conceptual framework developed for this project, the core functions listed as one of five principles for IDS are based on the *Technical Guidelines for Integrated Disease Surveillance and Response in the African Region*.[5] In the conceptual framework they are listed as "Detect", "Report", "Analyze", "Investigate/confirm/verify", "Respond", "Feedback", "Evaluate", and "Preparedness".

The survey found that the NPHIs were most often responsible for the various core functions, except for responding to public health events where the MOH more often was the lead agency. None of the reported findings in the three workstreams indicated a total absence or major gaps in countries' core functions. However, there are varying degrees of weaknesses between the core functions. The scoping review identified many of the attributes of a surveillance system necessary to provide good quality surveillance data and highlighted for many of the core functions that need to be in place. Those attributes include that data should be collated, compiled and managed in a consistent way to allow for effective analysis and use. The underuse of work aids such as standard operating procedures (SOPs), standardized case definitions, technical guidance was a problem mentioned in many of the included articles. This could be explained by poor IT infrastructure and web access in many African countries. Also the extensive, 500-page-long IDSR technical guideline may be too long and itself act as a barrier to implementation.

For HICs the core functions for disease surveillance systems were noted to generally work well. However, their systems still had room for improvements such as increasing automation, clarifying data protection and confidentiality concerns, improving standardization and improved IT systems. For optimal data flow there needs to be a system allowing data from local and provincial infrastructures to feed into compatible infrastructures at the federal or national level.

In LMICs, some of the weaknesses listed were difficulties in outbreak detection, lack of systematic quality checks, analytical capacity and timely reporting, lack of basic resources and equipment in the laboratories. The "human factor" was listed by several HIC and LIC respondents as a facilitator for well-functioning surveillance systems. The actor responsible for the collection and analysis of the data usually have extensive knowledge and experience with their data. Collaborations take place within existing surveillance networks that replace some of the advantages a common infrastructure might have.

5 World Health Organisation, Technical Guidelines integrated Disease Surveillance and Response, Africa Region, third Edition, https://www.afro.who.int/publications/technical-guidelines-integrated-disease-surveillance-and-response-african-region-third

Poor reporting and poor data quality were noted across the workstreams, especially from private health facilities. This is a major problem in many countries where a substantial proportion of the population relies on private healthcare services. Poor reporting may in part be due to the low priority given to surveillance tasks, and poor knowledge of the purpose of IDS among surveillance staff. This might be mitigated through implementation aids, enhanced training, and incentivization of reporting excellence.

The survey highlights a moderate-strong level of establishment for the core functions "detect," "analyze," and "respond" and a moderate level for "investigate," "evaluate," and "provide feedback," the latter being the least advanced, including in HICs. Developed IDS systems reported most frequently a moderate-strong level of establishment for the core functions to "detect," "analyze," and "respond." From the deep dives, several countries report limited analytical capacity. Consequently, there is a need for prioritization of disease areas and surveillance activity.

In the scoping review, little or no data was provided on monitoring and evaluation, or on preparedness, in the included articles. In the survey, developed IDS systems reported moderate levels for "investigate," "evaluate," and "provide feedback." Partial IDS systems reported a moderate-strong level of establishment for all core functions, except for "evaluate," and "provide feedback," which was reported to be at the moderate to weak levels of establishment. HIC respondents most frequently reported a moderate-strong level of establishment for all core functions except for "evaluate." The UMIC group also reported weak to moderate levels of establishment for the "evaluate" core function, and stronger establishment levels for the other core functions. LIC and LMIC groups reported similar findings.

Summary

The reported performance of the core functions varied by country, but tended to be weaker in LICs, particularly for the "report", "evaluate" and "feedback" elements. Weak "evaluate" function was common to both LICs and HICs. IDS systems need to be monitored and evaluated on a routine basis, and they require enhanced feedback mechanisms at all levels of the system. There is a clear need to strengthen the evaluation function, as well as to conduct a systematic assessment to identify gaps and weaknesses in the core functions for improvement, with consideration too of the "human factor" in surveillance systems.

7. Resourcing Requirements (Inputs)

7.1 Human Resources

The adequate and efficient provision of resources are essential for a sustainable IDS system. All three workstreams identified the importance of having sufficient human resources with enhanced and continuous training. All the LMIC deep dives reported the lack of human resources, both in terms of quantity and quality. Dedicated and motivated staff coupled with regular supervision and feedback are needed. Another aspect identified in the project was the need for continuity of the workforce, and succession planning when staff leave. Although most survey respondents reported there was average workforce capacity to support indicator-based and event-based surveillance systems, the need for expert analytical input to ensure appropriate interpretation of surveillance data was highlighted. The shortage of trained public health professionals with necessary skills and competencies was also raised. The most common gaps in the workforce identified in the survey were in the fields of data science and analytics, information technology, epidemiology, administration, data entry, laboratory, and public health generalists. Other gaps identified included an overburdened workforce and variation in skills. A shortage of workforce can lead to exhaustion and low morale, as evidenced by the additional work pressure during the COVID-19 pandemic. Surveillance workforce development initiatives were predominantly led by the MOH or NPHI, and there was no difference when stratified by IDS maturity and income group.

Summary

There is a major need to invest as part of an active and sustained national policy in workforce capacity, development, and retention. Having the right skills and expertise are essential, with data science and analytics, and information technology being common priority areas.

7.2 Infrastructure and Tools

An effective IDS system requires enhanced laboratory facilities and capacity, updated infrastructure and technology, including IT systems and databases that communicate well, and data management tools. Standardization, including clear standard operating procedures, protocols, and training materials, as well as the creation and distribution of all reporting tools across every level of implementation are needed. Survey respondents indicated that laboratory data were reported from public, private, and regional supranational lab sources, and two-thirds of the respondents reported that lab data were integrated into their IDS system electronically through compatible IT systems. Genomic testing and sequencing were available for most respondents with a developed or partial IDS system.

Summary

Laboratory and IT infrastructure are essential building blocks for IDS systems. These need to be maintained, integrated, and developed, across various levels and sectors.

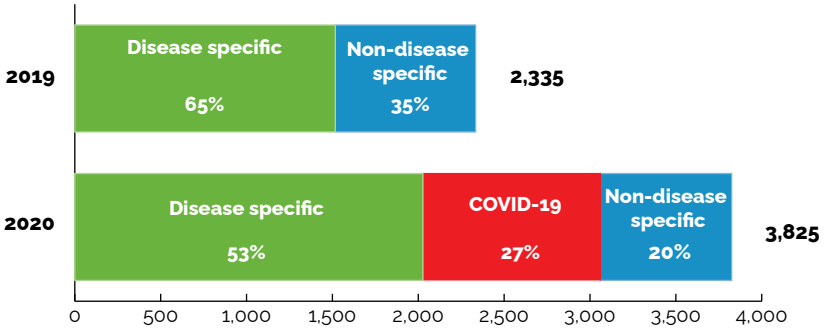
7.3 Financing

Resource requirements are highly dependent on adequate and sustainable financing of IDS. Even though financing and ownership were not discussed in-depth in the articles included in the review, there were several brief mentions of inadequate and unsustainable funding. Inadequate investment and the lack of a multi-year budget were identified as challenges in setting up and running their IDS systems by most respondents with either a full or partial IDS system. Just over half of those countries with no IDS system identified finance as one of the barriers that had prevented them from establishing an IDS system.

Financing for disease surveillance was provided by national governments for most respondents with developed IDS, for approximately half of those with partial IDS systems, and less than a third for those with no IDS. For countries without an IDS system, disease surveillance systems were often funded through international aid from a non-government organization or international aid from another country partner. In one LMIC country it was reported that 80% of their surveillance and response funding comes from external development funding, showing how critically important external funding is, but also that it contributes to the fragmenting of the disease surveillance system.

Funders often do not have a shared definition of funding for disease surveillance.[6] Different motivations for investing in disease surveillance result in different perspectives on what constitutes disease surveillance.[7] International funding for disease surveillance is overwhelmingly disease specific, and less international funding is available for IDS or often neglected diseases.[8] For example, although funding for disease surveillance increased by 64% from 2019 to 2020, at least 68% (US$1 billion) of the increase was directly related to COVID-19 activities.[9]

Share of disease specific disease surveillance funding 2019-2020 *US$ millions*



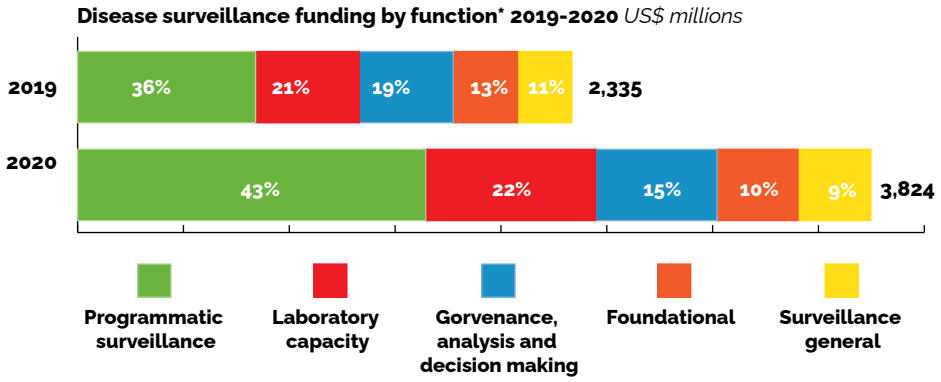
Source: Multilateral and philantrophic split of funding by function is based on assumptions informed by expert interveiws and available data.
Bilateral split was identified basd on CRS purpose codes

6 Donor Tracker, Donortracker.org

7 Donor Tracker, Donortracker.org

8 Donor Tracker, Donortracker.org

9 Donor Tracker, Donortracker.org



Source: Multilateral and philantrophic split of funding by function is based on assumptions informed by expert interveiws and available data.
Bilateral split was identified through keyword search of project descriptions of disease surveillance system.
*Surveillance general category includes funding directed at multiple components or to no specific component.
Significant share of funding from bilateral donors partly reflects keyword approach to classifying bilateral funding.

The unavailability of multi-year financing was identified as a constraint across WHO regions, ranging from 13% to 15%. It was also noted that budget cycles tended to be short and there was no additional budget for improving surveillance or enhancing integration in surveillance. The lack of sufficient, sustained, and stable funding inhibits the ability to modernize and maintain surveillance IT infrastructure, resources, and capacity. And when new surveillance activities are initiated, there may be a lack clarity as to which agency will fund which aspects. For example, many of the surveillance systems set up for the COVID-19 pandemic were reported to be resource intensive and expensive, and therefore not sustainable in the long-term.

The reliance on international aid funding is not a sustainable source of investment and governmental commitment will be necessary to enable countries to optimize the use of an integrated system, with the tools and skills to build capabilities. A solution-based approach to donor funding that builds sustainable structures for IDS systems and integration of vertical surveillance is required.

Summary

Sufficient, sustained, multi-year funding is required to establish, maintain, and integrate disease surveillance systems. LICs/LMICs are heavily reliant on external funding for their systems, but this may exacerbate fragmentation of surveillance systems. Consequently, donors and funding agencies are key actors in these settings and have a critical role to play in fostering and maintaining IDS systems.

8. Governance

The scoping review showed that governance of surveillance systems is a rare subject of research in scientific literature. A few articles briefly mentioned how governance was inadequate (e.g., lack of regulation of notifiable disease reporting in India, poor leadership, etc.), and that good leadership and governance at all levels of the system, as well as government commitment, were needed for successful IDS implementation and effective functioning. Similarly, the issue of governance was highlighted in the survey, including the need for adequate legislative and regulatory frameworks, good governance and political engagement, appropriate control, monitoring, and evaluation.

Leadership and clear ownership of surveillance were also identified to be vital. In the survey, MOHs and NPHIs were reported to be the lead agency responsible for public health surveillance in most settings, with a quarter of respondents with joint leadership, either shared between the MOH and NPHI (12%; 7/65) or between multiple regional, national, or subnational agencies (12%; 8/65). Almost half of respondents indicated that the NPHI was either the sole (32%; 21/65) or joint lead agency for public health surveillance. The MOH was more often the lead agency particularly in LICs, Africa or the Americas. Likewise, either the MOH and/or NPHI had the legal mandate to require reporting of notifiable diseases, hazards, or other threats to human health (the MOH had sole mandate in 52%; 33/64, and shared mandate in 19%; 12/64). The mandate applies to public sector providers (all), as well as to a large majority of the private sector (95%), NGO providers (87%), animal health and agricultural sector (96%), food industry and water sector (89%), chemical and poison sector (87%), occupational health (85%) and the pharmaceutical sector (80%).

Adherence to legal mandates was another issue. Half (30/59) of respondents reported partial adherence to the legal mandate and just over one-third reported good adherence (23/59). Respondents with developed IDS (100%) or partial IDS (91%; 32/35) reported having either partial or good adherence to the legal mandate compared to countries with no IDS (75%; 9/12). UMICs and HICs respondents stated that adherence to the mandate was good (54%; 20/37) compared to only 14% (3/21) for those from LMICs and LICs. Adherence to the mandate was good for 59% (13/22) in Europe, 36% (5/14) in the Americas and 23% (3/13) in Africa.

There was also an ethical dimension to the governance of IDS. Privacy protection was not optimal. Of 63 survey respondents, 49% indicated that privacy protection was well established, 41% partially established or in development and 10% not established. Privacy protection tended to be better established in countries with developed IDS (56%; 9/16) or partial IDS (51%, 18/35) than in countries without an IDS (33%, 4/12). Privacy protection was better established in HICs and UMICs (59.5%, 22/37) compared to LICs and LMICs (32%, 8/25). It was well established in 64% of respondents (14/22) in Europe, 50% (7/14) in the Americas and 38% (6/16) in Africa.

The deep dives corroborated findings from the survey, including the reported lack of coherent legal framework and ownership for various aspects of IDS in some LMIC settings. For example, although the MOH often plays the leading role for human health, and the ministries of animal health or agriculture are responsible for animal health and food safety, responsibility within the ministries can be split between departments. The deep dives also revealed a lack of strategy or clear instruction from the central authority. Weak communication between central stakeholders, the lack of political awareness and support, and a lack of clear support to and allocation of power to the NPHI was also noted.

Similarly, the deep dives in HICs demonstrated the importance of a legal basis and mandate for surveillance. A legal framework such as Sweden's Constitution Act helps articulate the roles and responsibilities of the different actors in the system. Laws and other regulations facilitate surveillance by mandating groups to report and provides a legal instrument for the sharing of data. Data collection can be steered by laws and regulations. Where there was a lack of clarity on responsibilities between agencies, this can result in gaps in governance and a poorer response.

A strong legal system also gives stability to the surveillance system but makes changes and adaptations difficult. Existing legal frameworks make it challenging for integration, such as issues with accessing data, data linkage, and data sharing between organizations and regions. Information governance, data protection and confidentiality are important to protect data subjects, but their implementation is time consuming and can delay timely effective data sharing. A unified data collection at the national level requires multiple agreements corresponding to the privacy legislations for each jurisdiction. Consequently, having formalized data sharing agreements between different federal, provincial, and territorial administrative levels are important facilitators.

Summary

Different systems organized by different authorities make coordination and cooperation difficult. However, making wide-scale changes to existing surveillance systems would require political will and support, funding, and clarity of organizational governance structures. Not all NPHI have sufficient authority to mandate the integration of systems in other organizations for example. Neither are all hazards of public health importance supported by legislation. The presence of an enabling legal and regulatory framework could help facilitate surveillance. It is also important to consider the ethical dimension and privacy protection of surveillance systems.

9. Other Emerging Findings

In addition to the core dimensions above, there were a few other notable themes that emerged from the data. These are briefly presented below:

9.1 Effect of the COVID-19 Pandemic

The COVID-19 pandemic has revealed acute and long-term needs to improve surveillance. Overall the pandemic contributed to strengthening surveillance in all regions of the world by leveraging existing surveillance systems and developing new and innovative schemes for response. For some countries, however, the improvement was only for COVID-19-related data and did not last long. In a few countries in sub-Saharan Africa, COVID-19 even destabilized existing surveillance systems or failed to strengthen them. There were various examples of innovation and good practice related to greater cross-sector collaboration, capacity building and enhanced capabilities, data sharing and better analytics, the adoption of technology and creation of tools and training. The pandemic experience demonstrates how surveillance systems can rise to the challenge with adequate resources, but these developments are unlikely to be sustained without adequate resources going forwards.

Summary

The pandemic has shown that there is potential to improve surveillance effectiveness through leveraging existing surveillance systems and cross-sector collaboration. In addition, the pandemic legacy of good practice and innovative COVID-19 surveillance initiatives could be embedded into current systems. Sustaining these developments will require appropriate funding, resources, workforce development and infrastructure, and alignment to priority needs.

9.2 Influence of External Funding on IDS

Although the external funding of disease programs with surveillance systems in LICs and LMICs is critical for many of these donor dependent countries, it also creates challenges because the donors are often less interested in the totality of national disease surveillance systems and solely focused on diseases related to their mission and funding, or "their diseases." It creates parallel systems of data collection for the various diseases, and generates duplication of work, which imposes an additional burden on already stretched local services. There is also indirectly a lack of incentive to integrate systems. Despite this, external funding does lead to improvements in the quality and coverage of surveillance. Donors should be encouraged to fund whole systems and not just disease-specific surveillance systems. Investments in the general surveillance infrastructures could help strengthen the resilience of these systems as well as help improve the quality of their reporting. Donors, governments, MOHs and NPHIs should also coordinate surveillance efforts to minimize duplication and parallel systems.

Summary

There would be considerable value to national disease surveillance systems if external donors for various programs were able to harmonize and rationalize their reporting requirements, thereby minimizing the reporting burden on local services.

9.3 Purpose of IDS

Another key theme was the need for clarity regarding the purpose of IDS. IDS should ideally be driven by its purpose and focused on intended public health outcomes. Local context and needs matter, and surveillance priorities and timelines are different at both the national and local levels. Different disease groups have been prioritized over others, which can lead to disparities, for example in genomic surveillance coverage. Priorities can change over time. For example, interest has shifted from surveillance of endemic diseases that may impact productivity to the surveillance of new and re-emerging threats. Surveillance systems need the flexibility of being able surveille a wide range of diseases.

It is important to recognize that national disease surveillance systems worldwide are at different stages of maturity with regards to integration of their systems. Integration of surveillance systems may be an ideal, but in reality it may not be realistic, affordable, or sustainable. Indeed, none of the HICs had IDS systems despite having highly developed and functional surveillance systems able to inform public health assessments and decision-making. These HIC systems also had room for improvement and efficiency gains. For the more resource constrained LICs and LMICs, a gradual, incremental approach to surveillance system strengthening and integration may be more achievable within existing resource envelopes.

Summary

The purpose, scope and intended public health outcomes of IDS need to be explicit and clarified. Integration activities should be tailored to local needs, priorities, and the level of maturity of the system.

9.4 Need for More Research and Learning

More research, evaluation, and learning are needed, as outlined in section 4.6. Only process outcomes were uncovered in the scoping review, and none of the included articles had attempted to assess the effect of IDS on disease control, or on mortality, lives saved or morbidity in the population. Whether or not IDS is cost-effective, for example by reducing redundancies, use of the same organizational infrastructures, processes, or people, was not addressed in any of the included articles. Also, while a One Health approach to surveillance appears to hold great promise and have many benefits, the effects, and costs of the heterogenous existing One Health systems have yet to be evaluated.

A particular gap identified through the scoping review was for metrics for measuring the success of integrated disease surveillance. Stakeholders need to know that the IDS system meets their expectations (35), and therefore, to ensure continued funding, it is of utmost importance to be able to demonstrate to funders (e.g., ministry of finance or donors) the measurable benefits of IDS such as cost savings and lives saved through the investments in IDS. There is a need for adequate and robust evaluations of the effectiveness of current IDS systems, using measurable elements, and an assessment of the effectiveness, suitability, and application of IDS (e.g., MERLA (41)).

The deep dive respondents indicated the usefulness of peer-to-peer involvement in the deep dives and national evaluations. Participants particularly valued international opportunities to learn and collaborate. They reported that coordinated evaluation of the surveillance system is not done routinely, and there are challenges in assessing the level of IDS in the absence of a standard definition. It is also difficult to demonstrate the effectiveness of disease prevention activities, including surveillance, and whether it provides value-for-money. The cost-effectiveness of surveillance activities is highly dependent on context, with greater value ascribed to higher-consequence infections during outbreaks compared to normal times.

Summary

There is a need to invest, at national and global levels, into health services research applied IDS, preparedness, and response. The evaluation of IDS needs to be planned in a systematic way and based on a priority set of validated metrics and core criteria. Further work is also needed to develop generic protocols to assess the effectiveness and cost-effectiveness of IDS. Evaluations need to be conducted and could be coordinated to enable comparisons between different health systems and countries (including different income groups).

9.5 High Trust Collaborations and Networks of Professionals

One theme emerging from the HIC deep dives was the value of trust between colleagues working in the surveillance systems, collaborative working relationships, and goodwill, which helped to overcome issues encountered. Data sharing relies on good relationships between NPHI and data collectors and reporters. These networks also provide an informal mechanism for sharing good practice and innovation. Having stakeholders committed to IDS, willing to work together, and a culture of collaboration, were particularly valuable during public health crises where high levels of collaboration are essential. This all relies on trust and extensive personal knowledge between the actors for data sharing and knowledge production. While there is considerable value in investing in collaborative partnerships, the converse is that these organic networks and systems may not be sustainable. They need continued nurturing and sustenance. Public health system reorganizations, as have happened in the past, can hinder system integration by disrupting these networks and systems.

Summary

High-trust, collaborative, professional relationships and networks among key stakeholders involved in disease surveillance act as a "social glue" that holds the system together. This may be especially important in fragmented systems. These collaborations and networks should be fostered. NPHIs, academic and professional public health societies are well placed to develop and support these networks and relationships.

Endnotes

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4 Strengthening the global architecture for health emergency preparedness response and resilience, World Health Organization (2022) https://www.who.int/publications/m/item/10-proposals-to-build-a-safer-world-together–strengthening-the-global-architecture-for-health-emergency-preparedness–response-andresilience–white-paper-for-consultation–june-2022 (Retrieved 11 November 2022)

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