Public Health Institutes of the World

IANPHI

Integrated Disease Surveillance Report

# MULTI COUNTRY SURVEY OF INTEGRATED DISEASE SURVEILLANCE

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# ABBREVIATIONS

| | |
|---|---|
| ANLIS | National Administration of Laboratories and Health Institutes of Argentina |
| BMGF | Bill & Melinda Gates Foundation |
| CARPHA | Caribbean Public Health Agency |
| CDC | Centers for Disease Control and Prevention |
| CMS | CARPHA Member States |
| COS | Centre of Statistics |
| CSV | Comma Separated Values |
| EBS | Event-based surveillance |
| eIDSR | Electronic Integrated Disease Surveillance and Response |
| EOC | Emergency Operations Centre |
| GDPR | General Data Protection Regulation |
| HIC | High-income country (World Bank classification) |
| HMIS | Health Management Information System |
| IANPHI | International Association of National Public Health Institutes |
| IBS | Indicator-based surveillance |
| IDS | Integrated Disease Surveillance |
| IDSR | Integrated Disease Surveillance & Response |
| IT | Information technology |
| LIC | Low-income country (World Bank classification) |
| LMIC | Lower middle-income country (World Bank classification) |
| MOH | Ministry of Health |
| MOHCC | Ministry of Health and Child Care, Zimbabwe |
| NCD | Non-communicable disease |
| NICD | National Institute for Communicable Diseases, South Africa |
| NMCSS | Notifiable Medical Conditions Surveillance System, South Africa |
| NOID | Notification of infectious disease |
| NPHI | National Public Health Institute |
| ORS | Outbreak Response System |
| RTSL | Resolve to Save Lives |
| SpF | Santé publique France |
| UKHSA | UK Health Security Agency |
| UMIC | Upper middle-income country (World Bank classification) |
| VHT | Village Health Team |
| WHO | World Health Organization |

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# 1. EXECUTIVE SUMMARY

The International Association of National Public Health Institutes (IANPHI) received funding from the Bill & Melinda Gates Foundation (BMGF) to explore the status of national surveillance systems in terms of integration of data, the role of National Public Health Institutes (NPHI), the extent to which Integrated Disease Surveillance (IDS) systems have been developed and operationalized and the evidence base for the effectiveness of IDS.

The international response to the COVID-19 pandemic revealed that global surveillance systems were ill-prepared to identify and manage this emerging public health threat. "Disease surveillance for the COVID-19 era: time for bold changes," published in *The Lancet* June 2021[a], discusses the challenges to disease surveillance highlighted by COVID-19 and postulates that integrating separate disease surveillance systems would help to strengthen national disease surveillance [1]. This survey of country experience of IDS is part of a global study to explore the evidence-base for IDS, which although intuitively logical had not, to date, been effectively evidenced through systematic evaluation and applied research.

The global study of IDS has been divided into three projects:

1. A systematic scoping review of the literature, which helped to inform this survey design [2]
2. A survey of IANPHI members, which is reported here
3. Seven deep dive studies in three high-income countries (HIC) and four low and-middle income countries (LMIC), undertaken between April and October 2022 [3].

The three projects have contributed to the development of a framework for describing IDS, validated against the global literature and NPHIs' understanding and operational experience of IDS. Findings from the survey report, the systematic scoping review, deep-dives and complementary projects undertaken by the Robert Koch Institute (an IANPHI member) and Resolve to Save Lives will be reflected in a final report. This will enable a comprehensive analysis to identify themes for action–to prepare for and combat the impact of pandemics and epidemics. Information from the final report will also inform practical, realistic, implementable steps that reflect challenges and opportunities in-country to strengthen not only IDS systems but also the collaboration across sectors required to enable decision-making and shape response measures to future pandemics and epidemics.

[a] 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. Epub 2021 May 14.

This survey sought IANPHI members' understanding of IDS, how it has developed in different geographies, and the opportunities and challenges to the integration of surveillance systems. 65 IANPHI members, responded to the survey, representing 59 percent of IANPHI's membership.

This report aims to increase understanding of what IDS means and the current status of IDS across the IANPHI network, mapping variations in approaches to IDS, and collating case studies on how IDS has been developed and managed.

Key findings from the survey include:

1. Concept of Integrated Disease Surveillance: The understanding of "integrated disease surveillance" or IDS differs by country. There was no definition of IDS that is universally agreed and understood. Respondents understood "integration" as a complex process that involves multiple stakeholders and sectors, occurs at all levels of the health system, and should include non-health sector data.–The purpose and functions of disease surveillance (how the system enables better decisions and response to health threats) were key considerations. Health systems need to be agile, responsive and resilient.

2. Role of National Public Health Institutes/public health entities: Most surveillance systems involved the MOH. In most countries where there are NPHIs, these institutes played a major role, either jointly with the MOH or as sole lead agency, particularly for core surveillance functions. This was especially true for countries in higher income groups and those with more developed IDS systems.

3. Data systems integration: Integration issues were documented at the interfaces of systems that were often too vertical — either between different organizations, between local and national levels, or between sectors. Fragmentation and lack of integration between sectors was evident, and more acute in LICs and LMICs, particularly regarding One Health strategies deficiencies in integrating data from the private and pharmaceutical sectors, laboratories and genomic data. Integration issues were much 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.

   HICs reported other barriers related to data ownership, agreement and data access, the absence of a mandatory enforcement for reporting and a lack of funding for IT systems development, infrastructure and maintenance. Deficiencies in integrating data from the private sector and pharmaceutical sectors were more acute in LICs and LMICs.

Data integration was better for national public health laboratories, followed by subnational public laboratories, compared to other laboratories in the public or private sectors. Genomic testing and sequencing were predominantly available for developed or partial IDS systems, but the types of laboratories used varied by country income groups.

There were case studies and exemplars of good practice provided by respondents that also point to the enabling role of technology, including greater automation, electronic reporting systems, algorithms, and data platforms.

4. Workforce: There is a major need for sustained investment in the development of workforce capacity and capabilities. This needs to be supported by development in technology, and improved governance and policy, to establish systems that enable the integration of disease surveillance systems with multisectoral perspectives, analyses, and responses.

   There were gaps in skills identified related to data science, analytics and information technology, followed by epidemiology, administration and data entry, laboratory, and public health generalists. Respondents with no IDS were more likely to report workforce capacity gaps in IT than respondents with partial or fully developed IDS. Respondents reporting a developed IDS were more likely to report workforce capacity gaps in the laboratory compared to respondents with partial IDS and no IDS. Surveillance workforce development initiatives are led by the MOH or NPHI with no difference by IDS status (developed, partial or none) and country income group. In-country academic institutions and externally supported/funded initiatives were also reported, but not as frequently. LICs more commonly reported initiatives led by in-country academic institutions and externally supported/funded organizations compared to LMICs, UMICs and HICs.

   A collaborative approach between sectors including academic and training providers, need to focus on developing skills needed across functions for IDS.

5. Governance: MOHs or NPHIs lead public health surveillance in most settings, with approximately a quarter sharing joint leadership between the MOH and NPHI. The survey reveals limitations in governance, with integration issues at the interfaces between organizations, local and national levels, or sectors. The survey also reveals insufficient adherence to existing legal mandates. Better developed IDS systems tended to have better governance and protections for citizens. Data protection was recognized to be an issue that needs attention to enhance public trust in public health surveillance. Limitations in governance and adherence to legal mandates are a major barrier to more effective integration. Other reported weaknesses related to governance across the surveillance cycle included the lack of 'evaluation and feedback'.

6. Finance: While gaps in resourcing requirements were reported in all country income groups, it is much more critical for LICs that have more limited capabilities, less government financing, and are much more heavily dependent on external funding. International aid is not a sustainable source of funding. Greater investment and governmental commitment will be necessary to enable countries to develop and optimize the use of a system of integration, with the skills and tools needed to build capabilities.

7. Effective surveillance systems: The survey corroborates the proposition by Morgan et al. (2021) of the various key components needed for effective surveillance, but also identifies other critical factors for IDS. Among respondents' suggestions on how Morgan et al.'s concept of integration could be enhanced, the issue of governance was stressed, including the need for adequate legislative and regulatory frameworks, political engagement, appropriate control, evaluation, and monitoring. Respondents also suggested there is a need for better data management to ensure data integrity and confidentiality, interoperability and multisectorality, including interdisciplinary collaboration. Equity and guaranteed access to surveillance outputs were also identified as key for supporting strong, well-functioning integrated surveillance systems, as well as flexibility, simplicity, and acceptability. Resilience and capacity building were also identified as important factors.

## Key recommendations from the survey

I. As there is a different understanding on integration of disease surveillance, defining IDS and its purpose using country level outputs to achieve targeted outcomes (detection, decision making, response, recovery) will provide clarity in terms of the mandate and the function of an IDS system.

II. The framework for IDS, which describes the building blocks of national surveillance systems, presents a robust framework for evaluation of surveillance systems, and should be used as a tool for assessing the scope for further integration of surveillance systems. For a fully functional IDS the key building blocks of surveillance systems need to be in place, from governance and legal enablers through to infrastructure, processes, and resourcing.

III. Resourcing surveillance systems and investing in a sustained way, as part of government policy, to ensure the establishment of a robust integrated system able to perform multisectoral surveillance and analysis, to inform public health policy and response to public health threats. In order to maximize the efficient and effective use of limited resources for surveillance, sustainable investment strategies should be developed, which seek to maximize governments

own funding and rationalize external funding, so that it is aligned to nationally identified need.

IV. To ensure integrated surveillance systems capture data from other key sectors, for example in support of One Health (including animal and environmental data) national surveillance strategies need to consider all surveillance systems, irrespective of sectors and consider what is needed to ensure that relevant data can be collated and analyzed in a timely and effective way.

V. Significant gaps in national surveillance systems, linked to building blocks such as the workforce (capacity and skills), laboratory and IT infrastructure need to be addressed in the context of broader sector strategies. For example, workforce surveillance capability needs to be an integral part of public health workforce development, laboratory surveillance data needs to be a priority within laboratory diagnostic capacity development and IT structures need to be considered alongside broader hospital and health facility information system needs, critically important to health system planning.

VI. Monitoring and evaluation, data access and quality, and feedback loops, also need to be tackled as they are essential for quality improvement and assurance, and the creation of learning systems.

VII. Building a knowledge base on IDS systems within country context and its application, through research, accelerating evidence into practice and support for innovation in practice can act as a catalyst to implementation. Supporting open access to sharing of best practices and innovation to facilitate shared learning and country context implementation is important.

VIII. National Public Health Institutes and other public health entities are system enablers for IDS. They can provide a critical interface across sectors for analysis of multi-sectoral data, evidence gathering, and the generation of cross-cutting intelligence. Stronger legal and policy mandates that clarify roles of system enablers will improve interactions across sectors for key IDS functions, including analysis, reporting for decision making, early warning evidence, preparedness, recovery, evaluation and monitoring.

Findings from this report, the systematic scoping review [2], deep dives [3] and complementary projects undertaken by the Robert Koch Institute (an IANPHI member) and Resolve to Save Lives will be reflected in a final report.

This will enable a comprehensive analysis that identifies themes for action and change, integration and analysis of surveillance data, drawing on evidence to better prepare and combat health threats,

epidemics and pandemics. Information from the final report will also aim to inform practical steps to address challenges and opportunities to strengthen IDS systems and collaboration across sectors for One Health and all-hazards preparedness.

# 2. INTRODUCTION

This report presents the findings of a survey undertaken to better understand integrated disease surveillance (IDS) among member countries of the International Association of National Public Health Institutes (IANPHI). It also presents survey methodology, results, a discussion of the survey's findings and concludes with a set of recommendations.

The survey is one of three workstreams which comprise a project to explore IDS funded by the Bill & Melinda Gates Foundation (BMGF) and led by IANPHI. The survey aims to show how IDS is conceptualized, operationalized, and how best to use the lessons from the COVID-19 pandemic to move IDS forward as part of international efforts to strengthen global health security.

## 2.1. Background

### 2.1.1 Integrated Disease Surveillance and Response

Integrated disease surveillance 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" [2], which was the definition used in the systematic scoping review [2]. Following the re-emergence of large outbreaks due to meningitis, cholera, yellow fever and measles in West Africa, in 1998, the World Health Organization (WHO) African Region adopted a strategy called Integrated Disease Surveillance [3]. The aim was to support countries to improve their disease surveillance and response capabilities so that they could detect and respond in a timely manner to communicable disease threats [3]. In 2000, the approach to IDS in Africa was renamed Integrated Disease Surveillance and Response (IDSR) to emphasize the essential link between surveillance and response [3].

According to WHO, IDSR strategy focuses on the provision of comprehensive public health surveillance and response systems for priority diseases, conditions and events at all levels of health systems [5]. It aims to make surveillance and laboratory data more usable and to help public health managers and decision-makers improve detection and response to leading causes of illness, death, and disability. The IDSR strategy makes explicit the skills, activities and resources needed at each level of the health system to operate all surveillance functions.

In 2016, Member States endorsed the Regional Strategy for Health Security and Emergencies 2016 – 2020. Based on this strategy all member states were expected to implement the IDSR strategy with over 90% national coverage by 2020 (Regional strategy for IDSR, WHO Africa, 2019). By December 2017, 44 out of 47 African countries were implementing IDSR [7]. However, the initial

momentum of IDSR implementation between 2000 and 2010 was not sustained (Regional strategy for IDSR, WHO Africa, 2019). Several challenges with IDSR implementation were identified, including inadequate sustainable domestic financing, inadequate staffing, high turnover of peripheral staff, limited sharing of surveillance data and information, inadequate supervision and mentorship, inadequate laboratory capacity and limited availability of community and transport systems (Regional Strategy for IDSR, WHO Africa, 2019).

### 2.1.2 Responding to the COVID-19 Pandemic

The COVID-19 pandemic drove innovation in public health practice, including the development of surveillance systems in many countries. However, the pandemic also demonstrated that global surveillance systems were not well prepared to identify and manage the emerging threat it posed to health and wellbeing and continue to be "dangerously unprepared" for future pandemic threats [6].

Recognizing the weaknesses that COVID-19 had exposed in disease surveillance systems around the world, Morgan et al. (2021) set out five principles for IDS that should underpin future improvements to surveillance systems and describe the central role that National Public Health Institutes (NPHIs) should have in collating and analyzing surveillance data in order to respond more effectively to public health threats [1].

The IANPHI IDS project, funded by the Bill & Melinda Gates Foundation (BMGF) and undertaken over eight months, pulled together the current understanding and development of IDS systems globally, incorporating the lessons learned from the COVID-19 pandemic. The project comprises three workstreams:

1. Conduct a systematic scoping review [2] to document current state of knowledge and evidence for definitions and characteristics of IDS and assess how these have evolved over time using a bespoke conceptual framework (Figure 1) which include the five core principles of integrated disease surveillance (IDS) set out by Morgan and colleagues [1].
2. Survey IANPHI members to develop a clear understanding of current status of IDS across the IANPHI network, mapping variations in definitions and approach to IDS and collecting, and collating case studies on how IDS has been developed and is managed.
3. Conduct deep dives in several LMIC and HIC (Canada, England, Malawi, Mozambique, Pakistan, Sweden, and Uganda) on the state of IDS including challenges and barriers to implementation as well as identifying opportunities

In addition, there will be reflections on the similarities, alignment, and variations with the complementary projects conducted by Resolve To Save Lives (RTSL) and Robert Koch Institute, both funded by BMGF.

This report provides findings from the survey workstream. Due to time limitations and the agreed scope and objectives this project focused on Integrated Disease Surveillance (IDS) functions and systems, not IDSR.

## 2.2. Survey aims and objectives

A cross-sectional survey of IANPHI member countries was undertaken in order to develop a clear understanding of the current status of IDS across the IANPHI network, mapping variations in definitions and approaches to IDS, and collecting and collating case studies on how IDS has been developed and is managed.

The aim of the survey was to understand how IDS is conceptualized and implemented by IANPHI member countries, with a focus on the lessons learned during the COVID-19 pandemic:

1. Describe the key features of the current status of IANPHI member country's surveillance systems and how they are implemented and integrated.
2. Understand how IDS is defined and conceptualized at country level and how definitions might be further developed.
3. Characterize the development, implementation and current status of IANPHI member country's IDS systems or their plans to implement these systems where they are not in place.
4. Identify the organizational factors required for the operationalization of IDS, including governance, systems and structures, and the core and support functions of surveillance.
5. Assess barriers to creating an IDS system and possible levers towards creating an IDS system if reported to have no IDS.
6. Identify the key stakeholders in current surveillance systems and the role of NPHIs in central surveillance coordination, and decision making.
7. Explore the impact the COVID-19 pandemic has had on surveillance and response activities, with particular reference to IDS.

As one of the three workstreams in the BMGF funded IANPHI project to explore IDS, the findings from this survey will contribute to the overall findings for the IDS project, will support a better understanding of IDS and will identify future priorities for its implementation.

# 3. METHODOLOGY

## 3.1. Conceptual Framework and Scope of the Survey

The survey was developed using a conceptual framework (Figure 1) that was developed for this project; this framework informed the development of all three workstreams which comprise IANPHI's work to better understand IDS.

The conceptual framework is based on the initial WHO IDSR framework, incorporating Morgan et al.'s (2021) [1] five principles for IDS. Regardless of the type of surveillance (notifiable disease and IDSR like surveillance; pathogen surveillance including sequencing, sewage and septic surveillance; specialized programs etc.), the framework considers the vision of an IDS system from organizational and operational aspects. It comprises five key domains: 1) governance, 2) system and structure, 3) financing, 4) core functions, and 5) resourcing requirements.

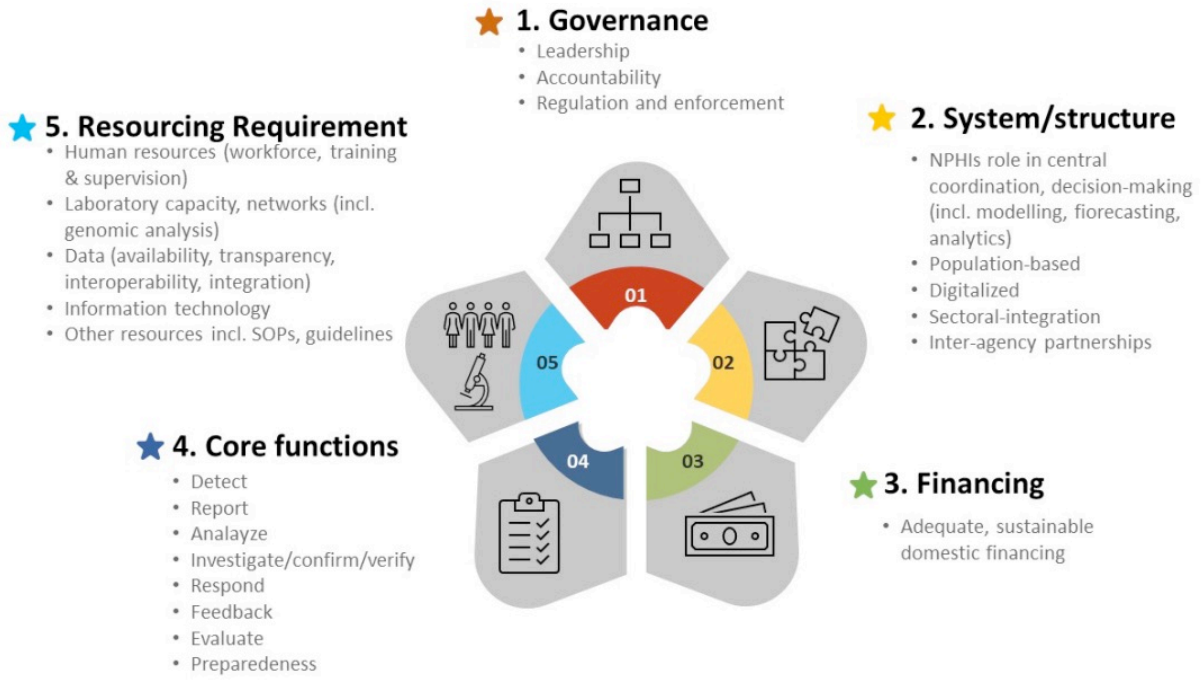



Figure 1. Conceptual framework developed for the IDS project

A survey working group was established from NPHI countries from IANPHI's members[b] who were members on the IDS Executive and Technical Committee. The group met weekly and participation was voluntary. Targeted skills including IDS expertise, survey development, qualitative and quantitative research expertise were made available from a cross-section of NPHIs. Ad hoc advice was also sought from IANPHI regional network leads, members of the IDS Executive Committee including the WHO Hub for Pandemic and Epidemic Surveillance.

Survey questions were designed to explore the current surveillance systems in IANPHI member countries and the maturity of any IDS systems that may have been developed or implemented in the country. Where respondents indicated that an IDS system was either fully implemented, or in development, survey questions aimed to examine five key domains of their IDS system, as shown in Figure 1. Where respondents indicated that they did not have an IDS in place, reasons for this and future plans were explored through survey questions.

In addition to the current state of surveillance and IDS systems, the survey also looked to understand how responses to the COVID-19 pandemic might have influenced IDS in respondent countries, to identify areas of innovative practice related to IDS, as well as reflections on the usefulness and appropriateness of current IDS definitions.

### 3.2. Survey Development and Piloting

The survey included 104 questions which were developed to collect quantitative and qualitative data. Questions asked in the survey are provided in Appendix 1.

The majority of questions included in the survey were multiple choice, tick box type questions to which respondents were asked to select one or more answers. Definitions were provided within the question text to support understanding and to ensure respondents had a common frame of reference when providing answers. Many of the multiple-choice questions were followed with 'other, please specify' boxes, in which respondents were able to provide free text responses to supplement their multiple-choice answers.

There were a small number of questions which only requested a free text response. These questions were designed to explore how surveillance and IDS had been impacted by the country-level response to the COVID-19 pandemic, to identify examples of innovative practice related to IDS, and to explore their response to definitions of IDS provided in the literature, including the definition of IDS provided by Nsubuga et al. [4] and the framework for IDS proposed by Morgan et al. [1]. The question focusing on innovative practice was intended to provide respondents with an opportunity to share

[b] A list of IANPHI members can be found on the IANPHI website: https://ianphi.org/about/member-countries.html

successful ways in which they had implemented integrated surveillance systems in a way which others may benefit from, and which might contribute to a better understanding of the opportunities afforded by integrated disease surveillance.

Questions were presented on a series of survey pages, with each page focused on different aspects of surveillance or the operationalization or conceptualization of IDS. The survey contained some conditional formatting which meant that respondents were presented with slightly different sets of questions depending on previous responses. The most significant of these related to the question on IDS system maturity status, asking respondents to state whether their IDS system was fully developed, still in development (partially developed) or no IDS system in place at all. Respondents who reported that they had either a fully developed or partial IDS system were then asked questions related to that level of IDS system maturity. Respondents who reported that no IDS system was in place were asked questions related to the challenges associated with IDS system development and plans to implement IDS systems.

Survey questions were developed collaboratively by the IANPHI IDS Project working group, guided by the survey's aims and objectives, and the IDS conceptual framework. Prior to launch, the questionnaire was piloted by four IANPHI member country representatives. Countries were selected to ensure they were from different income groups and used different languages to reflect the range of IANPHI country member respondents who would eventually use the survey. Comments from the piloting process were incorporated into the final survey tool prior to dissemination. Before launch, the survey was reviewed and approved by the IANPHI IDS Technical and Executive Committees.

The survey was written in English but made available in four other languages: Arabic, French, Portuguese and Spanish. Translations of the English survey were undertaken using Google Translate and the input of a professional translation service. Translators double checked for accuracy as part of the survey piloting process. This included the survey being disseminated to IANPHI regional chairs, vice chairs and members from the IDS Executive committee to review and provide feedback on the questions and layout of the survey.

### 3.3. Survey Deployment

The survey was created and deployed using a web-based survey tool, SelectSurvey v5.0. The survey was sent to all 110 IANPHI members representing 95 countries, using a country member contact list held by IANPHI. The contact list represents every country member of IANPHI in addition to the

Caribbean Public Health Agency (CARPHA), the regional public health agency for countries in the Caribbean[c].

A sample size calculation was not undertaken but the aim was to maximize the survey response rate to represent the views of IANPHI member countries as diversely as possible, so it was not considered relevant for this project.

One individual from each member country, acting as the focal point for that country, was sent the survey link, together with email text setting out the aims and objectives of the IANPHI IDS research project overall and of the survey specifically. The individual selected aimed to be someone in a senior position from the member country's National Public Health Institute (NPHI) or Ministry of Health (MOH), who was likely to have access to the wide range of information related to surveillance and IDS that was needed to complete the survey.

Respondents were able to complete the survey in more than one session, using a username and password to log in and update survey responses as many times as they wanted until they pressed the 'submit' button at the end of the survey.

Respondents were given six weeks between July and August 2022 to complete the survey. An email from IANPHI's president was sent to IANPHI members to introduce the IDS project and the survey itself was also sent to IANPHI member countries by the president prior to the survey being launched. Over the course of the six weeks of data collection, reminder emails were sent to survey respondents to support a high survey response rate.

### 3.4. Data Governance and Protection

IANPHI complies with the General Data Protection Regulation (GDPR) that came into effect on May 25, 2018. Survey responses were collected on the SelectSurvey platform, which is password protected. Only a small number of the survey project team had access. Once the survey closed, survey data were downloaded from SelectSurvey as a comma separated values, or .CSV file. Survey data was stored on IANPHI's EU-based server with only the core survey team having access to it for the purposes of analysis and interpretation. The drive on which the survey data is stored is a secure cloud-based system which is fully backed-up to limit the risk of any loss and data leakage. Data will be retained for a maximum period of three years and will be only used for the purpose of this exercise.

[c] Further details about IANPHI's membership can be found on their website: https://ianphi.org/about/member-countries.html

## 3.5. Ethics

The protocol for the survey was reviewed and approved by the IANPHI IDS project Technical and Executive Committees. Prior to being launched, the survey protocol was submitted to Emory University's Institutional Ethics Review Board, which determined the survey was exempt from requiring Institutional Ethics Review Board approval.

The first page of the survey explained participation in the survey was voluntary and provided an opportunity for respondents to opt out, or to indicate their consent to taking part in the survey.

Questions were designed to explore issues around surveillance and IDS and were not deemed to be of a sensitive nature. However, except for the question asking for contact details, and the question asking whether respondents countries had a full, partial or no IDS system, none of the questions were mandatory.

While the survey project team were able to identify respondents, responses to the survey are presented anonymously. This principle was set out to survey respondents prior to undertaking the survey with one exception. Where respondents described innovative practice examples related to surveillance or IDS that the survey project team thought might be helpful to share as case studies, it was stated that respondents would be approached for permission to collect further information and, where permission was granted, this data is presented in the report.

## 3.6. Data Analysis and Interpretation

Data analysis and interpretation was undertaken collaboratively by members of the IANPHI IDS survey working group. Once the survey had closed, data was extracted from the online survey tool to a Microsoft Excel v2013 spreadsheet.

Quantitative analyses were undertaken using R [8] and STATA v14 [9]. Data was described and presented in tables and charts, accompanied by a narrative interpretation of the data set out in the results section below. To support the analysis, responses were stratified by region [10], World Bank Income Group [11] and by self-reported IDS maturity status (developed, partial, or no-IDS system).

Responses are often presented throughout this report as proportions. In some instances, for example where stratified results are presented, the denominator used to calculate these proportions may vary. In each case where proportions are presented, the denominator used in this calculation is presented to confusion.

Only survey responses which were deemed to be fully complete were included in the analysis. Surveys were deemed to be complete either where the respondent had pressed the 'submit' button or those in which it was clear that the respondent had read through and responded to every page.

Four IANPHI member countries submitted more than one survey response. In two of these cases respondents were representatives of NPHIs with responsibility for distinct and separate parts of their country of origin and these responses were retained in their totality in the analysis. In the remaining two cases, the duplicated responses were compared on a question-by-question basis and, where responses matched, were merged. IANPHI survey working group team members discussed the answers for which there were discrepancies between the two responses and decided which response to retain. Free text responses were merged.

When necessary, qualitative data were translated into English. Qualitative analysis of the data was conducted using a thematic analysis approach [12, 13]. Microsoft Excel v2013 and NVivo v1.6 software were used to assist with cleaning and categorizing the data, and to perform the theming process. The thematic analysis process consisted of systematically identifying, grouping, and secondarily examining the discourse of the themes addressed in the survey, the task of analysis was assigned across the authors of this report with quantitative skills. We specifically looked for commonalities in responses, or any significant contrasts. Responses were associated with one or more themes, which were then entered into Excel and tabulated. The responses were also stratified by WHO region or World Bank income group to look for any trends by region or country-income level. Description of results were accompanied by a narrative interpretation. In some categories, a selection of insightful quotes from participants through the qualitative data were reported verbatim in the written presentation of results to illustrate relevant points of interest. Case studies were identified linked to findings from the survey and permission was sought to use those in the report.

Results were reviewed and discussed on a weekly basis during survey working group meetings. This served to guide further analysis of the data, resolve any uncertainties in interpretations, review merging findings and to facilitate interpretation of the data. The latter drew on the extensive collective technical expertise of the survey working group from around the world. The findings, the discussion and recommendations presented at the end of this report were developed collaboratively by the IANPHI survey working group. The emergent findings were shared with technical expert colleagues from IANPHI, leading NPHIs engaged in the project, colleagues at the Robert Koch Institute, BMGF and WHO Berlin Hub in October 2022. Their comments further helped confirm and refine the survey conclusions drawn.

# 4. FINDINGS

## 4.1. General Overview of Respondents

### 4.1.1 Overview of respondents and response rates

Of the 110 IANPHI member institutions sent the survey, 65 (58.6%) provided a complete response (out of 69 received). In four countries, two responses were received from two different IANPHI member institutes. There was also a response from CARPHA, the regional public health agency for the Caribbean representing 24 countries and territories, on behalf of its member states in the Caribbean Community (CARICOM).

Most respondents worked for NPHIs (69.2%; n=40), followed by MOHs (23.1%; n=15) and other organizations, including other Government Departments and National Public Health Laboratories. Most respondents (72.3%; n=47) completed the survey in English, followed by French (n=9), Portuguese (n=5) and Spanish (n=4). There were no complete responses to the Arabic version of the survey.

The greatest number of responses (35.4%; n=23) were from countries classified as high income by the World Bank[d] (Figure 1) Most responses were received by countries in the WHO European region (33.8%; n=22), followed by the African region (26.2%; n=17) and the Americas (23%, n=15). Figure 2 details the proportion of IANPHI members and responses by World Bank income group and WHO Region.

[d] The World Bank. The World by Income and Region [website]. Accessible at: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html#:~:text=The%20World%20Bank%20classifies%20economies%20for%20analytical%20purposes,which%20is%20applied%20to%20smooth%20exchange%20rate%20fluctuations.

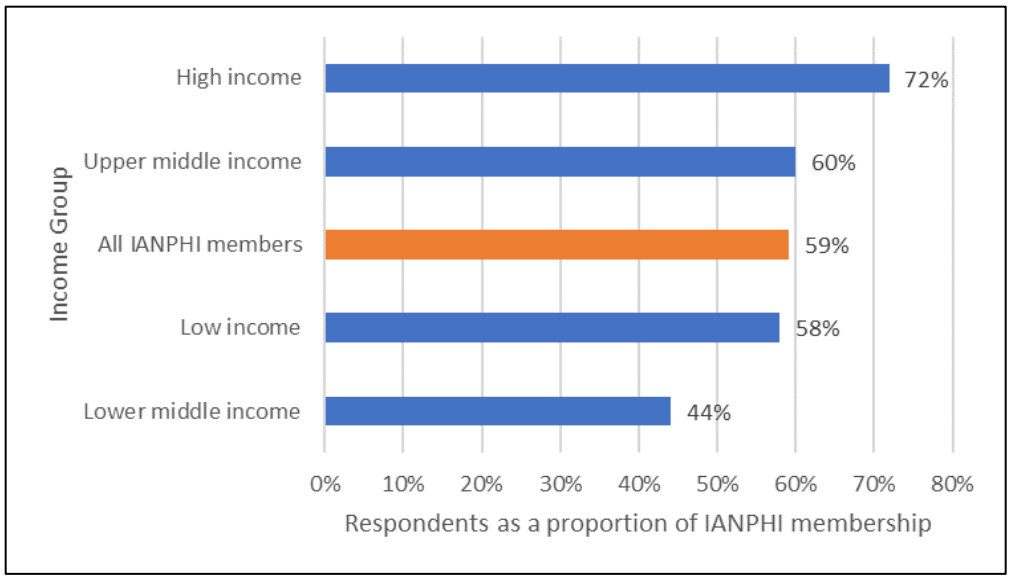



Figure 1. Complete survey responses by World Bank income group (n=65)

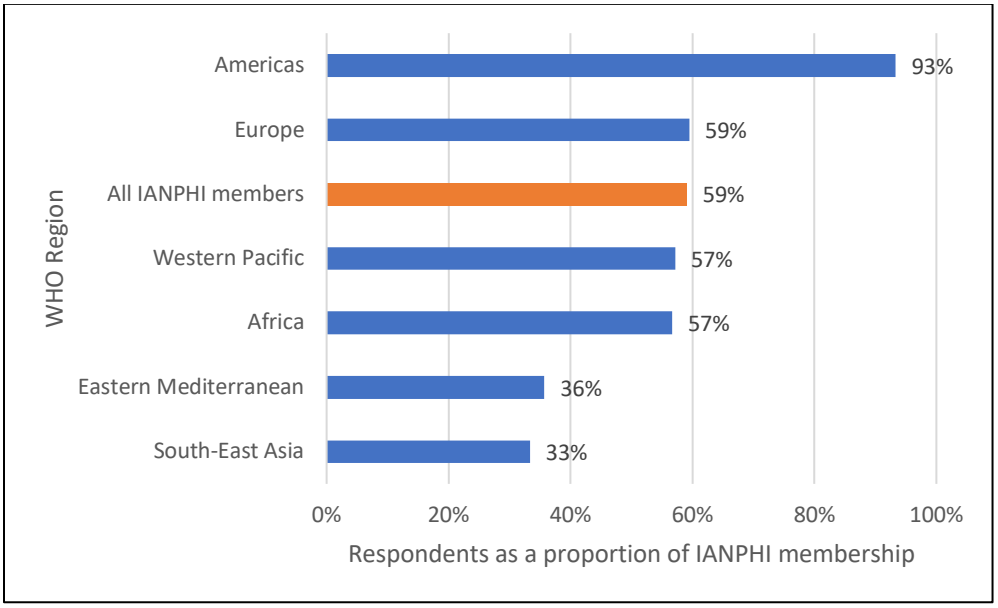
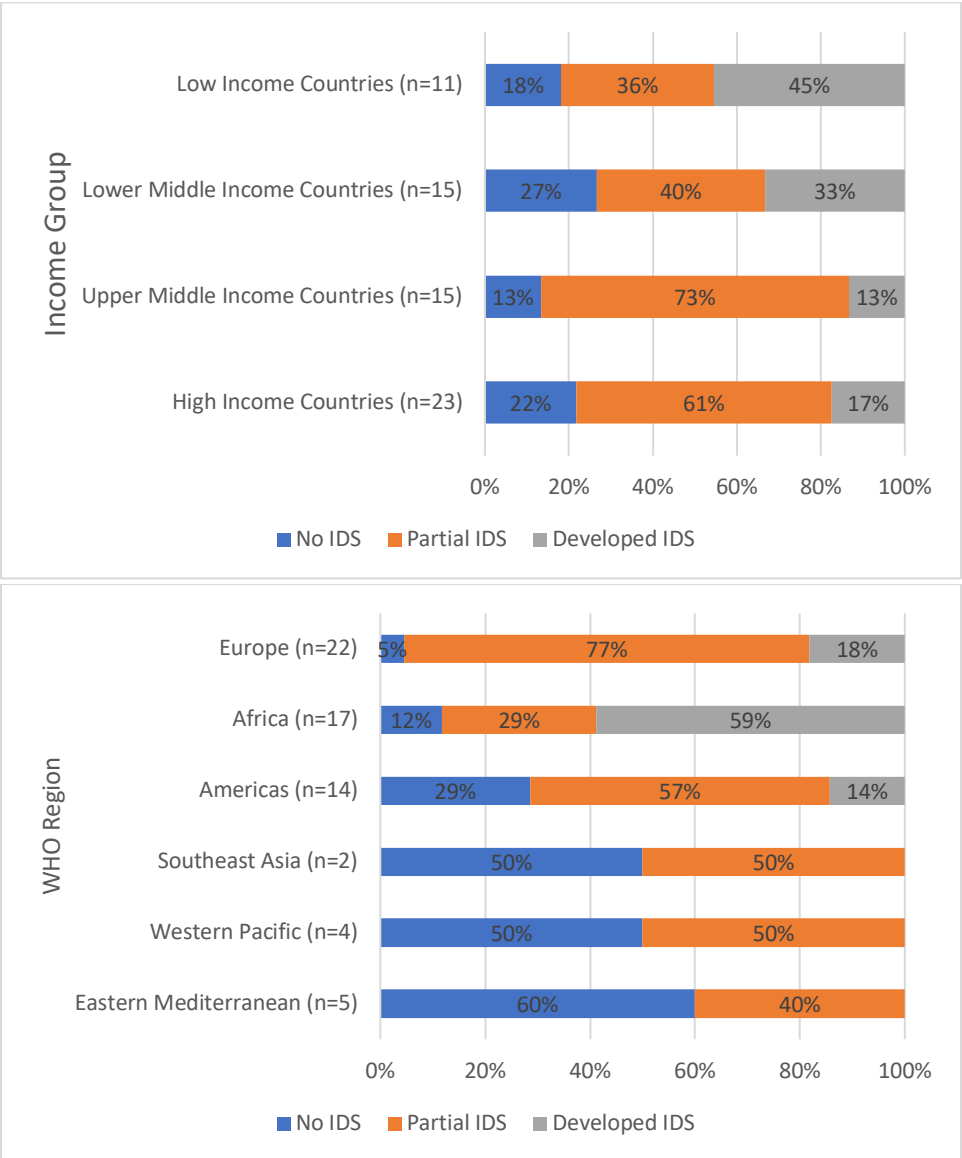



Figure 2. Complete survey responses by World Bank income group and WHO region (n=65)

### 4.1.2 Self-reported IDS system maturity status

Respondents were provided with Nsubuga, et al.'s definition of IDS [4] and asked to respond whether their country had a fully developed, partially developed, or no IDS system in place. Most respondents report having a partially developed IDS system (55%; n=36) versus a developed (25%; n=16) IDS system versus having no IDS system in place (20%; n=13).

From a regional perspective, most respondents reported having partial IDS systems, as follows; Southeast Asia (100%; 2/2), Western Pacific (100%; 4/4), Eastern Mediterranean (60%; 3/5), Africa (59%; 6/17), the Americas (50%; 7/14), and Europe (73%; 6/22). Respondents from Africa (35%; 6/17) and the Americas (36%; 5/14) were more likely to report having fully developed IDS systems (Figure 3). When examined by World Bank income groups, again most respondents tended to report having partial IDS systems. The proportion of respondents reporting having developed IDS systems was higher amongst LICs (46%; 5/11) and LMICs (33%; 5/15), whilst UMICs (73%; 11/15) and HICs (61%; 14/23) were more likely to report having partial IDS systems (Figure 3).




***Sample sizes: W. Pacific (4), SE Asia (2), Europe (22), E. Med. (5), Americas (14), Africa (17)*

Figure 3. Self-reported IDS system maturity by income group and WHO region

There was a trend towards an inverse relationship between the level of IDS system maturity and country World Bank income group. Lower income countries, all of which were in Africa, were more likely to report having developed IDS systems than HICs (Figure 4). Out of the 16 respondents who reported having developed IDS systems: ten were in Africa (five LICs and five LMICs), compared to two in the Americas (one HIC and one UMIC) and four in Europe (three HICs and one UMIC).

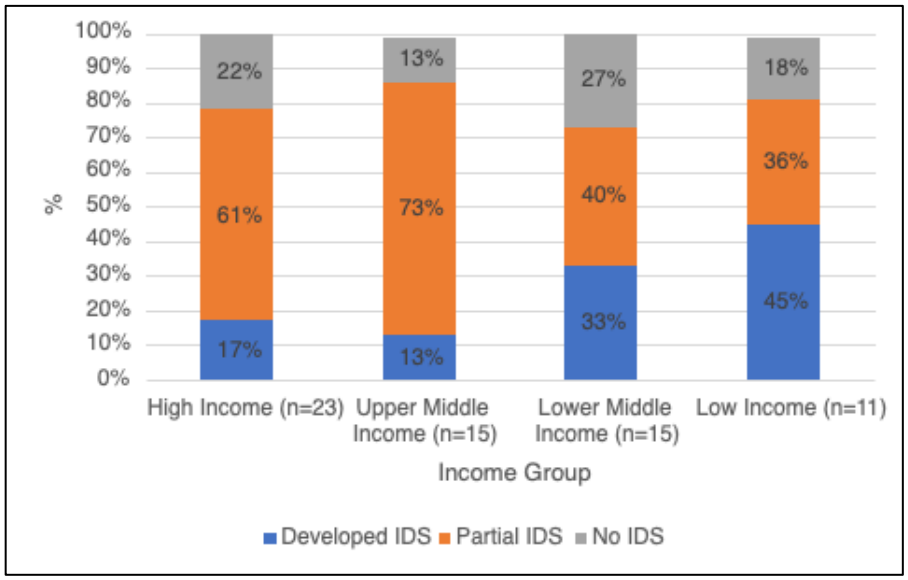


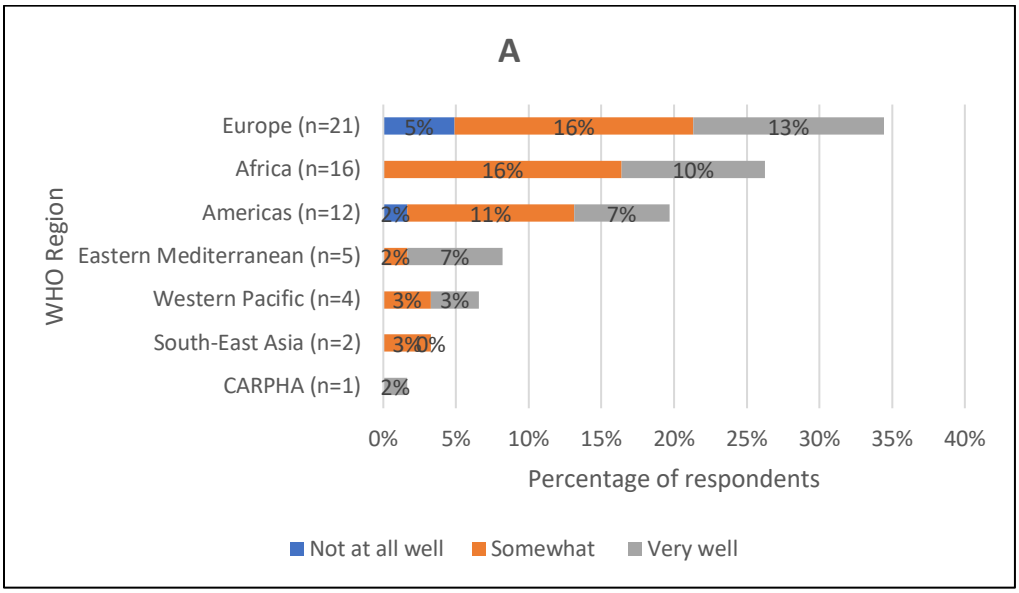

Figure 4. Relationship between reported IDS maturity and country income group

## 4.2. Integrated Disease Surveillance - What It Means in Different Country Settings

### 4.2.1 Most respondents agree, to an extent, with the Nsubuga et al. (2003)[e] definition of IDS

Nsubuga et al. defined IDS as: "a combination of active and passive systems using a single infrastructure that gathers information about multiple diseases or behaviors of interest (to ensure robust early warning and a prompt public health response)" [4]. Participants were requested to indicate how well the definition of IDS provided by Nsubuga et al. [4] describes IDS: not at all well (it misses important elements of IDS), somewhat well (it is a good definition, though does not describe IDS in its totality) or very well (the definition completely captures all elements of IDS). As respondents were provided with an explanation of integration in the survey questionnaire (Appendix 1) in order to determine the level of integration of surveillance systems, it was not investigated how respondents interpreted "integration". This aspect was investigated in the deep dives – workstream 3 of the IDS project [3].

Most of the respondents agreed to an extent with the IDS definition provided by Nsubuga et al. (2006) [4]: 52% (32/61) selected "somewhat well" and 41% (25/61) selected that the definition describes IDS very well. Four respondents indicated that the definition does not describe IDS well. The four respondents who indicated that the definition did not describe IDS well were from HICs; three were from Europe and one from the Americas. All income groups as well as WHO regions were represented in the other two responses ("somewhat well" and "very well") (Figure 5).



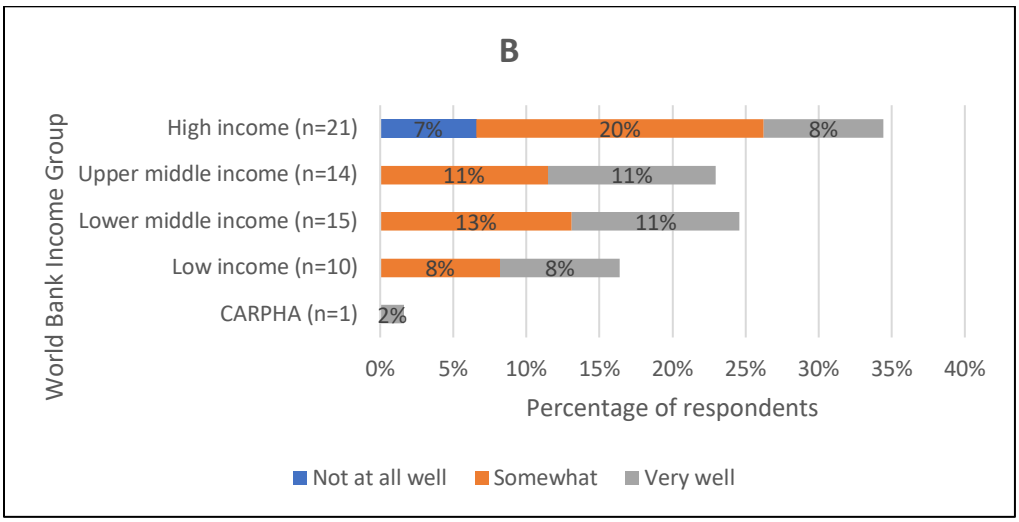




Figure 5. Level of agreement with the IDS definition by Nsubuga et al. (2003) according to (A) WHO Region and (B) country (World Bank) Income Group (N=61)

Analyzing the level of agreement with the IDS definition by IDS maturity (Figure 6), most respondents with no IDS agreed "very well" with the IDS definition (54%, 7/13). For respondents with a partial IDS system, the majority agreed "somewhat" with the IDS definition (55%; 18/33). Similarly, most respondents with a fully developed IDS system also agreed "somewhat" with the IDS definition (53%; 8/15).

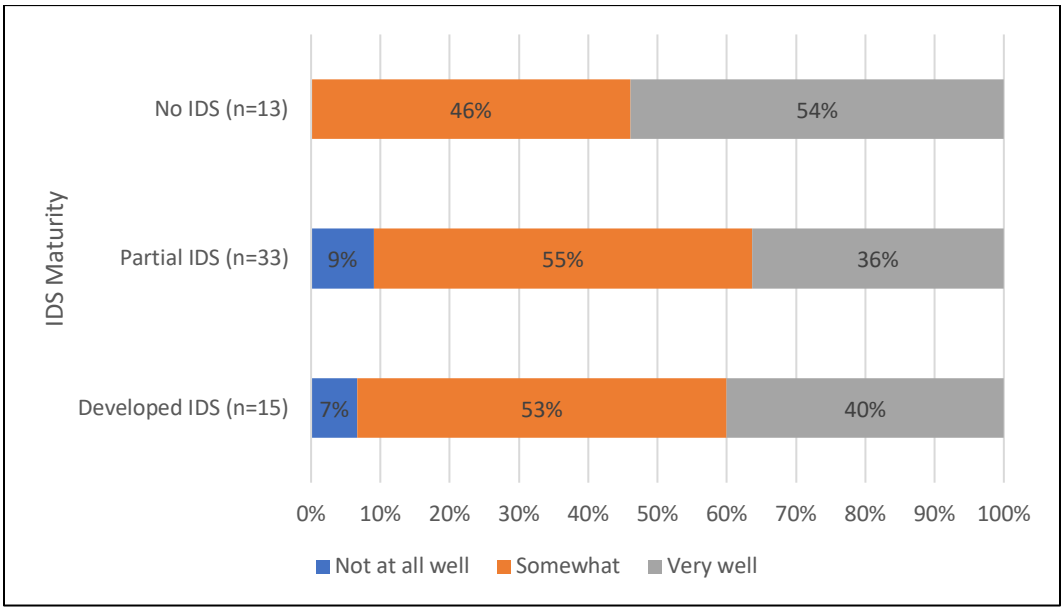



Figure 6. Level of agreement with the IDS definition used in the survey by IDS maturity (N=61)

## CASE STUDY: CARIBBEAN PUBLIC HEALTH AGENCY
### Integrated Surveillance Approach

To adequately address the wide spectrum of diseases and public health threats in the Caribbean, CARPHA's surveillance work spans from traditional to novel/special programs, as listed below:

- Health information, communicable diseases and emergency response
- Laboratory (clinical (Trinidad), food and environmental (St. Lucia) and medicines (Jamaica)) testing
- Nutrition and food security
- Non-specialized programs focusing on specific disease burdens/public health issues
- Chronic diseases and Injury
- Vector-borne diseases
- Travelers health (tourism and health program) and food-borne diseases
- Field epidemiology and laboratory training program
- Environmental health and sustainable development
- Medicines quality control and surveillance
- Caribbean regulatory system, VigiCarib

CARPHA has been implementing an integrated surveillance approach to synthesize and analyze CARPHA's surveillance data, to increase allocative and technical efficiency, and allow for the provision of a cohesive report on overall regional public health surveillance and social determinants of health since diseases do not occur in isolation or without complex social drivers. It is a work in progress aimed at strengthening the critical link between epidemiology, laboratory and epidemiological surveillance; for early detection and rapid response, prevention and control, and resulting in consolidating systems, eliminating unnecessary redundancies in reporting and reducing the reporting burden on member states.

CARPHA is providing CARPHA member states and other stakeholders with an improved, holistic, complete set of information for functional disease prevention and control, public health decision-making and policy formulation, that aims to meet the needs of all in the population. This strategy aims to reduce the workload on member states, given that a consolidated surveillance report which addresses overall public health surveillance in the region and their country would be available, as opposed to several disease specific reports. This new approach will foster the call for integrated surveillance systems and promote south-south cooperation between member states.

### 4.2.2 The IDS definition does not comprehensively cover all aspects and considerations

Almost half of the respondents (42%) provided further qualitative feedback and made additional suggestions to the IDS definition based on some of the challenges they faced. For instance, integration lacks a common definition and has been confused with summation and other terms that often misses the aspect and the process of 'bringing together'. IDS has been defined as a single infrastructure concept that must have the ability to analyze and model the data, but it is a complex system to implement and manage effectively.

Several respondents did not agree with the use of a single infrastructure for IDS. Responses included:

> The use of a single infrastructure may not be needed to use varied data sources (e.g. IDS using a One Health approach) from multiple stakeholders

> Not necessarily using a single infrastructure taking operational aspects into account; could be single / multiple infrastructures.

> A single system would be too complex and the disconnectedness from stakeholders is what is important

> What is important is interoperable data that is accessible for decision making, even if the system is not using a single infrastructure

> Single infrastructure not always the only way to organize the integration of data and multisectoral collaboration.

> The notion of having to pass through a single data model doesn't make sense for all data and monitoring; although it is essential to have information from the different surveillance systems

> May not be able to link all key surveillance systems in a single system, a number of standalone systems and platforms should be maintained that will still provide valuable insights for public health action.

Instead of this single infrastructure, it was also suggested that multiple, collaborative infrastructures could be used, based on greater data exploitation through appropriate and effective data sharing and better coordination between different monitoring systems and jurisdictions.

In addition, respondents suggested integration should not be seen as a "wall-to-wall" solution for all diseases, that integration across all topic areas is not needed, and that IDS should be prioritized by topic area to inform public health action.

Several respondents indicated that the IDS definition lacks the purpose or goal of the surveillance systems, i.e., public health action and disease control, supporting decision-making, produce informative outputs to different stakeholders, inform policies, proper use of data, provide curative evidence on indicators affecting health for transparent and collective decision making, provide an early warning system, analyzing and modelling of data and risk assessment.

The definition does not consider the different levels of the surveillance system (from local, regional/sub-national, state, to national), as well as the aspect of collaboration between sectors, agencies, and organizations required for the control and prevention of diseases. It was also mentioned that other components such as people, different data sources, or systems were also missing from this IDS definition. The definition also does not explicitly include the collection of information on "diseases" and indicators affecting "health", or the use of a health concept that identifies the main actors. Also missing from the definition was mention of the collection of information from different sectors, sources, and platforms, as part of an early warning system, to optimize the public health responses.

The definition needs to clearly identify the different sectors and responsibilities, and state how the different actors will make use of the information and avoid silos in data collection and data flows. Other aspects include: the integration of surveillance systems and data sources (from multiple stakeholders), legislation, data protection and the continuous and systematic collection of data, lines of responsibility (for data flow and use of data) and identification of key stakeholders (using the One Health concept) as well as other surveillance methods (sentinel site, population-based, etc.). It should also add a geographical dimension to enable the integration of data based on the local structure of the health system and social, economic, and environmental determinants.

### 4.2.3 Suggested enhancements to the Morgan et al. (2021) core principles for integrated disease surveillance

Respondents also provided suggestions on how Morgan et al.'s (2021) concept of principles for integrated disease surveillance could be enhanced (Table 1). They stated the need for adequate legislative and regulatory frameworks, good governance and political engagement, appropriate

control, and evaluation, as well as monitoring. Respondents suggested there is a need for data management, to ensure data integrity and confidentiality, interoperability and multisectorality, including interdisciplinary collaboration and analysis. Equity and guaranteed access to surveillance outputs were also identified as important in supporting strong, well-functioning integrated surveillance systems, as well as flexibility, simplicity, and acceptability. Resilience and capacity building were also identified as important factors.

Table 1: Suggested enhancements and additions to the core principles of IDS as set out by Morgan et al. (2021)

| *Core principles | Enhancements to proposed principles |
|---|---|
| Population | Social & economic denominators for the establishment of indicators and correlations on inequities |
| | Include all dimensions to understand epidemic (core functions) |
| Laboratory confirmation | None |
| Digital data and data transparency | Data quality, integrity and standards |
| | Data equity and access |
| | Data protection, privacy and security |
| Adequate funding | Linked to a certain fraction of healthcare spending |
| **Other principles** | **Elaboration** |
| Governance | Strong management |
| | Independence/integrity from government |
| | Political commitment |
| Legislation | General Data Protection Regulation |
| Human Resources | Capacity building |
| | Continuity of human talent |
| | Training |
| | Monitoring and evaluation |
| | Supervision |
| System attributes | Goal oriented and used for purpose (public health action) |
| | Continuous strengthening and improvement |
| | Surveillance system attributes (resilience, flexibility, simplicity, acceptability) |
| | Systems interoperability |
| Multisectoral | One health |
| | Stakeholder consensus (on IDS goal) |

A description of the self-defined level of agreement and proposed additions to the IDS definition and IDS principles, by IDS type, can be found in Appendix 3.

## 4.3. The Role of National Public Health Institutes

### 4.3.1 NPHI leadership of public health surveillance most common for HIC respondents

To understand the status of public health surveillance, all respondents were asked to define the lead agency responsible for, and having ownership of public health surveillance systems, regardless of whether these systems are integrated or not. Almost half (45%; 29/65) responded that the MOH was the sole lead agency, whereas 32% (21/65) reported that the NPHI was the sole lead agency. NPHI leadership was more common in HIC at 48% (11/23) compared to 18% (2/11) of LIC respondents (Table 2).

Table 2. Lead agency for public health surveillance, by World Bank country income group*

| Lead Agency for Public Health Surveillance | All respondents (n=65) | Low (n=11) | Lower middle (n=15) | Upper middle (n=15) | High (n=23) |
|---|---|---|---|---|---|
| NPHI | 21/65 (32%) | 2/11 (18%) | 4/15 (27%) | 4/15 (27%) | 11/23 (48%) |
| MOH | 29/65 (45%) | 7/11 (64%) | 9/15 (60%) | 6/15 (40%) | 7/23 (30%) |
| Joint NPHI/MOH | 7/65 (11%) | 2/11 (18%) | 1/15 (6.7%) | 3/15 (20%) | 1/23 (4.3%) |
| Other | 8/65 (12%) | 0/11 (0%) | 1/15 (6.7%) | 2/15 (13%) | 4/23 (17%) |

* Proportions may not total 100 due to rounding

### 4.3.2 NPHI mostly share responsibility of IDS systems

Respondents who reported having a partial or developed IDS system were additionally questioned if the NPHI was responsible for the IDS system. The respondents could only select one option from "yes, sole owner", "yes, joint owner", or "no". NPHIs were more likely to share ownership of the IDS system in countries that reported having both developed (63%) and partial systems (59%) (Table 3). When stratified by income level, higher income country respondents were also more likely to report that the NPHI had shared responsibility of the IDS system (Table 3).

Table 3. NPHI responsibility for IDS systems, by IDS maturity, and World Bank country income group*

| | Sole | Joint | Other | n |
|---|---|---|---|---|
| *By level of reported IDS maturity* | | | | |
| Partial | 21% | 59% | 21% | 34 |
| Developed | 19% | 63% | 19% | 16 |
| *By World Bank country income group* | | | | |
| Low | 44% | 44% | 11% | 9 |
| Lower middle | 36% | 45% | 18% | 11 |

| | | | | |
|---|---|---|---|---|
| Upper middle | 8% | 62% | 31% | 13 |
| High | 6% | 76% | 18% | 17 |

n=number of respondents providing a response
* Proportions may not total 100 due to rounding

### 4.3.3 Shared responsibility of IDS systems with NPHIs most common with the MOH

If respondents indicated that the NPHI shared responsibility of the IDS system (section 4.3.2), they were asked to select one or more options to identify partnering organizations from MOH, COS and other. Responsibility was most often shared with the MOH in partial (48%) and developed (46%) IDS systems (Table 4). An exception was for the HIC respondents, who indicated responsibility was most often shared (60%) with an organization other than the MOH and/or Centre of Statistics (COS) (Table 4).

For respondents that indicated that the NPHI does not have sole or joint ownership and responsibility of the IDS system, they were then asked which institution was responsible for the IDS system given options MOH, COS and other. This subset of respondents all indicated that the MOH was the responsible institution (developed n = 3; partial n = 3).

Table 4. Percentage of agencies (MOH, COS, other) identified to share ownership and responsibility of the IDS system with the NPHI, by reported IDS system maturity, and by World Bank country income group*

| | MOH | COS | Other | Total, s | n |
|---|---|---|---|---|---|
| By level of reported IDS maturity | | | | | |
| Partial | 48% | 12% | 40% | 25 | 18 |
| Developed | 46% | 15% | 38% | 13 | 9 |
| By World Bank country income group | | | | | |
| Low | 80% | 0% | 20% | 5 | 4 |
| Lower middle | 67% | 17% | 17% | 6 | 5 |
| Upper middle | 71% | 14% | 14% | 7 | 5 |
| High | 25% | 15% | 60% | 20 | 13 |

n=number of respondents providing a response
s = number of selected options in total (respondents could select more than one option)
* Proportions may not total 100 due to rounding

### 4.3.4 NPHIs lead most of the core functions in IDS systems

Respondents from developed and partial IDS systems were asked to identify the lead agency (NPHI, MOH, COS, no lead, other) responsible for the core functions of the IDS system, i.e., case/event

detection, case/event reporting, analysis, investigation or confirmation, response, feedback, evaluation, and preparedness. Respondents could select more than one lead agency. For every core function, respondents with partial IDS systems more frequently reported that the lead agency was the NPHI, over the MOH and COS. This trend was similarly reported by respondents with developed IDS systems, with the exceptions that an equal number of respondents reported that the lead was shared between the NPHI and MOH for feedback, and more respondents reported that the MOH led on *response* rather than the NPHI (Table 5).

Table 5. Percentage of agencies (NPHI, MOH, COS, no lead, other) identified to lead, by core function, as stratified by IDS system

a) Partial IDS systems*

| Functions | NPHI | MOH | COS | No lead | Other | Total, s | Partial, n |
|---|---|---|---|---|---|---|---|
| Detection | 49% | 31% | 0% | 0% | 20% | 45 | 33 |
| Reporting | 50% | 33% | 3% | 0% | 15% | 40 | 33 |
| Analysis | 56% | 27% | 13% | 0% | 4% | 45 | 33 |
| Investigation | 54% | 28% | 0% | 0% | 17% | 46 | 33 |
| Response | 44% | 40% | 0% | 0% | 17% | 48 | 32 |
| Feedback | 45% | 38% | 0% | 2% | 15% | 47 | 31 |
| Evaluation | 45% | 39% | 2% | 2% | 12% | 49 | 32 |
| Preparedness | 43% | 41% | 2% | 2% | 13% | 54 | 32 |

n=number of respondents providing a response
s = number of selected options in total (respondents could select more than one option)
* Proportions may not total 100 due to rounding

b) Developed IDS systems*

| Functions | NPHI | MOH | COS | No lead | Other | Total, s | Developed, n |
|---|---|---|---|---|---|---|---|
| Detection | 48% | 35% | 4% | 0% | 13% | 23 | 16 |
| Reporting | 50% | 32% | 5% | 0% | 14% | 22 | 16 |
| Analysis | 54% | 25% | 8% | 0% | 13% | 24 | 16 |
| Investigation | 55% | 40% | 0% | 0% | 5% | 20 | 15 |
| Response | 35% | 45% | 0% | 0% | 20% | 20 | 16 |
| Feedback | 44% | 44% | 0% | 0% | 11% | 18 | 14 |
| Evaluation | 52% | 33% | 0% | 0% | 14% | 21 | 16 |
| Preparedness | 45% | 41% | 0% | 0% | 14% | 22 | 15 |

n=number of respondents providing a response
s = number of selected options in total (respondents could select more than one option)
* Proportions may not total 100 due to rounding

The NPHIs' dominant role in leading core functions of IDS systems is strongest for the HIC respondents and decreases with income group. UMIC and LMIC respondents indicated that

leadership is shared more evenly between the NPHIs and MOHs. The LIC respondents reported that the MOH is more frequently the lead for the core functions (Table 5).

Table 5. Percentage of agencies (NPHI, MOH, COS, no lead, other) identified to lead, by core function, as stratified by income group

a) High income countries*

| Functions | NPHI | MOH | COS | No lead | Other | Total, s | Developed, n | Partial, n |
|---|---|---|---|---|---|---|---|---|
| Detection | 59% | 5% | 0% | 0% | 36% | 22 | 4 | 12 |
| Reporting | 60% | 5% | 5% | 0% | 30% | 20 | 4 | 12 |
| Analysis | 64% | 9% | 18% | 0% | 9% | 22 | 4 | 12 |
| Investigation | 58% | 5% | 0% | 0% | 37% | 19 | 3 | 12 |
| Response | 43% | 24% | 0% | 0% | 33% | 21 | 4 | 11 |
| Feedback | 48% | 22% | 0% | 0% | 30% | 23 | 4 | 11 |
| Evaluation | 52% | 14% | 5% | 0% | 29% | 21 | 4 | 11 |
| Preparedness | 44% | 28% | 4% | 0% | 24% | 25 | 3 | 11 |

n=number of respondents providing a response

s = number of selected options in total (respondents could select more than one option)

* Proportions may not total 100 due to rounding

b) Upper middle-income countries*

| Functions | NPHI | MOH | COS | No lead | Other | Total, s | Developed, n | Partial, n |
|---|---|---|---|---|---|---|---|---|
| Detection | 44% | 39% | 6% | 0% | 11% | 18 | 2 | 11 |
| Reporting | 50% | 38% | 6% | 0% | 6% | 16 | 2 | 11 |
| Analysis | 50% | 28% | 17% | 0% | 5% | 18 | 2 | 11 |
| Investigation | 63% | 31% | 0% | 0% | 6% | 16 | 2 | 11 |
| Response | 47% | 35% | 0% | 0% | 18% | 17 | 2 | 11 |
| Feedback | 44% | 44% | 0% | 6% | 6% | 18 | 2 | 11 |
| Evaluation | 42% | 47% | 0% | 5% | 5% | 19 | 2 | 11 |
| Preparedness | 39% | 44% | 0% | 6% | 11% | 18 | 2 | 11 |

n=number of respondents providing a response

s = number of selected options in total (respondents could select more than one option)

* Proportions may not total 100 due to rounding

c) Lower middle-income countries*

| Functions | NPHI | MOH | COS | No lead | Other | Total, s | Developed, n | Partial, n |
|---|---|---|---|---|---|---|---|---|
| Detection | 46% | 46% | 0% | 0% | 8% | 13 | 5 | 6 |
| Reporting | 46% | 46% | 0% | 0% | 8% | 13 | 5 | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Analysis | 53% | 40% | 0% | 0% | 7% | 15 | 5 | 6 |
| Investigation | 47% | 53% | 0% | 0% | 0% | 15 | 5 | 6 |
| Response | 38% | 56% | 0% | 0% | 6% | 16 | 5 | 6 |
| Feedback | 42% | 58% | 0% | 0% | 0% | 12 | 4 | 5 |
| Evaluation | 53% | 40% | 0% | 0% | 7% | 15 | 5 | 6 |
| Preparedness | 44% | 50% | 0% | 0% | 6% | 16 | 5 | 6 |

n=number of respondents providing a response

s = number of selected options in total (respondents could select more than one option)

* Proportions may not total 100 due to rounding

c) Low income*

| Functions | NPHI | MOH | COS | No lead | Other | Total, s | Developed, n | Partial, n |
|---|---|---|---|---|---|---|---|---|
| Detection | 40% | 53% | 0% | 0% | 7% | 15 | 5 | 4 |
| Reporting | 38% | 54% | 0% | 0% | 8% | 13 | 5 | 4 |
| Analysis | 50% | 36% | 7% | 0% | 7% | 14 | 5 | 4 |
| Investigation | 50% | 44% | 0% | 0% | 6% | 16 | 5 | 4 |
| Response | 36% | 57% | 0% | 0% | 7% | 14 | 5 | 4 |
| Feedback | 42% | 50% | 0% | 0% | 8% | 12 | 4 | 4 |
| Evaluation | 40% | 53% | 0% | 0% | 7% | 15 | 5 | 4 |
| Preparedness | 47% | 47% | 0% | 0% | 6% | 17 | 5 | 4 |

n=number of respondents providing a response

s = number of selected options in total (respondents could select more than one option)

* Proportions may not total 100 due to rounding

The NPHI was reported not to lead on any of the assessed eight core functions for Germany, Hong Kong and Zambia. Respondents from 16 countries reported that an organization other than the NPHI, MOH, and COS was responsible for leading one or more core functions (Table 6).

Table 6. Respondent countries that report a lead agency other than the NPHI, MOH or COS leads the core function, as indicated by green for yes and red for no

| Country | Detection | Reporting | Analysis | Investigation | Response | Feedback | Evaluation | Preparedness |
|---|---|---|---|---|---|---|---|---|
| Germany | | | | | | | | |
| Hong Kong | | | | | | | | |
| Zambia | | | | | | | | |
| United States | | | | | | | | |
| Angola | | | | | | | | |
| United Kingdom | | | | | | | | |
| Czech Republic | | | | | | | | |
| Portugal | | | | | | | | |
| FYR Macedonia | | | | | | | | |
| Mexico | | | | | | | | |
| Netherland | | | | | | | | |
| Poland | | | | | | | | |
| Colombia | | | | | | | | |
| Finland | | | | | | | | |
| Norway | | | | | Y | | | |
| Kazakhstan | | | | | | | | |

## CASE STUDY: Kenya
## Improving the Weekly Reporting Rates in IDSR

The Integrated Disease Surveillance and Response Strategy that was developed by the WHO African region in 1998 and adopted by the region in 2001 aims to detect and respond to outbreaks early to reduce morbidity and mortality arising from epidemics. Over the years there have been a lot of gains made, as well as challenges encountered.

In Kenya, health facilities are expected to report every week. The epidemiological week starts on Monday and ends on Sunday. The facility surveillance focal person is expected to provide the report to the Sub-County Disease Surveillance Coordinator (SCDSC) report by 11.59 pm every Monday. The SCDSC then must upload the reports onto the Kenya Health Information System (KHIS) by 11.59 pm on Wednesday. At the national level, the information is collated, and a weekly epidemiological bulletin is prepared that is shared with the county, subcounty, and facility levels every week.

During 2021, the performance in terms of the weekly epidemic monitoring reporting was noted to be as low as 40% in some counties. To address this, Kenya initiated a virtual county surveillance

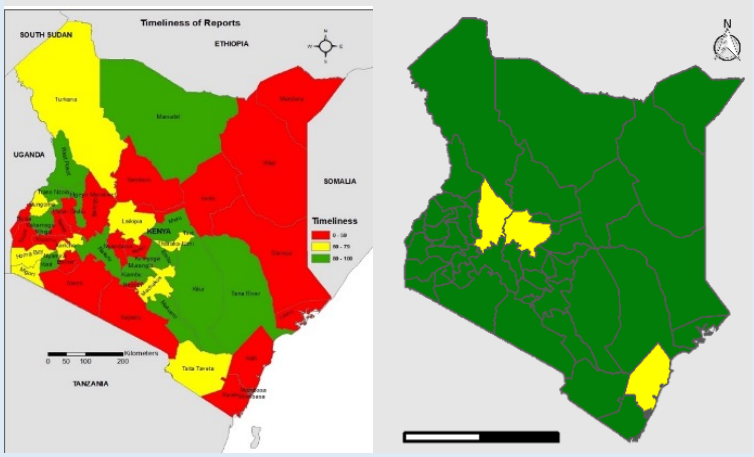
review with the view to identify best practices, challenges and possible solutions to the challenges encountered. 11 regional meetings were held, and the following were identified:

Best practices: Best practices identified included sending reminders to the facility surveillance focal persons, SCDSCs, and CDSCs, the formation of WhatsApp groups to ease communication between the various levels, weekly virtual meetings at the facility level and sharing of the weekly bulletin with the lower levels. Other best practices included having passionate staff, data review meetings, establishment of Public Health Emergency Operation Centers (PHEOC) and having Continuing Medical Education at the facility level.

Challenges: Various challenges were also identified, such as inadequate reporting tools, inadequate financial support at the county level, inadequate IDSR technical guidelines, knowledge gaps due to new officers who have never been trained on the IDSR strategy, erroneous entries due to transcribing errors, closure of some facilities due to insecurity in some parts of the country, and downtime of the KHIS.

Recommendations and solutions: Solutions that were proposed included the provision of IDSR reporting tools, quarterly surveillance review meetings, IDSR training for the new staff, and high-level lobbying at the national level for financial support for surveillance activities at the county level. This approach led to substantial improvements in the timeliness of reports, from less than half the country to almost all of the country achieving timely reporting. This has been achieved through collaboration with the counties, mainly through county review meetings and by addressing local concerns.

Figure: Before and after Improving the Weekly Reporting Rates in IDS



## 4.4. Levels of Maturity and Progress in Integrating Surveillance Platforms and Data

### 4.4.1 Most existing surveillance systems are partially integrated but there is substantial variation

While most respondents indicated that their country's current surveillance system allows for the integration of surveillance data from different sources for public health action, 18% (12/65) reported the system was not integrable. The ability to integrate data from other sources was inversely associated with country income level. Over a third of respondents from low-income countries (36%; 4/11) reported their surveillance systems do not allow for integration of data from other sources compared to 13% of upper-middle (2/15) and high (3/23) income country respondents.

A diverse collection of surveillance systems exists in IANPHI-partner countries, with varying levels of integration with the public health system. Almost all respondents reported the collection of data on notifiable diseases (100%), vaccination coverage (100%), disease-specific (100%) and sentinel (100%) surveillance. Wastewater (78%), community-based (77%), and behavioral (62%) surveillance were the least commonly reported systems.

While a substantial number of surveillance systems exist, the data they collect are frequently reported to be inaccessible to the lead public health surveillance agency and seldom integrated into the public health surveillance system (Figure 7).

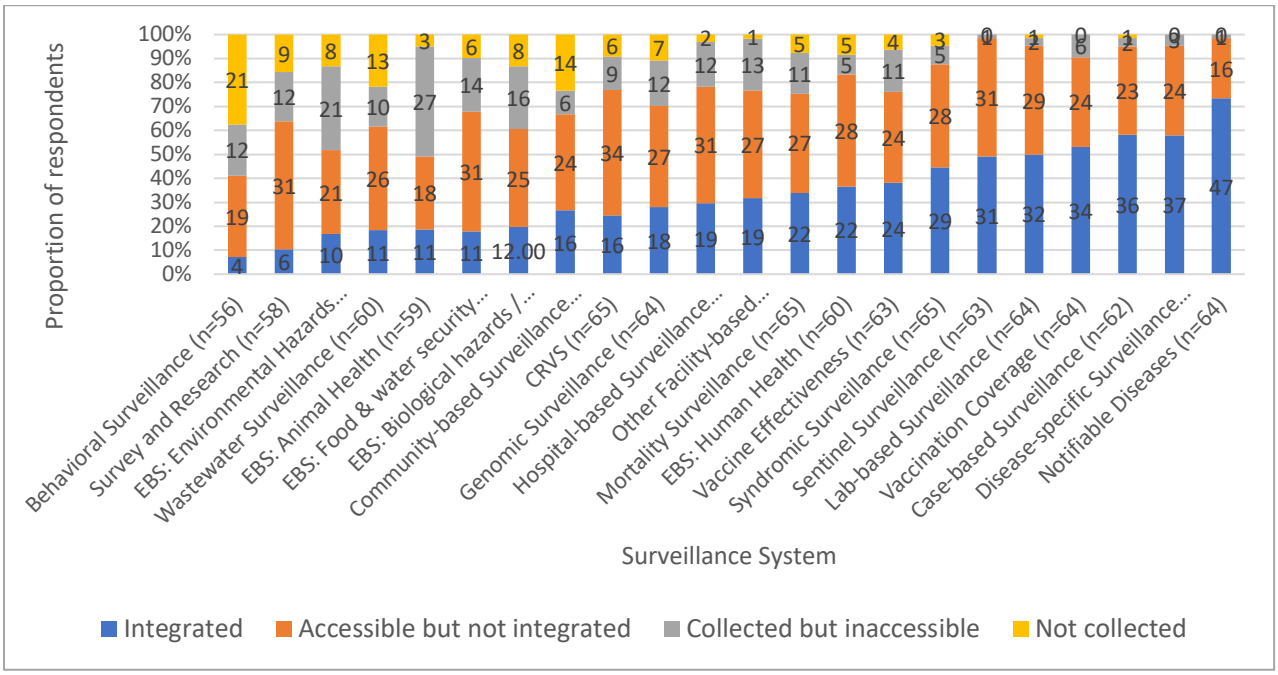



Figure 7. Proportion of data that is collected, accessible and integrated by type of surveillance

### 4.4.2 Notifiable diseases most likely to be integrated into disease surveillance systems

Among those reporting the existence of a specific surveillance platform, notifiable disease systems were the most integrated, with over 70% of respondents reporting the data were integrated into the public health system (Figure 8). Over half of respondents who reported the existence of case-based, disease-specific, vaccine coverage, and laboratory-based surveillance systems stated their data were integrated. However, less than a quarter of respondents reported that data from non-human health, event-based systems, wastewater surveillance, surveys/research, and behavioral surveillance were integrated into the disease surveillance system.

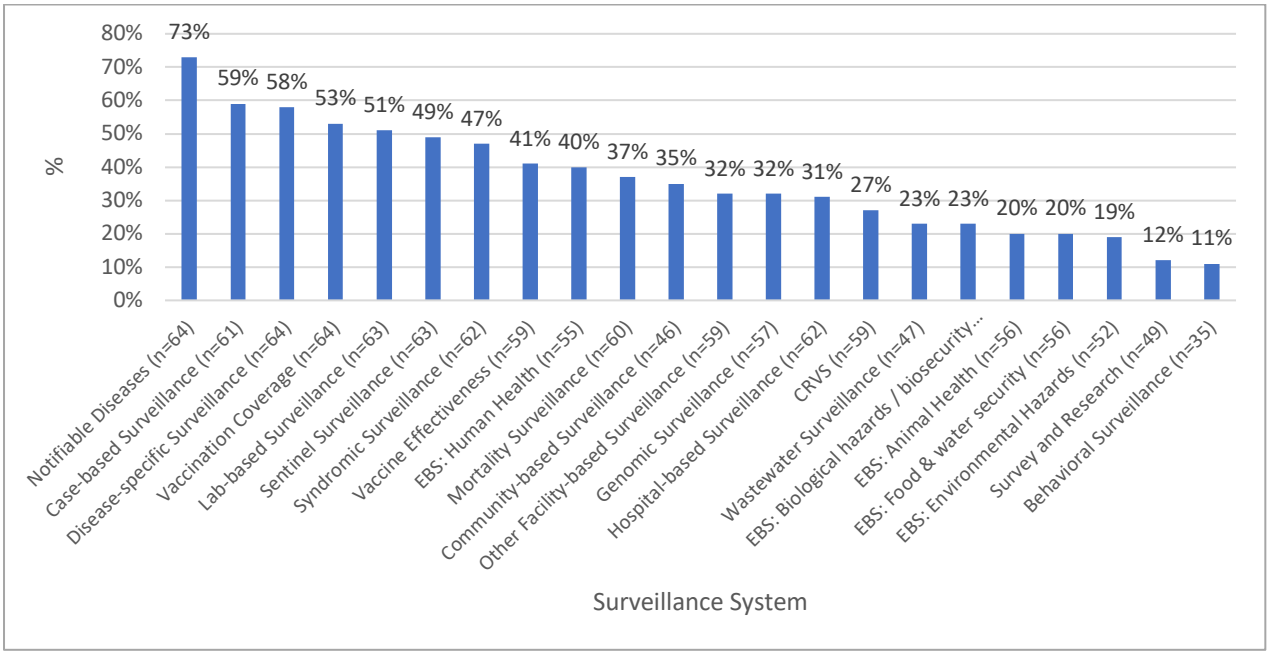



Figure 8. Proportion of existing surveillance systems that were integrated by type of surveillance systems

Respondents who classified their surveillance system as developed or partially developed more frequently reported that the data collected through existing systems were integrated into the larger public health system (Figure 9). However, even respondents who reported that they did not have an integrated system stated that data from some of their existing surveillance systems were incorporated into their public health response, most often including notifiable diseases and community-based surveillance systems.

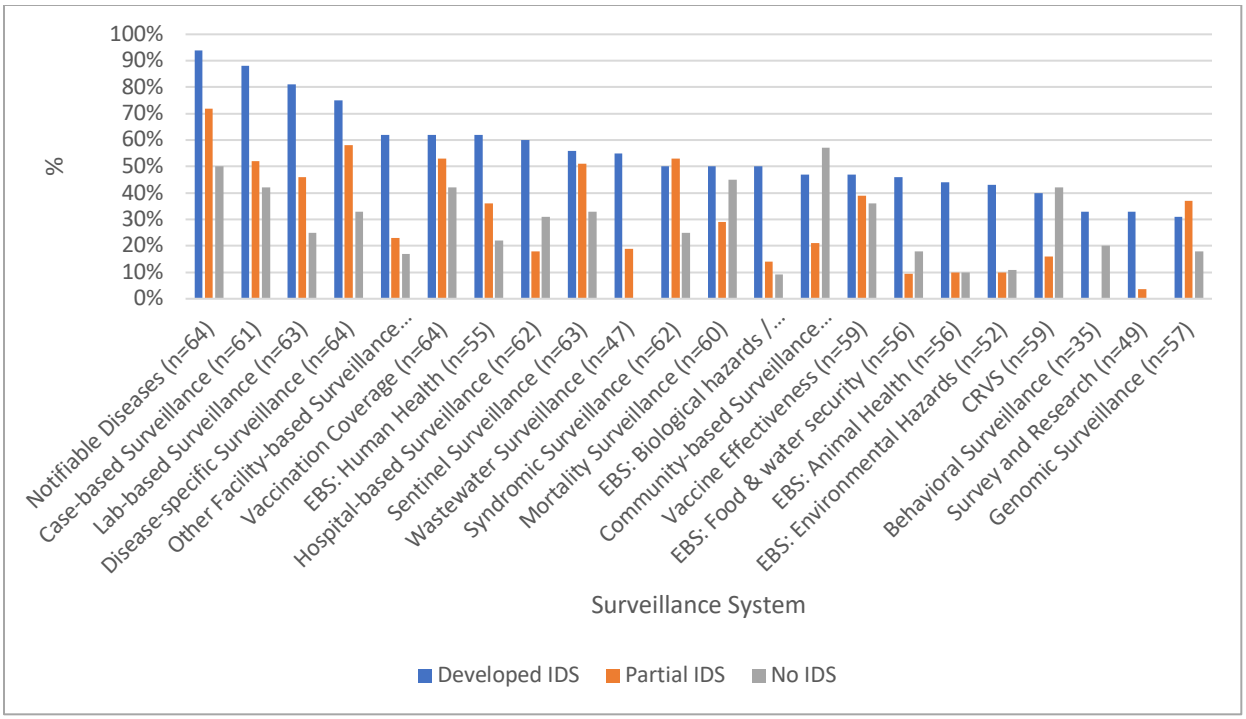



Figure 9. Proportion of existing surveillance systems that were integrated by type of surveillance and IDS status

### 4.4.3 Several challenges exist for IDS system development and maintenance

Respondents were asked to identify challenges in the development and maintenance of an IDS system (Table 8). Among respondents who reported the existence of a domestic IDS system, IT system interoperability was the most reported issue, followed by financial challenges, data sharing and workforce capacity (Figure 10).

Table 8: Description of challenges listed in the survey to develop and maintain an IDS system

| Challenge | Description |
|---|---|
| Governance | Leadership, accountability, regulation and enforcement |
| Financial | Inadequate investment, multi-year budget not available |
| Data availability | Requisite data not collected, not collected to a suitably high standard, or not shared by the organizations who are responsible for collecting that data |
| Data sharing and ownership | Lack of involvement, unclear roles and responsibilities, internal politics, unclear lines of reporting and accountability, territorialism, conflict / uncertainty re: intended use of data |
| IT systems interoperability | Incompatible IT systems to migrate data, migration from paper to electronic format, suboptimal IT systems, data security, data protection |

| | |
|---|---|
| Analysis and reporting | Lack of statistical package, unavailability of big data analysis |
| Laboratory | Lack of testing capabilities, lack of multisectoral reporting, lack of provider reporting |
| Workforce capacity and capabilities | Lack of experience and skills in multisectoral working, lack of analytical skills, lack of data collection skills |

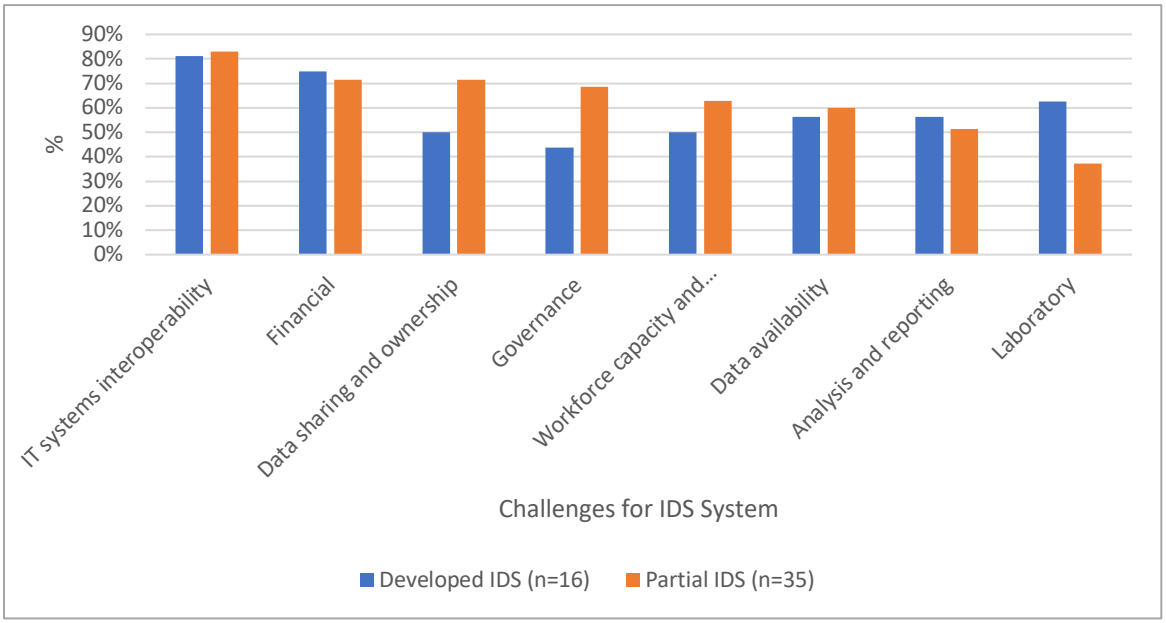



Figure 10. Challenges experience by respondents with developed or partially developed IDS systems

Respondents in settings without an IDS system reported similar barriers to developing an IDS system, emphasizing 1) a lack of coordination and collaboration between agencies and sectors, 2) limitations in data interoperability, and 3) insufficient IT systems for data integration. They were more likely to report having paper-based surveillance systems and manual data transfer compared to countries with an IDS system. Additionally, they reported other concerns with governance including the lack of clear definition of roles and lack of understanding between sectors, legal limitations for data collection and sharing, financial constraints, and workforce limitations. Surveillance system privacy protections were also less common in these settings.

When asked "what has prevented your country from establishing an IDS system?" the most common challenges that prevented respondents from establishing an IDS system were IT systems (77%), data sharing and ownership (77%), and governance (77%) (Figure 11).

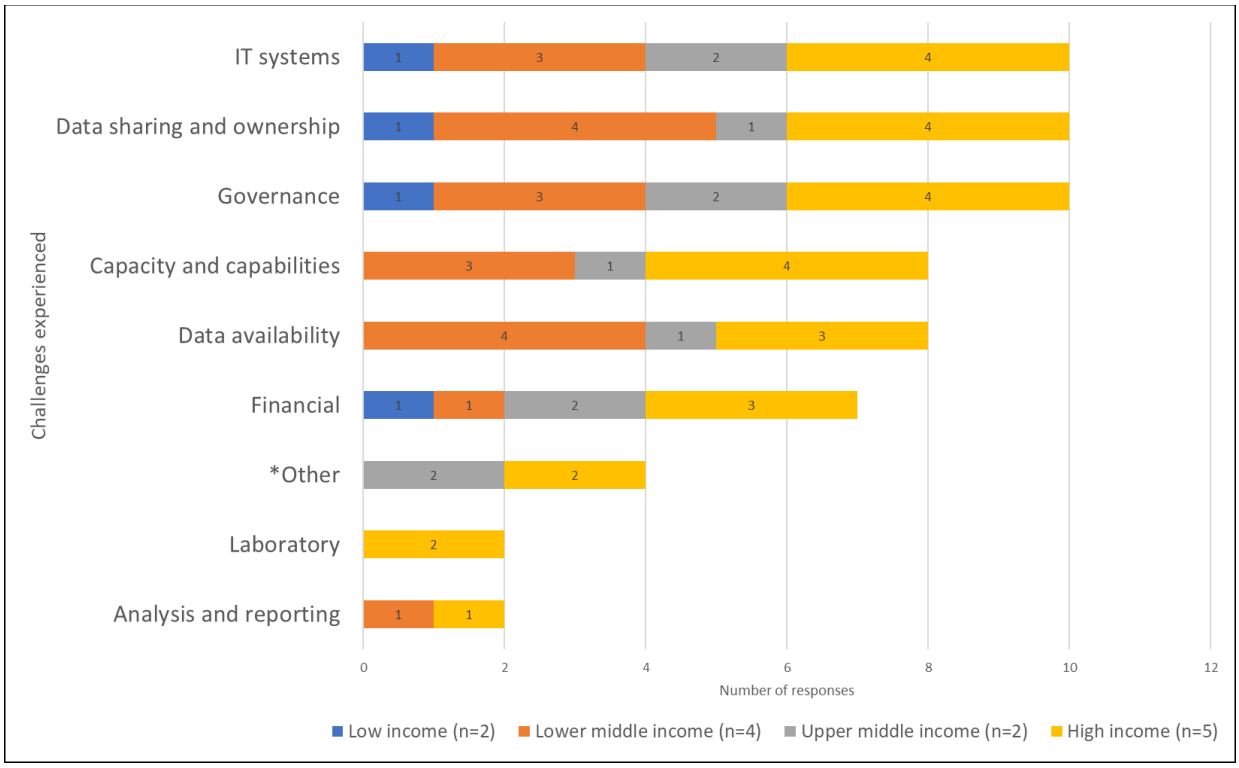



Figure 11. Challenges experienced by respondents (x axis number of responses) without an IDS system

When asked about their surveillance system development priorities, respondents without an IDS system (n=13) highlighted the need for 1) greater integration at the national level, 2) development of requisite IT and digital infrastructure, and 3) greater integration at the subnational level (Figure 12). This was followed by the need for increased interoperability, guideline development, and workforce development.

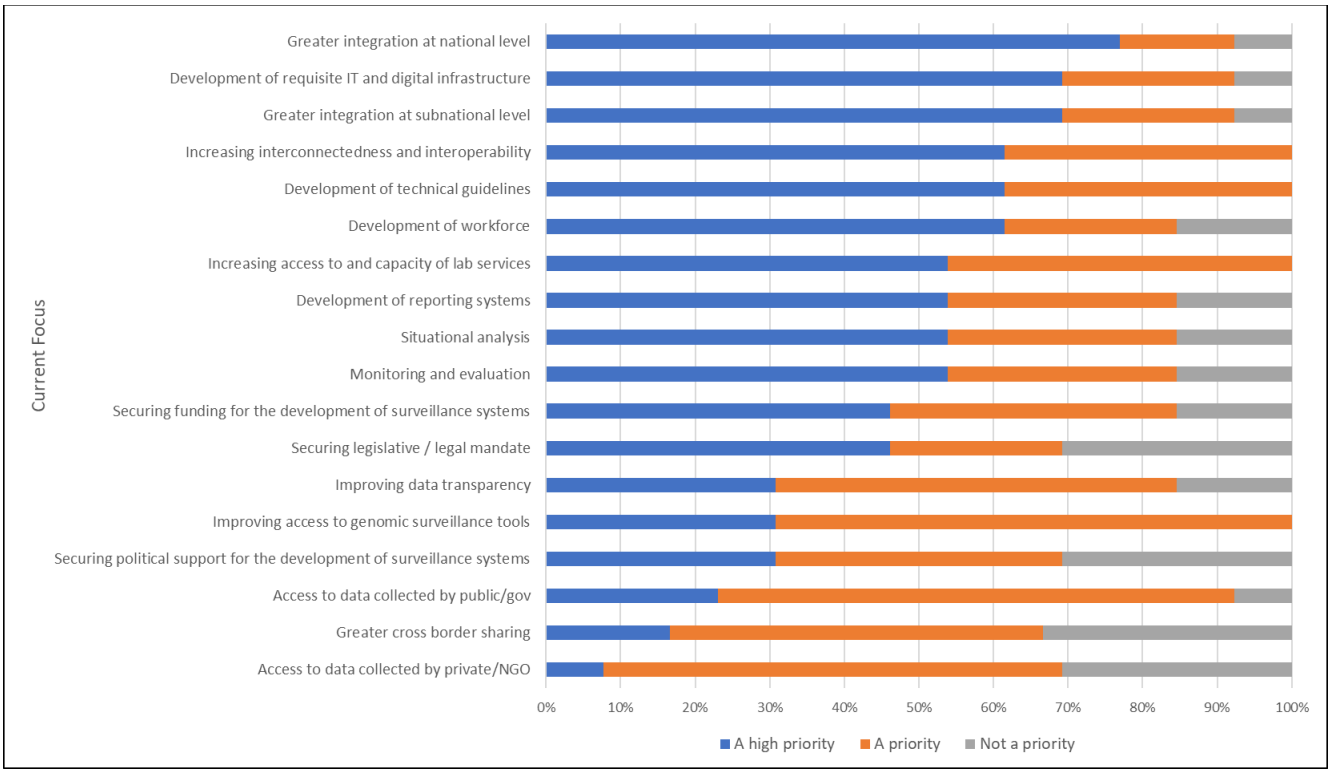



Figure 12. Surveillance development priorities for respondents without an IDS

### 4.4.4 Semantic consistency

Semantic consistency has been described by George et al., 2020 [14] as essential for "providing access to data and minimizing the potential for errors in human interpretation through the creation of standard data definitions and formats". The level of IDS integration (absent, partial, developed) likely influenced the response because lower levels of integration require less semantic consistency given that there are fewer transfers of data, information and knowledge in the public health surveillance system. Most respondents indicated there is some consistency, and only respondents with developed and partial IDS systems indicated a lack of consistency (Figure 13). This suggests as systems get more developed, achieving semantic consistency becomes more challenging. No respondents in a low-income setting without a developed IDS reported a lack of semantic consistency.

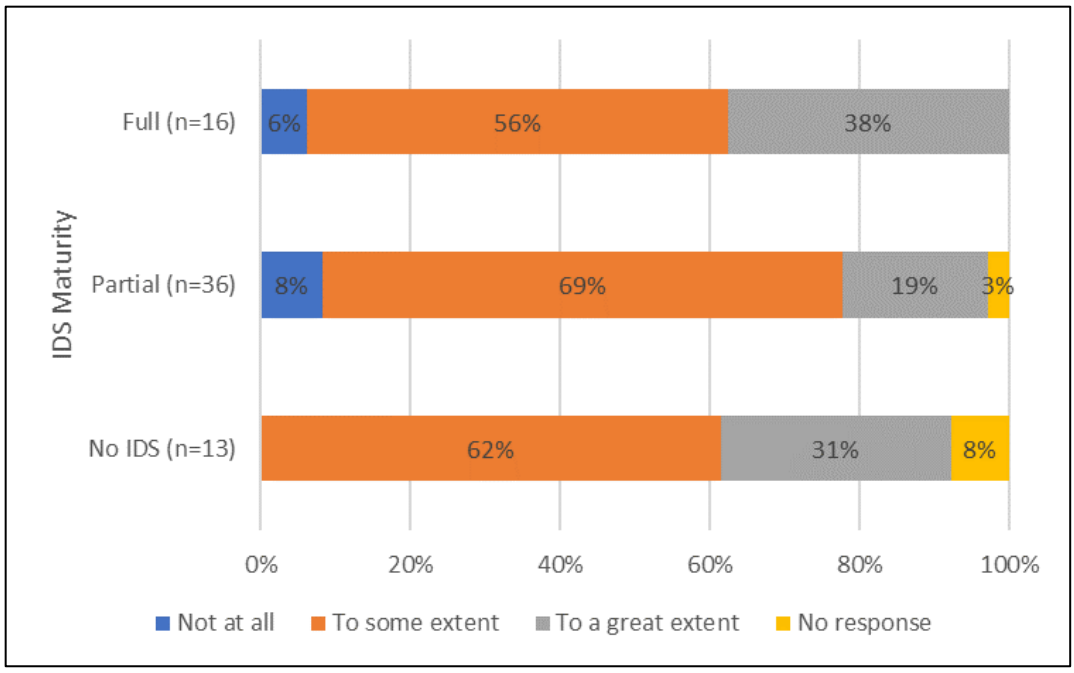



Figure 13. Proportion of respondents reporting semantic consistency in their disease surveillance systems, by reported IDS system maturity

## 4.5. Multisectoral Integration Within and Beyond Health Data – Including the Implications for One Health Surveillance

### 4.5.1 Variable multisectoral integration, especially for the private sector

Almost all respondents (>97%) indicated that public sector health providers and laboratories were involved in their country's surveillance system. Involvement by private sector providers was approximately 20% lower (80%; 52/65). Outside of the human health sector, involvement in the surveillance system was lower. Respondents commonly reported surveillance involvement in animal health (85%; 55/65) and environmental sector (71%; 46/65), but less frequently in the agricultural sector (54%; 35/65). Surveillance activities were inconsistently reported in the private (60%; 39/65) and pharmaceutical sectors (43%; 28/65). Biosafety and biosecurity related surveillance were also variable, ranging from 71% (46/65) of respondents reporting food security surveillance to only 38% (25/65) reporting surveillance related to the chemical and poison sector. Multisectoral surveillance involvement was more commonly reported in settings with a developed or partially developed IDS system (Figure 14).

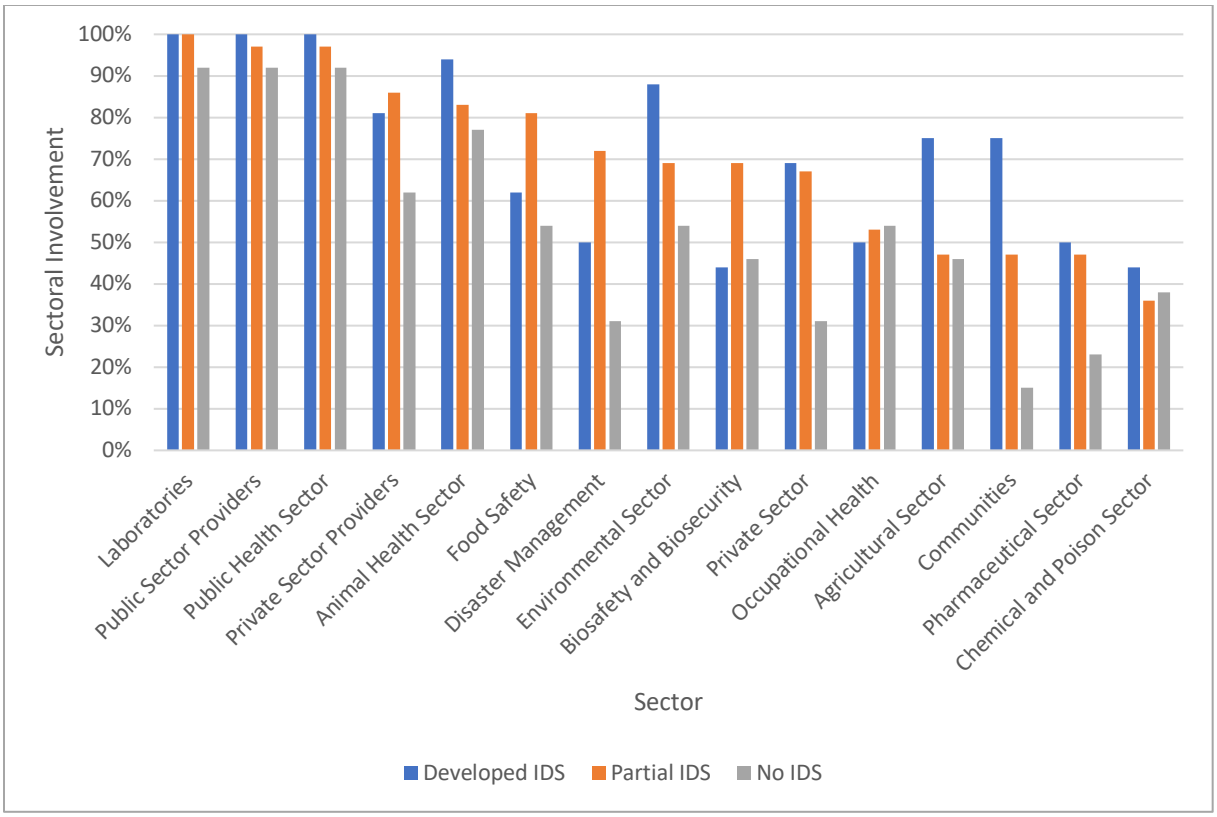



Figure 14. Sectors involved in IDS in countries reported to have developed or partially IDS, by level of IDS

### 4.5.2 Poorer sectoral integration for non-human health sectors

While many sectors were reported to be involved in the collection of surveillance data, these data were often inaccessible and rarely integrated into human disease surveillance systems. For example, most respondents reported the existence of event-based surveillance systems for animal health (95%), food and water security (90%), environmental hazards (87%), and biological hazards (87%). However, fewer than 1-in-5 reported that these data were integrated into the public health surveillance system (Figure 7– Section Q3).

When asked about barriers to multisectoral integration, some sectors were reported as more challenging to integrate with existing systems such as due to the lack of IT interoperability (82%; 42/51) or data sharing (65%; 33/51). The sectors most frequently reported as not being integrated were animal health (61%; 31/51), pharmaceutical (55%; 28/51), agricultural (53%; 27/51), environmental (51%; 26/51), private (49%; 24/51), and chemical and poisons sector (49%; 25/51). Public health (20%; 10/51), public healthcare providers (20%; 10/51), and laboratory (28%; 14/51) sectors were less frequently cited as not being integrated.

There was a trend seen for biosafety & biosecurity, food safety, disaster management, veterinarian and animal health services which tended to be more problematic for low-income countries than high-income countries (data not shown). Conversely, high income countries were more likely to report challenges with occupational health, the pharmaceutical sector, and community surveillance. Apart from public sector providers, respondents in settings with a partial IDS system more frequently reported sectoral challenges to integration compared to those with a developed IDS system (Figure 15).

## CASE STUDY: ARGENTINA
### Integrating Human and Animal Health sectors

The greater integration between the surveillance systems for Human and Animal Health started from 2018 due to the joint work conducted for the International Health Regulations. The integration materialized starting from the joint work for the implementation of a state-of-the-art laboratory for Animal Health surveillance. The Human Health laboratories helped to draft the Standard Operating Procedures for the new Animal Health laboratory, and both areas are developing joint projects on Antimicrobial Resistance as part of the "One Health" concept.

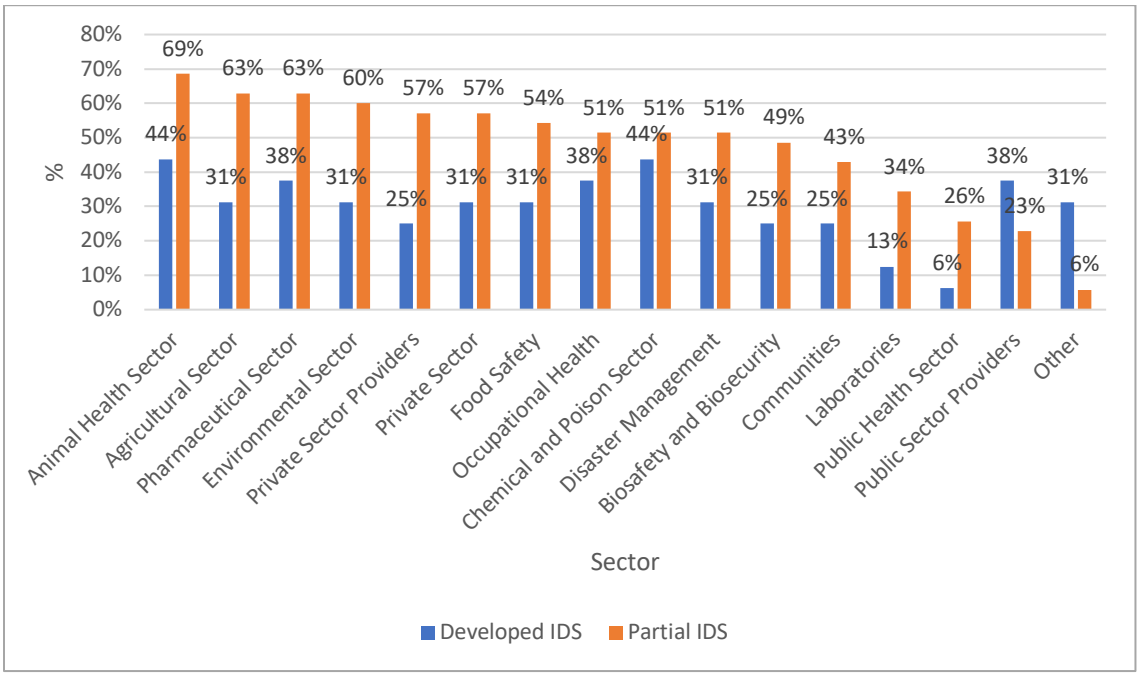



Figure 15. Proportion of respondents reporting integration challenges, by sector and by IDS maturity status

### 4.5.3 Poorer sectoral integration for non-infectious disease sectors

There were reported challenges for integration for some disease-specific programs, particularly for non-infectious disease sectors such as NCD programs (51%; 26/51), whereas issues with integration of specific infectious disease surveillance such as COVID-19 (16%; 8/51), measles (16%; 6/51) and cholera (10%; 5/51) were much less commonly reported. Integration challenges were reported commonly for surveys and research (47%; 24/51), health and demographic surveillance (47%; 24/51), and behavioral surveillance (41%; 21/51), but less commonly for notifiable diseases (10%; 5/51) or case-based surveillance (14%; 7/51) (Figure 16).

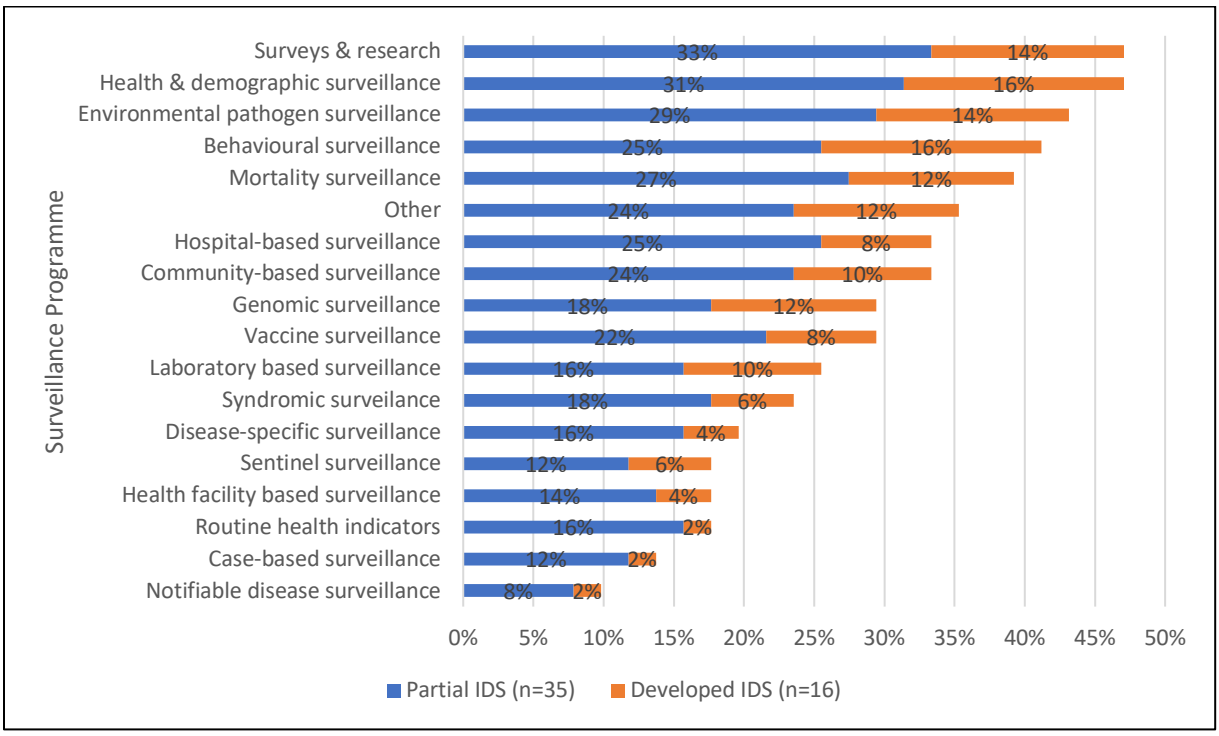



Figure 16. Proportion of respondents who reported integration issues with various programs

### 4.5.4 Multiple barriers exist to the integration of laboratory data into IDS systems

Multiple barriers were identified to the effective integration of laboratory data into developed and partially developed IDS systems. The most common was poor data systems/integration (53%; 27/51), followed by a lack of equipment/supplies (39%; 20/51), limited staff (39%; 20/51) and insufficient specimen transfer (18%; 9/51) (Figure 17). There was no substantial difference in barriers to the effective integration of laboratory data between respondents with a developed or partial IDS system (Figure 17).

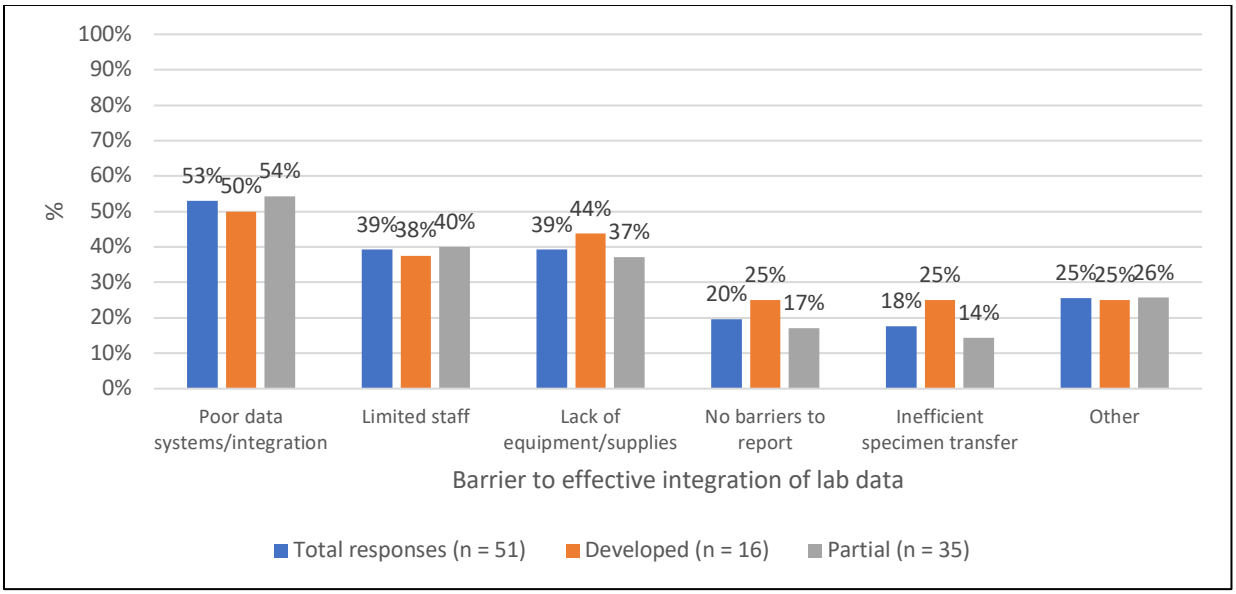



Figure 17. Barriers in the effective integration of laboratory data by IDS status

Some respondents reported no barriers to the effective integration of laboratory data into their IDS system (20%; 10/51), but this represented a minority of respondents and was predominantly reported by HICs (33%; 6/18) and UMICs (23%; 3/13) (Figure 18).

Respondents in HICs were less likely to report technical and resource barriers, such as poor data systems/integration, limited staff and lack of equipment/supplies, whereas these barriers were commonly reported in countries from all other income groups. However, respondents in HICs were more likely to report governance and funding barriers, these included data ownership, agreement and permissions, the absence of a mandatory enforcement for reporting and a lack of funding for IT systems development, infrastructure and maintenance (reported as Other) (Figure 18).

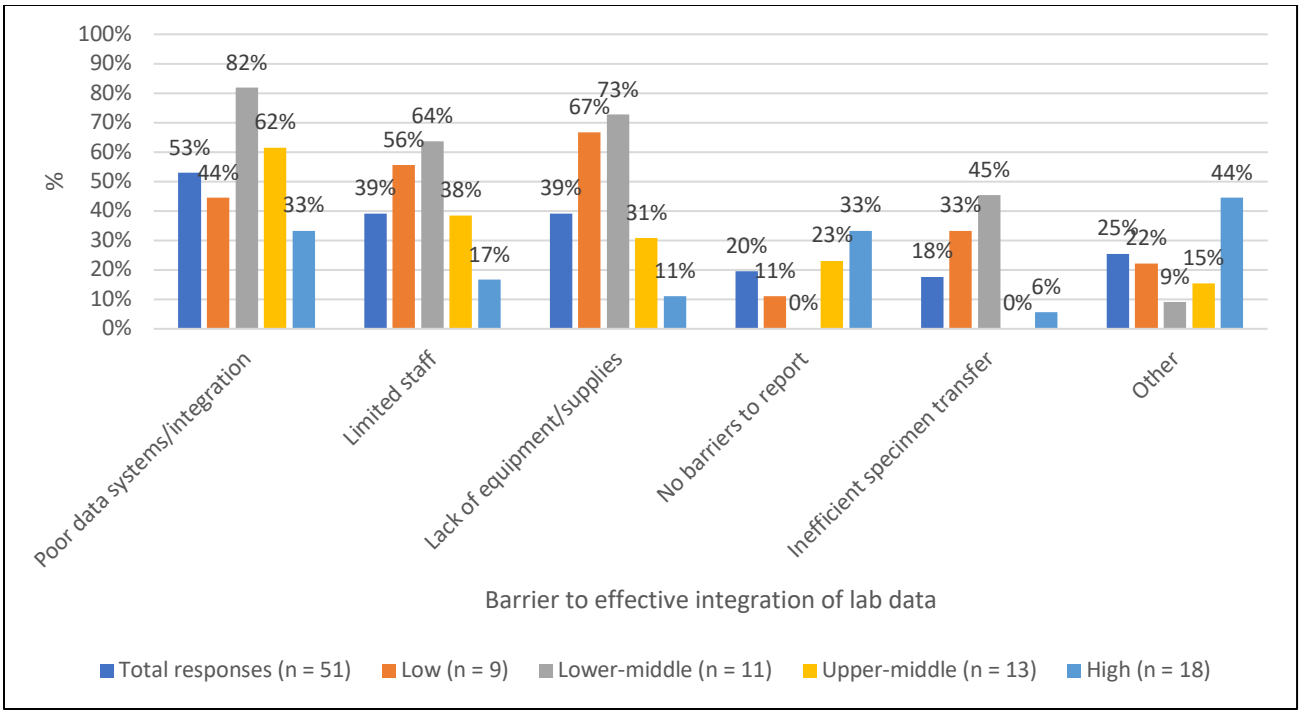



Figure 18. Barriers in the effective integration of laboratory data by income group

## 4.6. Core Functions and Activities of IDS Systems

Respondents were questioned about levels of establishment for the five core functions of IDS, as described by Morgan et al. [1]: to detect and report events/indicators (detect), investigate and/or verify events (investigate), analyze data and report results (analyze), respond to a public health event (respond), and evaluate and provide feedback for system improvement (evaluate and provide feedback). Respondents could select one of five levels of establishment, per core function. Here we summarize the selected options as strong, moderate-strong, moderate, moderate-weak, and weak. The definitions for these options differ for each core function (See Appendix 1).

### 4.6.1 Level of establishment for IDS core functions evaluate and provide feedback were weaker

Developed IDS systems reported most frequently a moderate-strong level of establishment for the core functions to detect, analyze and respond; and a moderate level of establishment for the investigate and evaluate and provide feedback (Table 9). 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-weak levels of establishment (Table 9).

High-income country respondents most frequently reported a moderate-strong level of establishment for all core functions except for "evaluate". The upper middle-income group also reported having weak

to moderate levels of establishment for the "evaluate" core function, and stronger establishment levels for the other core functions. Low and lower middle-income groups report similar, and wide ranging, levels of establishment for all core functions (Table 10).

Table 9. Percentage of respondents from a) developed and b) partial IDS systems indicating their level of establishment (weak, moderate-weak, moderate, moderate-strong, strong) for the five core functions**
Also shown is the number of respondents providing a response per core function, n. The highest and second highest percentages are shaded in dark and light grey, respectively.

a) Developed IDS systems

| Core functions | Weak | Moderate-weak | Moderate | Moderate-strong | Strong | Total | n |
|---|---|---|---|---|---|---|---|
| Detect | 6% | 13% | 13% | 44% | 25% | 100% | 16 |
| Investigate | 0% | 6% | 38% | 25% | 31% | 100% | 16 |
| Analyze | 0% | 6% | 25% | 38% | 31% | 100% | 16 |
| Respond | 0% | 0% | 6% | 56% | 38% | 100% | 16 |
| Evaluate and provide feedback | 0% | 20% | 33% | 20% | 27% | 100% | 15 |

b) Partial IDS systems

| Core functions | Weak | Moderate-weak | Moderate | Moderate-strong | Strong | Total | n |
|---|---|---|---|---|---|---|---|
| Detect | 9% | 18% | 18% | 44% | 12% | 100% | 34 |
| Investigate | 9% | 14% | 20% | 37% | 20% | 100% | 35 |
| Analyze | 11% | 9% | 17% | 43% | 20% | 100% | 35 |
| Respond | 14% | 6% | 11% | 51% | 17% | 100% | 35 |
| Evaluate and provide feedback | 27% | 24% | 33% | 6% | 9% | 100% | 33 |

** Proportions may not total 100 due to rounding

### 4.6.2 Range in levels of establishment for core functions narrower for HIC respondents

As reported by maturity of IDS system, all income groups generally reported a moderate-strong level of establishment for the five core functions; however, the trends varied more than when stratified by IDS system. The HIC respondents more consistently reported a moderate-strong level of establishment, while the other income groups reported a wider range in establishment levels (Table 10).

Table 10. Percentage of respondents from a) high, b) upper-middle, c) lower-middle, and d) low-income groups indicating their level of establishment for five core functions**

Also shown is the number of respondents from developed and partial IDS systems providing a response per core function, n, respectively. The highest and second highest percentages are shaded in dark and light grey, respectively.

a) High-income (Developed n = 4; Partial n = 13)

| Core functions | Weak | Moderate-weak | Moderate | Moderate-strong | Strong | Total |
|---|---|---|---|---|---|---|
| Detect | 0% | 24% | 12% | 59% | 6% | 100% |
| Investigate | 6% | 12% | 24% | 41% | 18% | 100% |
| Analyze | 0% | 0% | 24% | 41% | 35% | 100% |
| Respond | 6% | 0% | 12% | 65% | 18% | 100% |
| Evaluate and provide feedback | 20% | 33% | 27% | 7% | 13% | 100% |

b) Upper middle-income (Developed n = 2; Partial n = 11)

| Core functions | Weak | Moderate-weak | Moderate | Moderate-strong | Strong | Total |
|---|---|---|---|---|---|---|
| Detect | 15% | 8% | 23% | 31% | 23% | 100% |
| Investigate | 0% | 0% | 38% | 31% | 31% | 100% |
| Analyze | 8% | 8% | 8% | 54% | 23% | 100% |
| Respond | 8% | 8% | 0% | 54% | 31% | 100% |
| Evaluate and provide feedback | 23% | 23% | 23% | 15% | 15% | 100% |

c) Lower middle-income (Developed n = 5; Partial n = 6)

| Core functions | Weak | Moderate-weak | Moderate | Moderate-strong | Strong | Total |
|---|---|---|---|---|---|---|
| Detect | 9% | 18% | 9% | 27% | 36% | 100% |
| Investigate | 9% | 18% | 18% | 9% | 45% | 100% |
| Analyze | 18% | 9% | 27% | 27% | 18% | 100% |
| Respond | 18% | 0% | 9% | 45% | 27% | 100% |
| Evaluate and provide feedback | 18% | 9% | 45% | 0% | 27% | 100% |

d) Low-income (Developed n = 5*; Partial n = 4)

| Core functions | Weak | Moderate-weak | Moderate | Moderate-strong | Strong | Total |
|---|---|---|---|---|---|---|
| Detect | 11% | 11% | 22% | 56% | 0% | 100% |
| Investigate | 10% | 20% | 20% | 50% | 0% | 100% |
| Analyze | 10% | 20% | 20% | 40% | 10% | 100% |
| Respond | 10% | 10% | 20% | 40% | 20% | 100% |
| Evaluate and provide feedback | 11% | 22% | 44% | 22% | 0% | 100% |

*There were only 4 responses from developed IDS systems for the "*evaluate and provide feedback*" core function
** Proportions may not total 100 due to rounding

## 4.7. Resourcing Requirements and Inputs Required to Support IDS Systems

### 4.7.1 Workforce capacity (and gaps) for surveillance systems

Most respondents reported there was average workforce capacity to support the event-based surveillance systems (70%; 44/63) (Figure 19) and indicator-based surveillance systems (83%; 50/60) (Figure 20) in their country. There was no difference between respondents with developed, partial, or no IDS, or by WHO region. However, when stratified by income groups, although all income groups continued to report average workforce capacity for supporting indicator-based surveillance, LIC and LMIC respondents were more likely to report weak workforce capacity for supporting event-based surveillance systems (45%; 5/11 and 36%; 5/14, respectively) compared to UMIC and HIC respondents (13%; 2/15, and 3/22; 14%, respectively) (Figure 19). This trend was not observed for indicator-based surveillance systems (Figure 18) indicating while LIC and LMIC may invest workforce equally to HMIC and HIC in maintaining indicator-based surveillance systems, they may not have the resources to invest similar capacity to maintaining event-based surveillance systems. Only UMIC and HIC respondents indicated strong workforce capacity in either event-based and indicator-based surveillance systems (Figures 17 and 18).

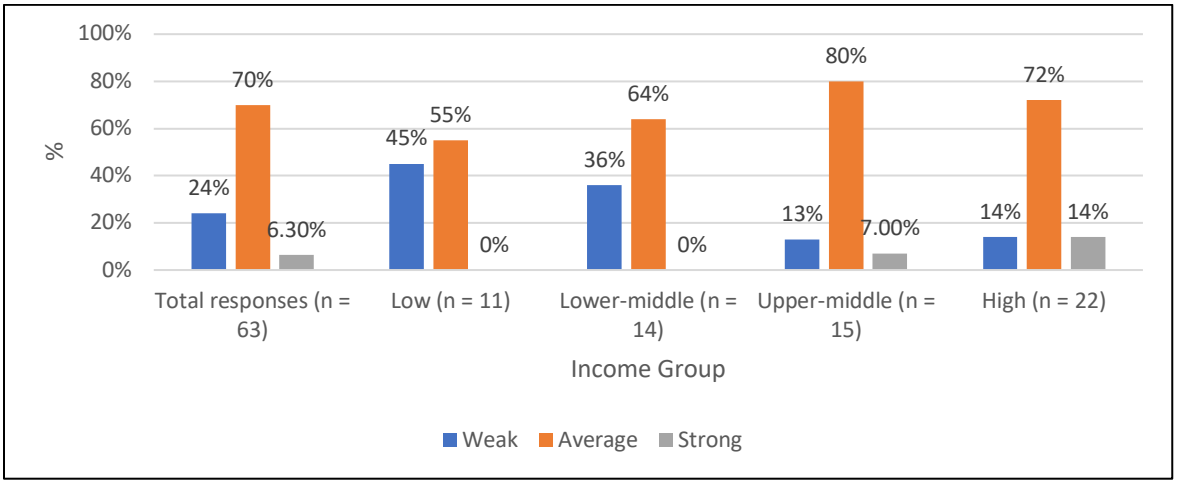



Figure 19. Self-reported workforce capacity to support event-based surveillance systems by income group

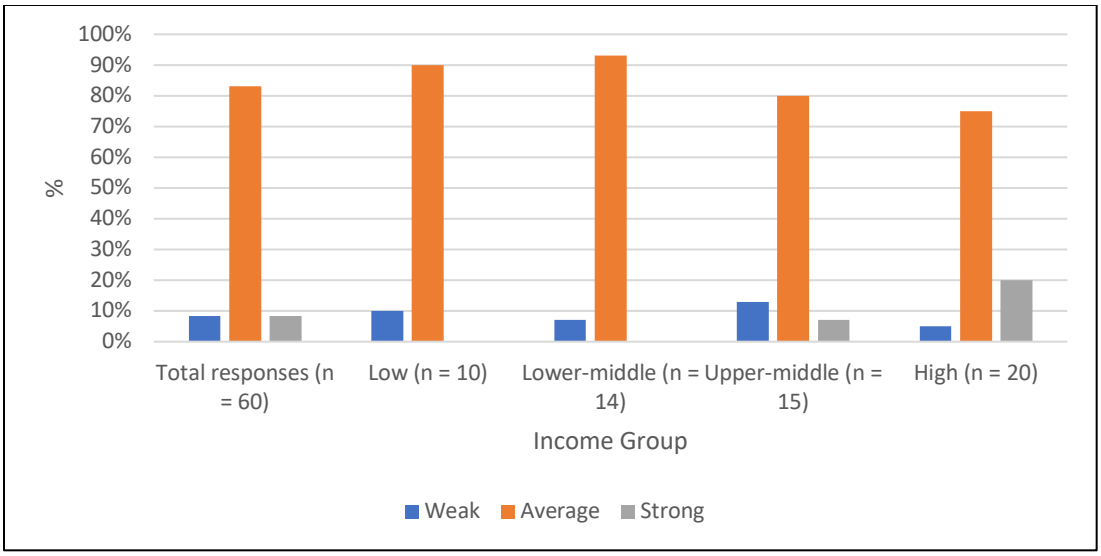
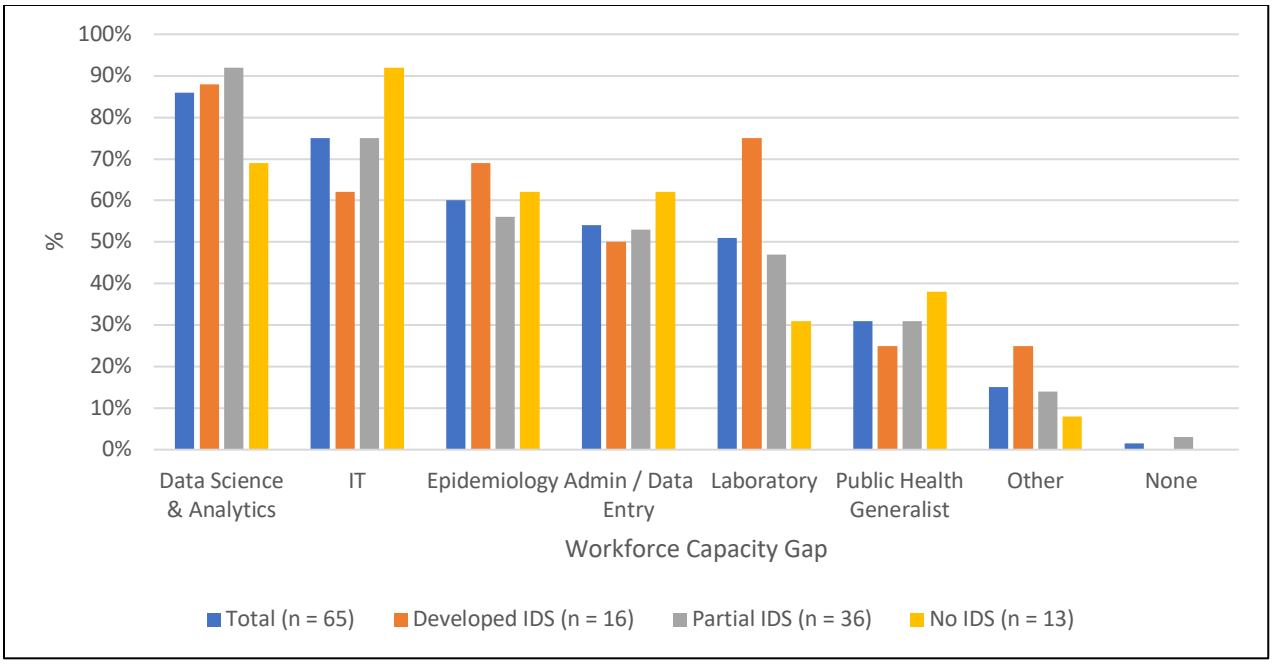



Figure 20. Self-reported workforce capacity to support indicator-based surveillance systems by income group

Gaps in surveillance workforce were common regardless of IDS status, WHO region or income group. The most common reported gaps within the capacities of respondents' surveillance workforce were data science and analytics (86%; 56/65) and information technology (75%; 49/65) (Figure 21). This was followed by gaps in epidemiology (60%; 39/65), administration/data entry (54%; 35/65), laboratory (51%; 33/65), public health generalist (31%; 20/65) and other gaps (Figure 21).

Other gaps included an overburdened workforce, variation in skills, systems/informatics gap and the lack of an event-based surveillance system. Data science and analytics and information technology were the two most common reported gaps regardless of income group (Figure 22). Respondents reporting no IDS were more likely to report workforce capacity gaps in IT (92%; 12/13) compared to respondents with partial IDS and fully developed IDS (75%; 27/36 and 62%; 10/16, respectively) while respondents reporting a developed IDS were more likely to report workforce capacity gaps in the laboratory (75%; 12/16) compared to respondents with partial IDS and no IDS (47%; 17/36 and 31%; 4/13, respectively) (Figure 21).




* Other includes overburdened workforce (3), variation in skills (3), systems / informatics (3), event-based surveillance (2)

Figure 21. Proportion of respondents reporting surveillance workforce capacity gaps by IDS status

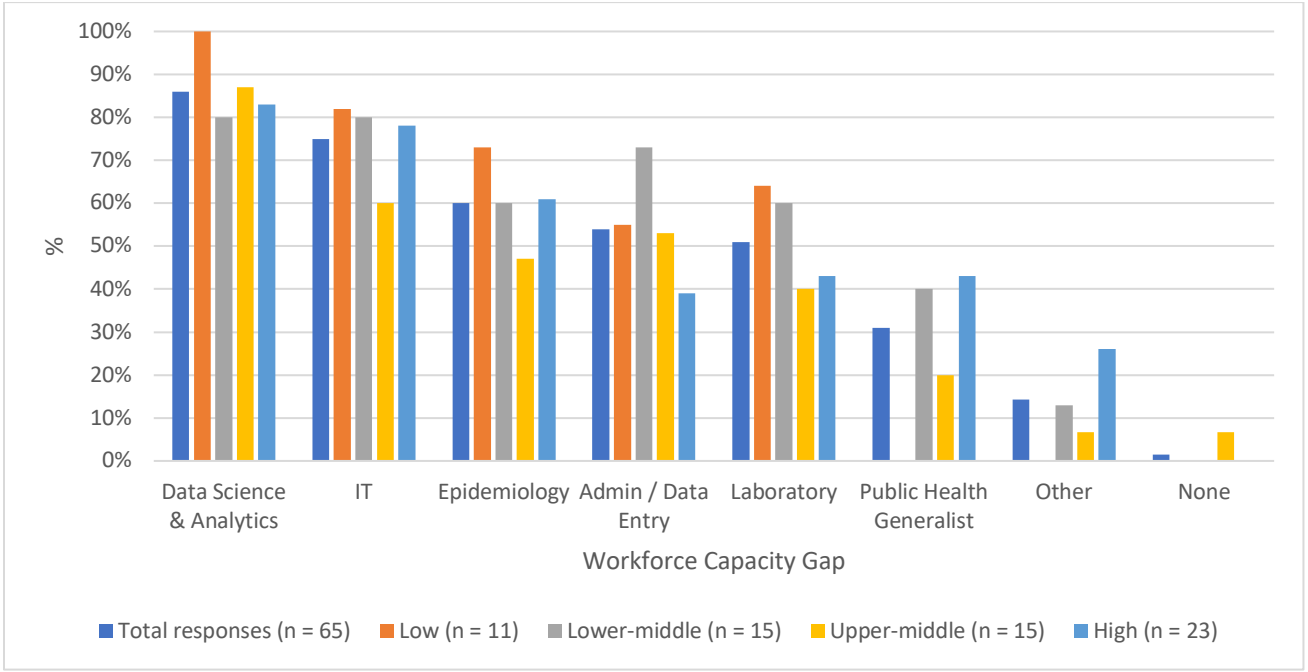



Figure 22. Proportion of respondents reporting surveillance workforce capacity gaps by type of gaps among respondents by income groups

CASE STUDY: ZIMBABWE
Workforce capacity building

The country introduced a new degree program on data analytics at the University of Zimbabwe. Trainees from this program have largely been attached to the surveillance center, creating practical training opportunities and passive feedback to academic institutions. In addition, a new directorate of data analytics was created within the MOHCC to build capacity in data handling.

This initiative was conceptualized after a government-wide national study on skills gap analysis in Zimbabwe. The need to build skills during undergraduate training was identified as the entry point for skills development. This resulted in restructuring of tertiary education in general and for medical education; data management and analytics training were one of the new programs introduced at the University of Zimbabwe (UZ) to address this gap.

Because most of the Faculty of Medicine and Health Sciences graduates are employed by the Ministry of Health and Child Care (MOHCC), it was important to create a directorate within the MOHCC that would absorb the graduates, and improve data management in the health sector. Students from the program are attached to the MOHCC's data analytics department. In addition, UZ provides data analysis support to the MOHCC. Students from undergraduate to masters are attached to the ministry as it has a fully developed staff from district to national to meet the university 's requirements. The MOHCC has also been assisting the university with teaching, particularly in the delivery of their 'practical' teaching sessions. The Ministry of Health staff are supported by government in the implementation of the digital health platforms particularly IMPILO suite of applications (the Zimbabwean-designed and built national EHR platform) covering surveillance to general HIS reporting.

Surveillance workforce development initiatives were reported to be led by the MOH or NPHI. Similarly, surveillance workforce development initiatives in place to address surveillance limitations were predominantly led by the MOH (60%; 39/65) or NPHI (58%; 38/65), there was no difference by IDS status (developed, partial or none) and income group. In-country academic institutions and externally supported/funded initiatives were also reported, but not as frequently (31%; 20/65, and 29%; 19/65, respectively). LICs more commonly reported initiatives led by in-country academic institutions (64%; 7/11) and externally supported/funded organizations (45%; 5/11) compared to LMICs, UMICs and HICs (13% to 27% by in-country academic institution, and 20% to 33% by externally supported/funded organizations). This suggests LICs may receive supplementary assistance in developing surveillance workforce initiatives in addition to their MOH or NPHI.

### 4.7.2 Laboratory capacity, data integration and genomic testing

Respondents with a developed or partial IDS system indicated that data were reported from a variety of different laboratories; the most common was from national public health laboratories (98%; 50/51), followed by sub-national public health laboratories (73%; 37/51), other public sector laboratories (67%; 34/51), private sector laboratories (63%; 32/51) and regional supranational laboratories (41%; 21/51) (Figure 23). There was no difference between respondents with a developed or partially integrated IDS, but HICs and UMICs were more likely to report data from private sector laboratories (78%; 14/18 and 69%; 9/13, respectively) compared to LMICs and LICs (45%; 5/11 and 44%; 4/9, respectively).

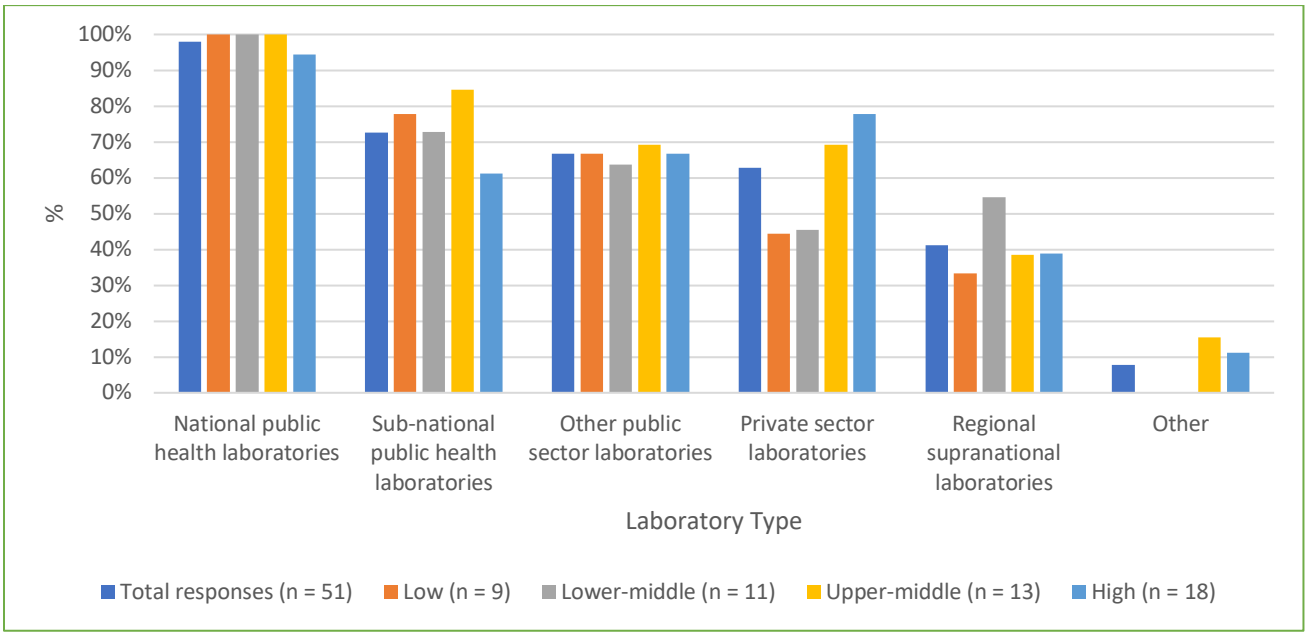



Figure 23. Proportion of respondents with full or partial IDS by income group and the different laboratories reporting into the IDS

Laboratory data integration into an IDS system varied by income groups. Two-thirds of respondents with a developed or partial IDS system reported that laboratory data was integrated into their IDS system electronically through compatible IT systems (69%; 35/51). Some also reported that data was integrated manually (29%; 15/51) and/or via other electronic means (29%; 15/51) (Figure 24). HICs and UMICs were more likely to report integration occurring electronically through compatible IT systems (83%; 15/18 and 77%; 10/13, respectively) compared to LMICs and LICs (36%; 4/11 and 67%; 6/13, respectively) (Figure 25). Conversely, LICs and LMICs were more likely to report that laboratory results are not yet integrated into their IDS system (22%; 2/9 and 36%; 4/11, respectively) compared to UMICs and HICs (7%; 1/13 and 6%; 1/18, respectively).

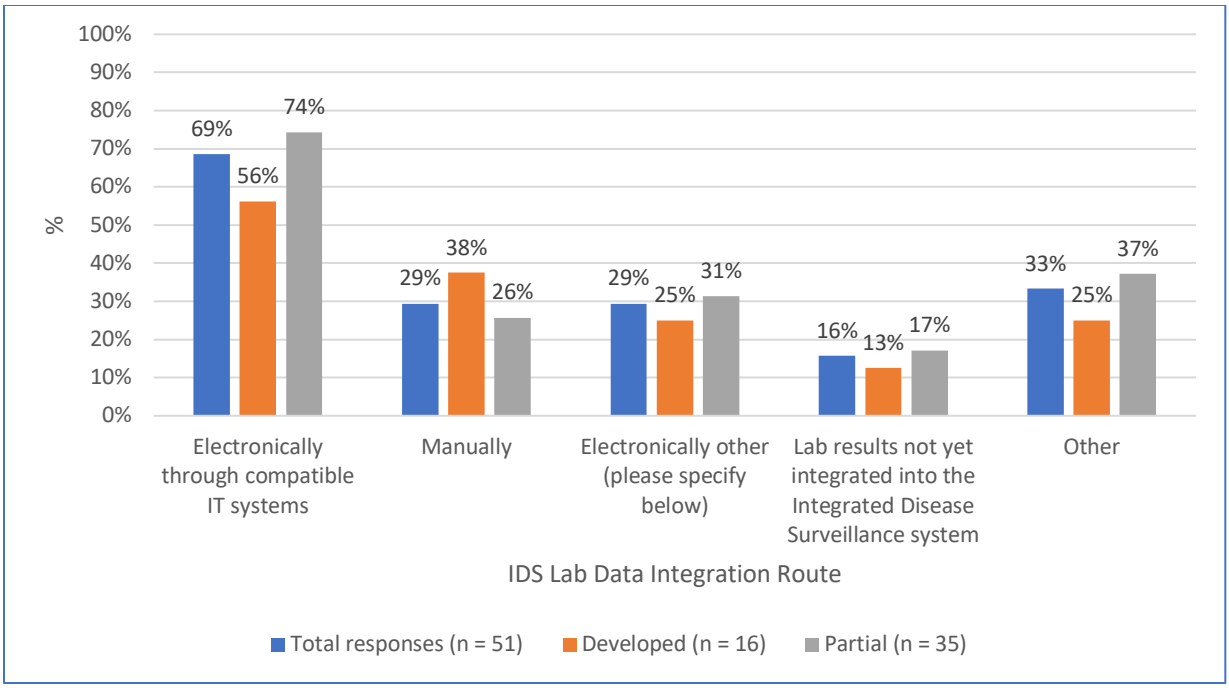



Figure 24. Laboratory results integration into IDS systems by IDS status

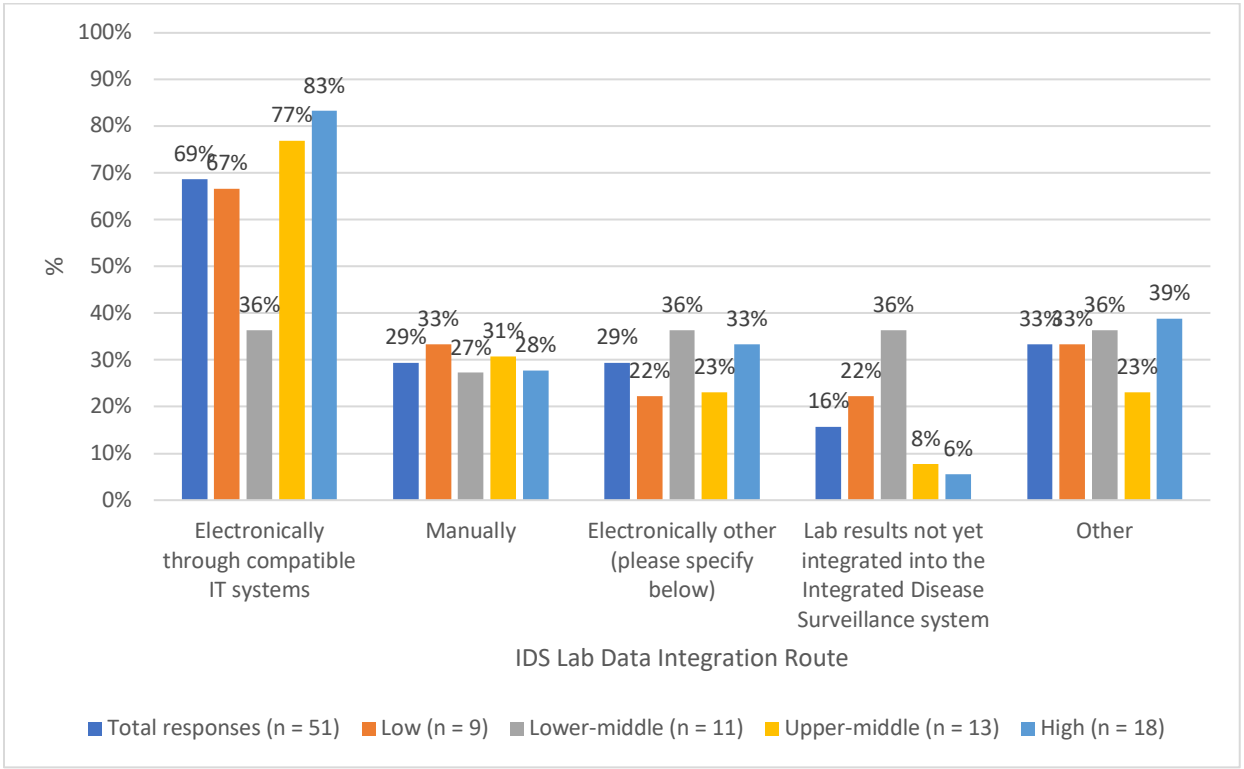



Figure 25. Laboratory results integration into IDS systems by income groups

Genomic testing and sequencing are predominantly available for developed or partial IDS systems, but the types of laboratories used varied by income groups. Most respondents with a developed or partial IDS system reported yes to genomic testing and/or sequencing for their IDS specimens (88%; 45/51). Genomic testing and/or sequencing was mainly conducted by national public health laboratories (76%; 39/51), with a minority of countries reporting testing/sequencing taking place at sub-national public health laboratories (27%; 14/51), private sector laboratories (22%; 11/51) and outside of the country (20%; 10/51) (Figure 26). Countries with a partial IDS were more likely to receive genomic testing and sequencing from laboratories outside of their national public health laboratories (Figure 26).

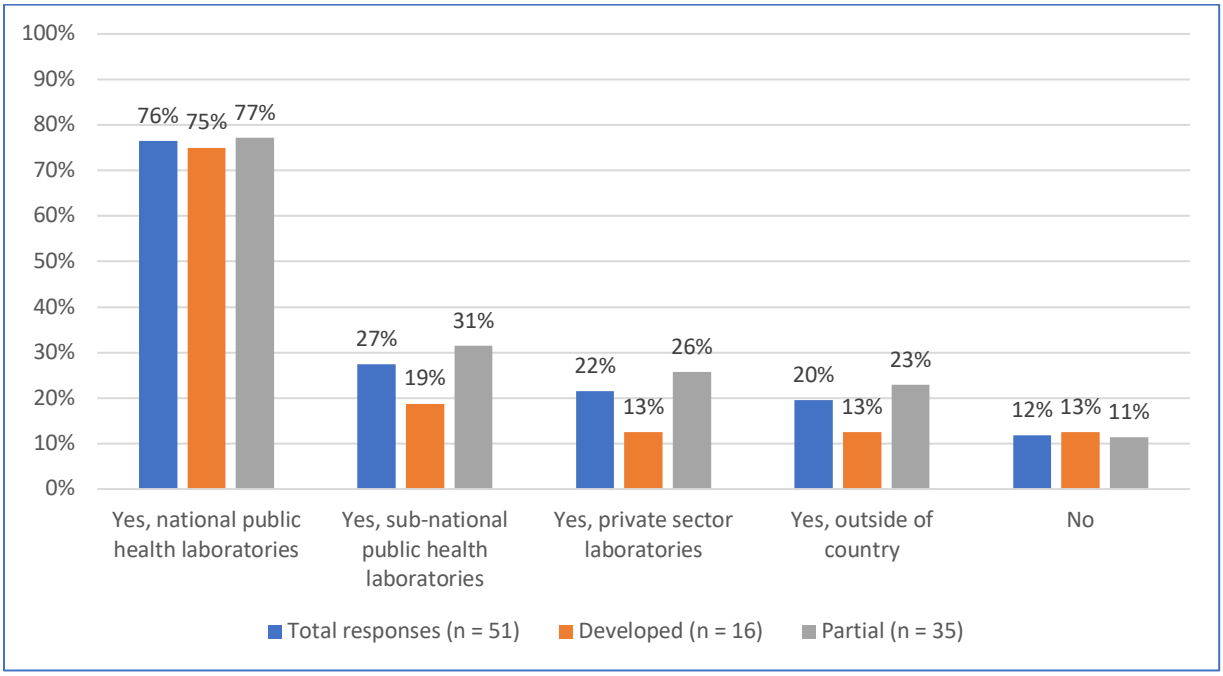



Figure 26: Laboratories where genomic testing and sequencing are made available for IDS systems by IDS status

All HIC respondents reported genomic testing/sequencing was available for their IDS system specimens (100%; 18/18) (Figure 27). HIC respondents reported that a range of laboratories were used for testing/sequencing including national public health laboratories (94%, 17/18), sub-national public health laboratories (67%; 12/18), private sector laboratories (50%; 9/18) and laboratories outside of the country (17%; 3/18) (Figure 27). In contrast, LICs and LMICs relied predominantly on testing at the national public health laboratories (56%; 5/9 and 82%; 9/11, respectively), outside of the country (11%; 1/9 and 27%; 3/11, respectively) or did not have genomic testing and sequencing available for their IDS system specimens (33%; 3/9 and 9%; 1/11, respectively) (Figure 27).

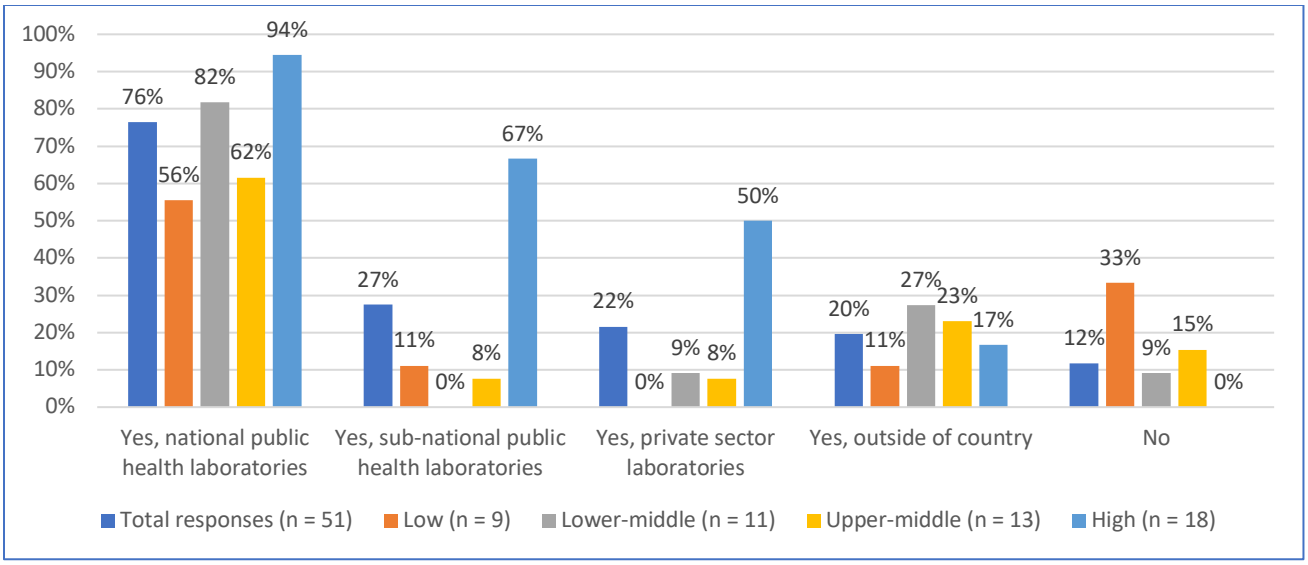



Figure 27. Laboratories where genomic testing and sequencing are made available for IDS systems by income group

## CASE STUDY: ANGOLA
### Building genomic analysis capacity

Angola has just started the implementation of genomic analysis by developing a framework to monitor the status and prospects for the implementation of this technology, which involve the acquisition of genomic equipment, training of workforce, and elaboration of guidelines. The elaboration of a framework document is in process, which will include: (i) clinical genomics guidelines, (ii) clinical organization, research infrastructure, and tools, (iii) data management, standards, and infrastructures, (iv) governance and strategy, (v) investment and economic model, (vi) ethics, legislation and policy, (vi) public awareness and acceptance, (vii) workforce skills and organization.

## CASE STUDY: ARGENTINA
### Acquisition of equipment to carry out genomic surveillance at the national and subnational levels

With regards to the optimization of genomic surveillance at the national and subnational levels in Argentina, this has been implemented through the creation of a Federal Genomics and Bioinformatics Network, developed and run by the National Administration of Laboratories and Health Institutes of Argentina (ANLIS) "Dr. Carlos G. Malbrán," under the National Ministry of

Health. This network is intended to develop the structural and technological capacity all over the country to generate genomic data, together with human resource training, in order to contribute to the generation of relevant information for decision making within the framework of integral health.

The Federal Genomics and Bioinformatics Network will have 14 permanent stationary centers with 15 high-capacity pieces of equipment, together with 24 portable devices with which the whole country will be covered for genomic sequencing and bioinformatic analysis. Consequently, all jurisdictions around the country will have access to portable sequencing devices for testing at different establishments engaged in molecular biology.

The equipment provided by ANLIS/Malbrán to the different jurisdictions around the country comprises next-generation sequencing technology with which it is possible to find out the genetic sequence of different microorganisms (viruses, bacteria, or any other organism) present in a wide variety of samples (human, animal, food, and environmental samples). Both the sequencers distributed to the laboratories, and the 24 portable devices sent to all jurisdictions, were purchased with funds from the "Solidarity Tax to Large Fortunes" implemented by the National Government.

Within this federal articulation framework, the national health ministry and ANLIS/Malbrán will assist with equipment, reagents and supplies, training and technical assistance in everything related to the implementation of the Federal Genomics and Bioinformatics Network. In turn, the jurisdictions have committed to providing building support and infrastructure to set up equipment, contributing human capital, and working in coordination with the National Government regarding research, action, and genomic surveillance at the regional/national level.

The genetic definitions analyzed with this equipment and shared through the above-mentioned network will allow preventive epidemiological health decision-making by recognizing, for instance, what viruses are making the community ill in the winter period. In addition, the equipment can be used to diagnose and treat tumor diseases, by analyzing and determining the most suitable therapeutic possibilities for the healing processes, a work that will take place at the hospitals, together with the anatomical pathology services.

This technology will benefit all of the country's inhabitants, as it makes it possible for investigations to go further using a health approach that is becoming much more ubiquitous globally. It also enables an effective, intersectoral approach and focus on the different pathogens that spread across human populations, between animals and human beings, among cattle, and along the food chain.

### 4.7.3 Financial requirements

Underpinning the successful establishment and sustainability of a surveillance system that integrates multi-level and multisectoral data is appropriate financing. This includes the investment in platforms required at primary source level as well as at any central system that integrates and analyses data. In this section we wanted to identify, for all three models of maturity whether funding has been provided that is adequate to enable a fit for purpose system and what are the common sources of funding. Respondents were able to choose more than one funding stream.

Financing for disease surveillance was provided by national governments for most respondents with developed IDS (n=7/16; 42%), for those with partial IDS systems (n=25/35; 57%) and (n=4/13; 29%) for those with no IDS. For countries without an IDS system, their disease surveillance systems were more often funded through international aid from a non-government organization (n= 6/13; 43%) or international aid from another country partner (n=2/13; 14%).

Finance, including inadequate investment and the lack of a multi-year budget, was identified as a challenge in setting up and running their IDS systems by the majority (73%, n=37/51) of those countries with either a full or partial IDS system (Figure 28). Contrary to what might be expected, a greater proportion of high-income countries identified finance as a challenge compared to countries in other income groups.

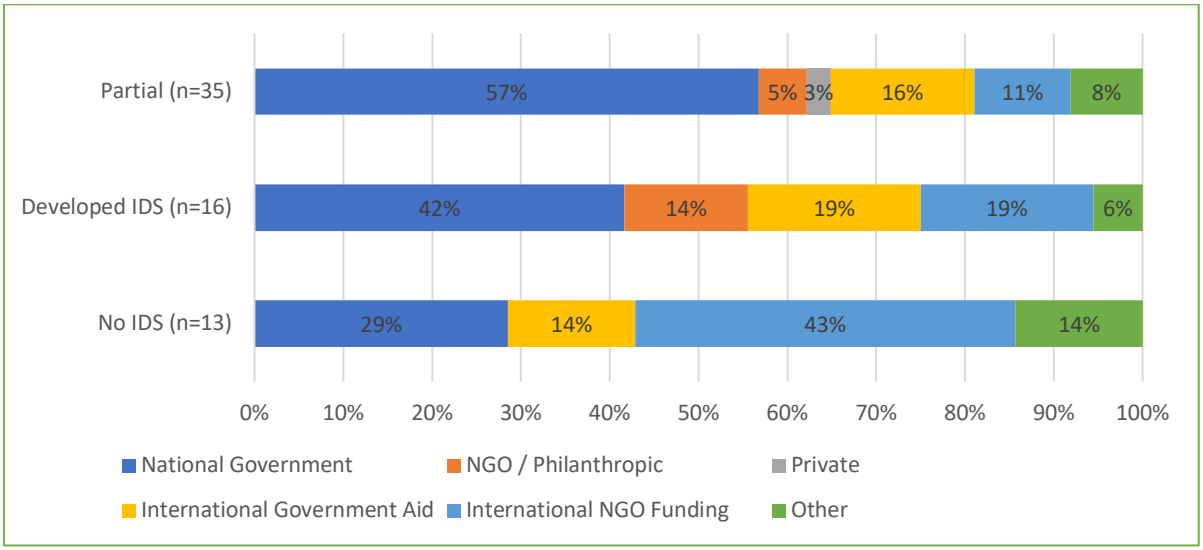



Figure 28: Sources of finance for IDS systems in place on in preparation by IDS system maturity

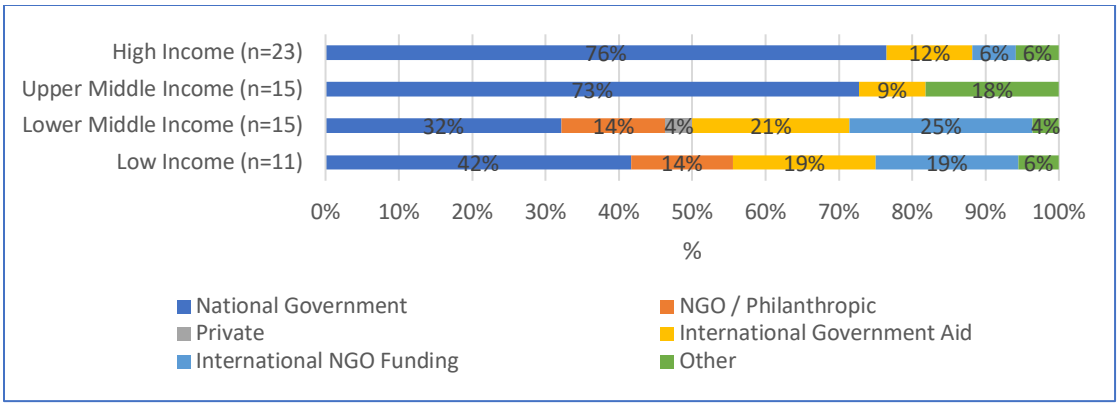



Figure 29. 'How is your IDS system financed' / 'Which sources of funding are you exploring for your IDS' - responses by country income group

Just over half (53%, n=7) of those countries with no IDS system identified finance as one of the barriers that had prevented them from establishing an IDS system. Just under half of those countries with no IDS (46%, n=13) indicated that they were exploring sources of funding with a view to developing their IDS system. Of those countries who indicated that they were exploring potential sources of funding (n=4), they indicated they were pursuing funding from domestic government, international governments and international NGOs.

Unavailability of multi-year financing was identified as a constraint across regions. Eastern Mediterranean, Europe and Africa respondents ranged between 13-15% identifying multi-year financing as a constraint. Southeast Asian respondents reported this as a significant factor in setting up and establishing IDS systems, although it is worth mentioning there were the least number of respondents to the survey from this region, so it is difficult to ascertain whether that is the case across the region.

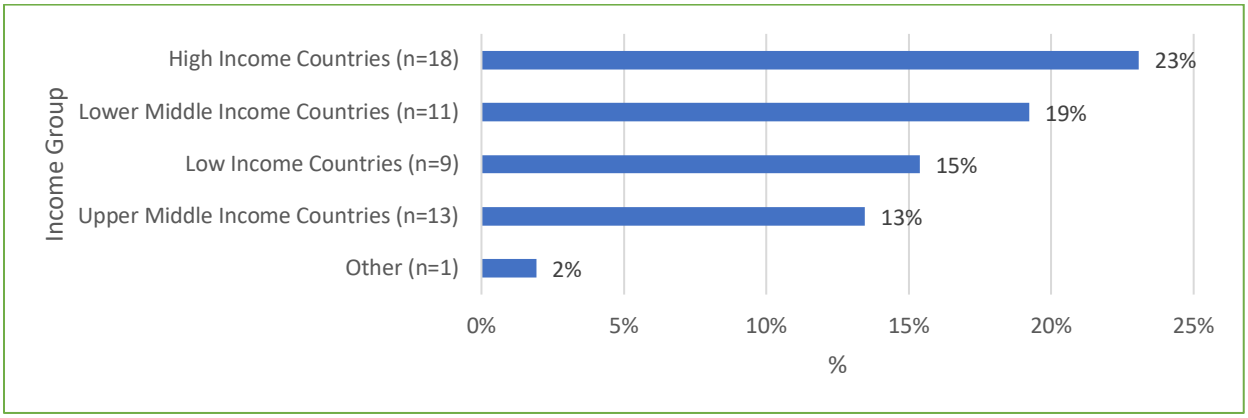



Figure 30. Number of countries with developed or partial IDS reporting 'finance' as a challenge for setting up IDS

Financing of IDS in LICs and some LMICs is insufficient for establishing and sustaining effective IDS systems. The financing of various disease programs (by external donors) also creates vertical data surveillance systems, which are vital for the needs of those disease specific programs, but fail to strengthen the capabilities of the whole system.

The lack of significant and sustained government funding is a barrier to the integration of surveillance systems, including the gathering of data from sources outside the health sector. There is therefore a critical need for much greater investment, as part of government policy. Moreover, the dependence on external donor financing limits national control over system development and design to enable multisectoral analysis based on country needs and nationally driven priorities. Donor funding is required that builds sustainable structures for IDS systems, integrates vertical surveillance and enables greater input and engagement with national governments and stakeholders.

From the data and analysis, it indicates that governments need to invest, as part of policy, to the establishment of a system that enables the integration of disease surveillance systems to enable multisectoral analyses. Similarly, it is important to note that 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 a system of integration with the tools and skills to build capabilities.

## 4.8. Governance of Surveillance System

### 4.8.1 Lead agency for public health surveillance

As stated in section 4.3, the MOH and/or NPHI were reported to be the lead agency responsible for public health surveillance systems in most settings. Approximately a quarter of respondents reported joint leadership, either shared between the MOH and NPHI (12%; 7/65) or between multiple regional, national, and/or subnational agencies (12.3%; 8/65). Almost half of respondents indicated that the NPHI was either the sole (32.3%; 21/65) or joint lead agency for public health surveillance in their country. However, the MOH was more often the lead agency (29/65 sole), particularly in lower income countries and in Africa or the Americas.

### 4.8.2 Legal mandate

Almost all (95.4%; 62/64) respondents indicated there was a legal mandate for organization in their country to report some human health threats. Either the MOH and/or NPHI were most often reported to have the legal mandate to require reporting of notifiable diseases, hazards or other threats to human health. The MOH was reported to have the sole legal mandate to require reporting in the majority of countries (50.7%; 33/64) and had shared authority in others (18.75%; 12/64).

This mandate was most often related to the reporting of communicable human diseases (98%; 61/62) or animal diseases (76%; 47/62) and cut across sectors. The legal mandate applied also to chemical and radiations hazards (63%), causative agents[f] (55%) and environmental hazards (53%). A few respondents (n=12) indicated other conditions that had a legal mandate for reporting, such as congenital conditions, antimicrobial resistance and hospital associated infections. There were no discernable trends by WHO region or country income group.

When analyzed by sector, respondents indicated that the mandate applied to the public sector providers (all), as well as to a large majority for 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%). These proportions were similar for countries that indicated that they had developed or partial IDS systems. Countries with no IDS had similar patterns with the legal mandate applying to the public, private, NGO, animal, water and occupational health sectors. The legal mandate for reporting was less often reported for the pharmaceutical (57%), food industry (71%), agriculture (75%), and chemical and poison sectors (75%).

Adherence to reporting mandates varied; half (30/59) of respondents reported partial adherence and just over a 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). UMIC and HIC respondents stated that adherence to the mandate was good (54%; 20/37) compared to only 14.3% (3/21) for those from LMICs and LICs. Adherence to the mandate was reported to be good for 59% (13/22) in Europe, 36% (5/14) in the Americas and 23% (3/13) in Africa. The level of adherence to the legal mandate was difficult to compare to the other WHO regions due to the small number of respondents in those regions.

### 4.8.3 Privacy protection

Respondents were asked if privacy protection was an established part of the surveillance system. Of the 63 respondents, 49% indicated that privacy protection of the surveillance system was well established. It was partially established or in development for 41% of respondents. Six respondents (9.5%) indicated that it was not established. Privacy protection tended to be reported as being well established more often in countries with developed IDS (56%; 9/16) or partial IDS (51%, 18/35) than for countries without an IDS (33%, 4/12). UMIC and HIC respondents indicated that privacy protection was well established in 59.5% (22/37) compared to 32% (8/25) for those from LICs and LMICs. Privacy protection was judged to be well established by 64% of respondents (14/22) in Europe, 50% (7/14) in the Americas and 38% (6/16) in Africa.

[f] Any virus, bacterium, fungus, parasitic agent or microorganism which is directly or indirectly responsible for causing the applicable disease.

## 4.9. Other Emerging Findings: COVID-19 and Examples of Good Practice

### 4.9.1 Impact of the COVID-19 pandemic

The COVID-19 pandemic was reported to have impacted on disease surveillance systems in countries in different ways. Overall, COVID-19 has totally or partially strengthened most surveillance systems in all regions of the world. COVID-19 surveillance has been made possible by leveraging existing surveillance systems in all regions of the world, primarily components of viral respiratory surveillance systems in the South Asian and North American regions.

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. Some respondents from sub-Saharan Africa stated that having a well-organized surveillance system allowed them to respond immediately to COVID-19 without creating parallel systems. As one respondent indicated, "In our COVID response, we were able to leverage components from existing viral respiratory surveillance systems and data streams to allow for a robust COVID surveillance system."

However, for some countries, the surveillance system was only improved for COVID-19-related data. Furthermore, a few countries in sub-Saharan Africa reported that COVID-19 had destabilized their surveillance systems or failed to strengthen existing surveillance systems (Figure 29). Most of the changes that happened during the pandemic were not always sustained.

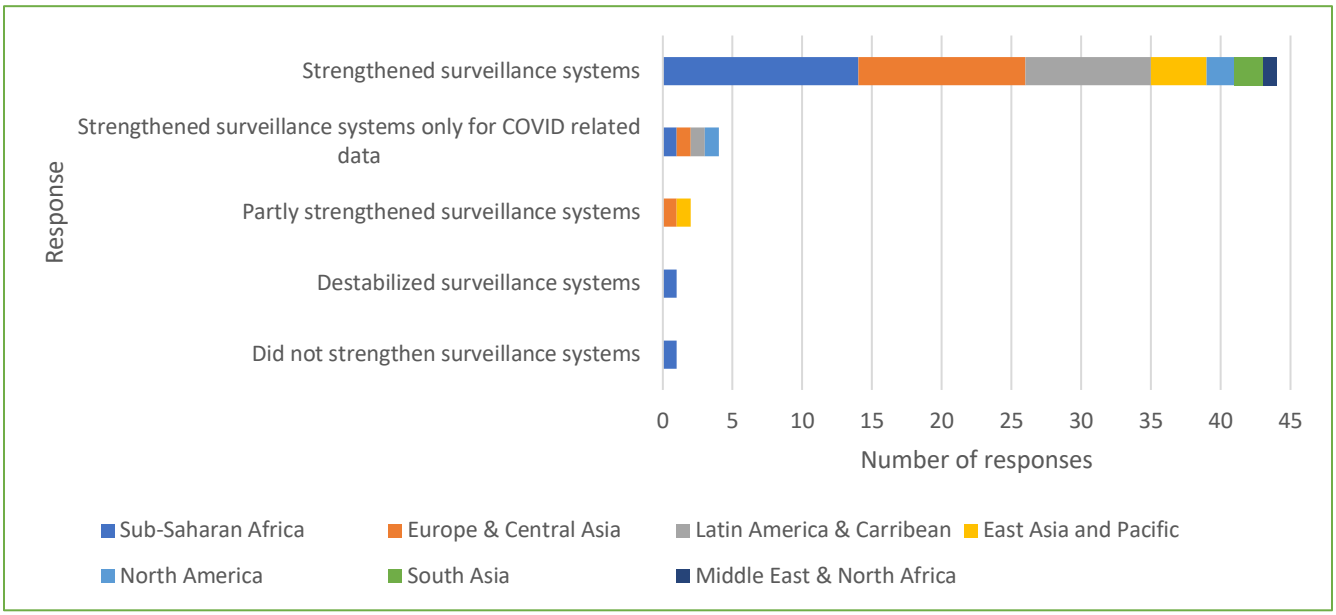



Figure 30. Impact of COVID-19 on surveillance systems

CASE STUDY: SOUTH AFRICA

## Addressing the immediate need during the South African COVID-19 pandemic response: Rapid development and implementation of a web-based case line-list system

The COVID-19 pandemic, as with any crisis or emergency, uncovered a number of areas requiring improvement. One such area was the ability of the South African Notifiable Medical Conditions Surveillance System (NMCSS) to provide laboratory confirmed SARS-CoV-2 case line-lists for public health action. In 2017 the National Department of Health directed the National Institute for Communicable Diseases (NICD), through a memorandum of agreement, to re-engineer the NMCSS, a legislated system for reporting 55 medical conditions.

Prior to the pandemic, agreements had been reached with a number of private healthcare and laboratory service providers to automate reporting of NMCSS conditions directly into the NICD curated database. The NMCSS system was designed to accommodate a maximum number of 20 000 case notifications per annum. With the pandemic these numbers were exceeded in one day.

COVID-19 met the criteria to be considered an NMCSS condition of, "a novel respiratory virus", making reporting of any SARS-CoV-2 positive test results to the NICD a legal requirement for both the public and private sectors. Initially in the outbreak the epidemiology team managing the COVID-19 data for daily reporting purposes resorted to using Microsoft Excel to manage the national COVID-19 line-list.

There was flurry of independent technology companies, government partners and service providers who presented the bid to provide a paid for service to address the challenges that were being experienced with the line-listing. However, prior to the COVID-19 pandemic, internal planning had been conducted at the NICD to develop an in-house outbreak response system (ORS) from lessons learned from the 2017-2018 listeria outbreak. The immediate need meant that ORS for line-listing had to be developed rapidly.

ORS, outwardly known as NMCSS line-list, is a surveillance platform developed to collate and report COVID-19 data from both private and public sector through a web-based user interface with graphical representation of data received by means of Application Programming Interface (API) or manual submissions. The ORS system was developed by the Head of Information Technology at the NICD, who has a science background with the support of the epidemiology team. The system was rapidly put in place with many long hours of intense effort. ORS utilizes algorithms to assign exceptions, deduplications and reinfections on any incoming data. All data

received is stored on relational database using a Structured Query Language (SQL) server. Confirmed cases get automatically assigned for the day and geocoded using ESRI's ArcGIS to the lowest possible level dependent on data quality.

Epidemiologists manually verified the cases classified as duplicates and exceptions by reviewing case-by-case details to confirm whether a case is a true duplicate or an exception and manually de-linked cases that were confirmed as individual cases (unique records) and those that were not exceptions. This process has since fallen away as data quality has improved.

Using different user access levels and permissions, only authorized members of the data management team are permitted to make updates on the line-list. ORS keeps an audit log of any action conducted by a user once logged into the system. The result is a system that can be accessed from anywhere with internet connectivity in a secure manner making both data sharing and basic visualization of data for decision-making convenient. Training for the use of the system was rapidly conducted by the Head of the Emergency Operations Centre (EOC).

The technology stack used in the development of the system included: C#, Microsoft SQL Server, Entity Framework, JavaScript, JQuery, HighCharts JS, Metro UI, Microsoft Windows services, API, MS Excel plugin, and Asp.NET. The information technology team together with epidemiologists are working towards the continuous integration of various data streams into the NMCSS with a focus on agility, self-service portals and building capacity for data for action.

## CASE STUDY: FRANCE
### Responding to COVID-19

Santé publique France (SpF) aims to protect and improve the health of the population. SpF carries out population health monitoring, surveillance, alert and investigation, public health intervention, prevention as well as health promotion programs.

To respond to the pandemic, the agency developed a crosscutting and integrated COVID-19 program very early on in February 2020 to adapt and optimize its response to the challenges posed by the pandemic and to provide better and faster information and evidence to decision-makers and the public. The program was organized into seven functions according to the mandate and main missions of SpF:

1) The development and management of an integrated surveillance system

2) Close monitoring at the regional and the territorial levels
3) prevention and public health communication
4) Risk assessment and expert advice
5) Management & deployment of the French health reserve corps and stocks strategies
6) Participate in the vaccine strategy
7) Disseminate & enhance knowledge

The program activities included the close monitoring of the dynamics of COVID-19, direct population health indicators (e.g., hospital admissions for COVID-19, COVID-19 mortality, etc.) or indicators on indirect consequences of the pandemic (e.g., mental health), behavioral surveillance, epidemic intelligence, rapid risk assessment, field investigation, as well as evaluation of the measures decided and implemented. This was completed by the production of expert advice to decision-makers.

Epidemiological monitoring producing population based useful indicators for epidemic response and policy public health decision: This was done through the management and integration of multi-source data systems. The surveillance systems used for responding to COVID-19 were either specifically created and developed (e.g., comprehensive laboratory surveillance, COVID-19 hospital and intensive care admissions and mortality surveillance, genomic surveillance, and behavioral surveillance) or were existing surveillance tools that were adapted to the new needs (e.g., syndromic surveillance, physician sentinel surveillance, weekly surveillance of excess deaths, and hospital discharges).The agency was able to provide a set of indicators necessary for surveillance at each level (from national to fine territorial scale) by age groups, gender and place of residence. The indicators were produced daily and weekly-they were extensively used for expert advice.

The identification and monitoring of SARS-CoV-2 variants of interest: SARS-COV-2 genomic surveillance was created *de novo* through a consortium with laboratories, research and academic structures (a.k.a. the EMERGEN consortium). This was complemented by the investigations of cases (individual or in clusters) during outbreaks and a fortnightly risk assessment to qualify the potential impact of emerging variants and propose appropriate prevention measures (according to the level of transmissibility, pathogenicity or immune escape capacity of the identified variant). Due to this investment, genomic surveillance of SARS-CoV-2 is today one of the pillars of the fight against the epidemic in France as it is around the world.

The various actions of the COVID-19 program contributed to the vaccine strategy: The acquisition and the distribution of vaccines is one of the main priorities of the agency as well as the participation in the definition of the vaccine strategy as part of its contribution to the work of the French National Authority for Health (Haute Autorité de santé, HAS)

Major efforts were made to monitor the vaccine coverage by territory and target populations, and to estimate vaccine efficacy (by matching several surveillance databases: laboratory, hospital admissions, and vaccine coverage). Transparent and evidence-based information on COVID-19 vaccination was provided to the public through the Vaccination Info Service website and via the media. Specific programs were dedicated to vulnerable and socially deprived populations.
SpF responded actively to social inequities: The agency conducted a knowledge mobilization process in order to identify the gaps and levers of screening, prevention and vaccination strategies in vulnerable groups. It aimed to understand the specific needs and underlying mechanisms to inform appropriate and targeted strategies. The prevention tools produced by SpF were adapted to the public and to the health professionals involved in their health care and prevention.

Anticipation and preparation for the mid- and long-term consequences of the pandemic and the social crisis that resulted: Many health care and public health activities were cancelled during the first pandemic wave, in particular during the first confinement with loss of opportunity for many patients. The limitation of social interactions and movement has had a negative impact on the mental health of French residents, on their physical health or on risky behaviors, addictions, as well as environmental and occupational health risks. Long COVID added to the burden of COVID-19 and other indirect health and social impacts. SpF developed and contributed to several projects to assess and characterize the full burden of the epidemic. This involved the implementation of specific studies and surveys to assess the medium and long-term consequences of all direct and indirect health effects of the pandemic with a specific attention to social inequities.

Further development of integrated surveillance for a sustainable organization. Based on its experience in responding to the pandemic, the agency has initiated reflections to capitalize on the various developments implemented in the context of the crisis to apply it to other public health threats. For example, this is being done and implemented for acute seasonal viral respiratory infections.

CASE STUDY: St. Lucia

Digital platform for entry into Saint Lucia to ensure that arrivals met criteria for entry based on quarantine and isolation protocols.

All travellers to Saint Lucia were required to complete an online COVID-19 pre-arrival application process at least five (5) days prior to arrival into St. Lucia. In all cases, the results of a negative

DNA PCR test were uploaded to the online platform prior to travel and approval for travel was granted based on satisfactory submission of and verification of required documents and room availability at the quarantine facilities.

This was implemented at the peak of the outbreak where quarantine was mandatory for all arrivals into St. Lucia and was considered a strategy to limit arrivals to ensure that the capacity of quarantine facilities as well as the human resources was not overwhelmed. This enabled the country to prepare and respond to surges in COVID-19 cases.

Establishment of Port Health surveillance medical units at the ports of entry:
Port Health serves as the first line of defence to protect the citizens of St. Lucia and visitors against the entry of communicable diseases associated with cross-border movement of people, conveyances, baggage, cargo and imported consignments. The Port Health Team assesses the risk of importation of quarantine diseases in accordance with the Saint Lucia Quarantine Act, Public Health Act and the International Health Regulations.

COVID-19 posed an increased demand for port health services and the need arose for additional staffing to address the deficiency in surveillance services at all ports of entry and allow for a complete coverage of surveillance activities aimed at detecting and mitigating threats to public health emanating from overseas. Duties performed included: surveillance of all passengers at Port of Entry, temperature checks for all arriving passengers and assessments of those with elevated temperatures, assessment and interviews of all incoming passengers, passenger evaluation, isolation or referral for further medical care or discharge to home/ state quarantine facility/hotel, COVID-19 testing of arriving passengers as per national protocols, exit screening of all departing passengers, and Port Health sanitation

Establishment of an outbreak system (Go.Data) which allowed for tracking of COVID-19 and is currently being used for monkeypox. Plans are also in motion for the integration of Go.Data and our Health Management Information Unit.

The WHO Go.Data tool is an outbreak investigation tool for field data collection during public health emergencies. Ministry of Health staff received training from the Pan American Health Organization prior to implementation. It includes functionality for case investigation, contact tracing and follow-up, and provides visualization of the evolution of outbreaks. This tool was managed at the central level by Ministry of Health staff as well as in the field by contact tracers who used tablets to enter data on confirmed COVID-19 cases and their contacts. It served as a useful tool for data collection and analysis. It is currently being used for the monkeypox outbreak.

Training and use of NGOs in contact tracing:
Prior to the confirmation of the first case of COVID-19 on the island, the Ministry of Health, Wellness and Elderly Affairs engaged NGOs to obtain support for contact tracing activities. As the pandemic progressed, the current staffing at the Ministry of Health proved to be insufficient for efficient contact tracing activities. These volunteers were then engaged to support our services and performed admirably. They served at the frontline while the ministerial staff offered supervision and guidance. The initial team consisted of eleven (11) volunteers, but with the increase in the COVID-19 incidence in the country, the volunteers increased to 30. The NGOs played a critical role in the continuance of the contact tracing process during the pandemic.

### 4.9.2 Examples of good practice reported

Various examples of good practice were provided by respondents. These were thematically categorized in terms of greater cross-sector collaboration, capacity building and enhanced capabilities, data sharing and analytics, the adoption of technology, and the creation of structures, tools and training:

- Greater cross-sector collaboration

Examples were given of strengthened working relationships at the local government level between district health teams and community village health teams (VHTs), greater participation in surveillance within the health sector and with collaborating partners, formation of a One Health platform at the national and district levels, as well as creation of multisectoral guidelines which were integrated with the surveillance system. Another respondent gave the example of how information analysis of communicable and non-communicable events has been integrated, and another mentioned the integration of surveillance processes in accordance with the One Health strategy. Cross-sector collaboration also included greater information sharing with neighboring countries through a cross border mechanism.

- Capacity-building and enhanced capabilities

Another best practice was capacity building using webinars (COVID-19 Health Rounds) conducted as a method of information sharing and training of relevant persons on various public health concerns related to COVID-19; including disaster preparedness, non-communicable diseases and infectious diseases. A further example was the deployment of highly qualified personnel to provincial public health laboratories in order to facilitate genomic surveillance data generation and sharing, as well as to national laboratories to provide coordination, training, and centralized analysis. One pandemic benefit cited was the acquisition of equipment to carry out genomic surveillance at the national and subnational levels.

One respondent indicated that surveillance capabilities were also enhanced through regular evaluation of the surveillance systems, improvement of the electronic disease surveillance system (EIDSS), establishment of a monitoring system with dashboards for 24-hour monitoring, and implementation of molecular diagnostics and regional laboratories in the country that perform genomic surveillance for COVID-19 and likely other pathogens in the future.

- Data sharing and analytics

Data platforms were developed to enable the centralization of COVID-19 morbidity and mortality data to provide timely and secure access for public health action. This allowed the creation of a dashboard that provided daily updates on key epidemiological metrics and indicators. Other examples of integration of data included genomic data, integration of communicable and non-communicable diseases in syndromic surveillance, integration with the notifiable disease system, and integration of epidemiology and vaccination data. The creation of operational guidelines that can capture all notifiable diseases, as well as other hazards to the human health, was also cited. Electronic data sharing between national and subnational level was another example.

- Adoption of technology

Technology was a common theme for good practice. This included the development of IT tools such as an algorithm for automated representative sample selection for whole genome sequencing (WGS) for COVID-19 cases, and another tool for automated decisions on isolation and/or quarantine which informed an infected or exposed individual via phone and SMS. The use of online platforms facilitated data reporting (e.g., web reports as part of the immediate identification of cases and mandatory notification) and sharing. Data analytics could also be improved and automated using R[8},and better data visualization (e.g., graphic reports) was also useful.

An integrated surveillance system involving community agents was also made possible using mobile devices. Another example given was the establishment of an outbreak system (Go.Data) [15] which allowed for tracking of COVID-19 that is currently being used for monkeypox with plans for further integration of Go.Data with their HMIS. A wastewater surveillance system that was built during COVID-19 could also now be applied to other pathogen surveillance (such as for monkeypox, cholera, influenza, norovirus and polio).

- Creation of structures, tools & training

Several respondents described how new tools were developed, such as an in-house outbreak response system with dashboards, sentinel-based surveillance module, vector surveillance module, as well as a module for exporting reports on rubella and measles to the WHO.

Other service developments included the establishment of Port Health surveillance medical units at the ports of entry, formation of a modelling consortium with its own dashboards, creation of a home medical monitoring team to monitor clinical evolution of confirmed COVID-19 cases as well as their contacts, mortality surveillance through verbal autopsy and morticians testing for COVID-19, as well as an ad hoc committee created at the national level that also incorporated the universities to make forecasts and projections. Hospital surveillance in the private and public sectors were rapidly upscaled.

Training was also another key element and included the training of healthcare and NGO staff in contact tracing and more training targeted community volunteers. In one country, a new degree program on data analytics at the national university was started. In another country, a new directorate of data analytics within the MOH was set up.

# 5. DISCUSSION

## 5.1. Key Findings

Our survey exploring IDS in IANPHI member countries found variation both in the way in which IDS is understood, as well as operationalized.

Although there was agreement to some extent as to the definition of IDS, the survey revealed that the understanding and interpretation of "integrated disease surveillance" differs from country to country. It was apparent that the concept of IDS is more than just the technical/technological viewpoint of integration as the summation of surveillance databases and data streams. Respondents clearly interpreted "integration" to mean much more and adopted what can be described as a "whole systems" perspective. Disease surveillance was seen as a complex system, involving multiple stakeholders and sectors, and occurring at all levels of the health system. From the system's perspective, the *purpose of integration* of disease surveillance, how the system enables better decisions and response to health threats, was a key consideration, for which the system needed to be agile, responsive and resilient.

The survey corroborates the proposition by Morgan et al. (2021) of the various key components needed for effective disease surveillance. This included the need for leadership, ownership and governance of the system, supporting legal mandates and regulations together with adherence to those mandates and enforcement of regulations. Financing that was sustainable, sufficient, and longer term, is necessary. Resourcing of disease surveillance is also evidently a crucial component for effective and functioning systems. These include the need for laboratory and IT infrastructure, but also skilled workforce (e.g., IT as well as data and analytics) necessary to operate the systems.

The various case studies and exemplars of good practice provided by respondents also point to the enabling role of technology including greater automation, electronic reporting systems, algorithms, and data platforms. These findings indicate increasing IT infrastructure and surveillance workforce capacity would help facilitate the development of integrated systems, especially in resource-constrained settings. Of note, the skills gaps are not evenly distributed across the different sectors and surveillance systems. The survey findings suggest that while LICs and LMICs may invest in workforce similarly to UMICs and HICs to maintain indicator-based surveillance systems, they may not have the resources to invest similar capacity to maintain event-based surveillance systems.

The survey also found that the self-reported level of IDS maturity does not necessarily mirror the level of country income. LICs were more likely to report having developed IDS systems; these tended to be African countries with greater familiarity of the WHO's IDSR strategy [4]. This is perhaps unsurprising in view of the fact this program has been promoted by WHO in the Africa region and in existence for over two decades. Additionally, many of those LIC countries which state that they have a fully developed IDS face a significant burden of communicable disease, and a growing burden of non-communicable disease [11]. While respondents were given a standard definition of IDS, ultimately respondents' self-classification of the maturity of their IDS system is somewhat subjective. Respondents from countries that have adopted the IDSR strategy may be more comfortable identifying their IDS as fully developed. However, this self-classification presented some conflicting results. Low-income countries that reported having developed IDS systems were Guinea, Rwanda, Mozambique, Togo and Zambia. Three of these countries (Mozambique, Togo, Zambia) also reported that there was no "integration of surveillance data from different sources into the response and management of outbreaks, diseases and other risks to human health". All respondents who self-classified their IDS as fully developed also reported specific sectors and surveillance mechanisms that were not integrated into their public health surveillance system. Through efforts to conceptualize and understand the implementation of IDS, we should take care not to see integration as an end, but a means to better inform public health action and to protect the health of the population more clearly.

Whilst most surveillance systems involved the MOH, it was clear that in many countries where there were National Public Health Institutes, NPHIs had a major part to play in disease surveillance, either jointly with the MOH or as sole lead agency. This was especially true for countries in higher income groups, and those with more developed IDS systems. NPHIs were also indicated to lead most core functions for the IDS system. These trends may indicate that NPHIs are key to the development and functioning of the IDS systems. It may also reflect the fact that the creation of a NPHI in a country is part of an enhanced strategy towards better disease control, prevention and response and therefore a more mature system.

More developed IDS systems were also more likely to have better governance and data protections for citizens, as reflected by the level of data privacy protections in place. This ethical accountability dimension is worth considering – in the pursuit of more integrated systems, it is important that citizen rights are not compromised in the process.

## 5.2. Challenges Identified

Various challenges to integration were identified by respondents. One major issue, as noted above, was financing; there was a lack of sustainable and sufficient national financing especially for LICs and some LMICs. External donor funding was seen to not be sustainable and had the added issue of

favoring vertical surveillance systems that contradicted integration efforts across systems. In countries where IDS was not developed there were few countries with national funding and the majority were dependent on international aid. Other issues, as mentioned above, included the lack of definition of IDS that was universally agreed and understood, limitations in governance and adherence to legal mandates, infrastructural barriers and resourcing gaps. Across the surveillance cycle, there were also reported weaknesses especially for the 'evaluation and feedback' aspect.

The survey also revealed integration issues at the interfaces, be it between different organizations, local versus national levels, or sectors. These integration issues were much more common for non-human health sectors such as environmental health and animal health sectors, as well as non-infectious disease sectors such as the non-communicable diseases, surveys and research, and occupational health. There were deficiencies too in integrating data from NGOs and the private, academic and pharmaceutical sectors, which was more acute in LICs and LMICs.

Data protection was recognized to be an issue for a substantial proportion of respondents (51% reported privacy protection as partially or not established). Morgan et al. [1] mentioned data transparency as one of the five core principles of IDS. Since data transparency and the social acceptability of data collection and use is dependent upon privacy protection, this is an issue that will need attention to enhance public trust in public health surveillance and the public institutions that have this responsibility.

### 5.3. Strengths and Limitations of the Survey

There are several strengths of this survey. No similar survey has been undertaken recently, and it provides useful insight into the state of surveillance systems and IDS at a time when the international community is looking to strengthen surveillance as part of efforts to support global health security. This survey took advantage of IANPHI's unique ability to pull together the collective experience and insights of its constituent member NPHIs across the globe.

All of the respondents were senior-level representatives and were therefore well-placed within their respective public health systems to provide a country-level overview of surveillance and IDS. The survey also achieved a good response rate (~60% of NPHIs) that is not commonly attained in multi-country surveys. There was good representation from Africa, Europe and the Americas, with a good distribution by country income group and reported IDS maturity. This enabled a robust assessment of IDS maturity and some of its determinants to be carried out. The findings could also be triangulated with outputs from the other IDS workstreams (systematic scoping review [2] and deep dives [3]) being undertaken by IANPHI that by and large corroborated the survey findings.

There were also limitations acknowledged. Data was self-reported, and the survey questionnaire was self-administered by respondents. There is the possibility that some questions may not have been consistently interpreted the same by respondents. Respondents may not have had the survey in their language of choice, despite attempts to provide questionnaires in several different languages. Some concepts (e.g., "IDS status") were self-defined by respondents and it is not possible from the survey to fully ascertain their interpretation of individual questions.

The survey was only administered to NPHIs and their perception of the role of the NPHI may be somewhat biased by their proximity to NPHI activities. The survey also only targeted NPHIs who were members of IANPHI and was administered to only one focal person per NPHI, which introduces the possibility of sampling bias; the experience and views of countries without an NPHI may therefore be under-represented. Respondents may also have had limited knowledge on specific survey topics, other organizations, or sectors. Moreover, the respondents were national representatives who may be less familiar with local, district or provincial contexts. There is also the issue of representativeness as some WHO regions were under-represented as well (e.g., Western Pacific, Eastern Mediterranean, and Southeast Asia) and there was possible mismatched comparison between some respondents (who represented a single country) and the sole CARPHA respondent (who represented multiple island nations of CARICOM); findings may therefore not be extrapolatable to these regions. Finally, as with all cross-sectional surveys, while trends and associations may be seen or suggested, it is not possible to infer causal relationships.

## 5.4. Conclusions

Based on the emergent findings from the survey, several concrete and implementable actions and conclusions can be drawn. First, there is value in defining more clearly the purpose of IDS, its functions and mandate. Ideally, disease surveillance systems should be developed based on the intended outcomes to be achieved through better surveillance. Presumably, the integration of disease surveillance should aim at improving system-wide policy decisions and response; for early warning, preparedness, response and recovery from epidemics and pandemics.

There is also a need for all the key building blocks of surveillance systems to be in place, from governance and legal enablers through to infrastructure, processes and resourcing. Governments need to sufficiently resource surveillance systems and invest in a sustainable way, as part of policy, to ensure the establishment of a robust integrated system able to perform multisectoral surveillance and analysis, to inform public health policy and response to public health threats. There is also a need to address the other major gaps: namely workforce (both capacity and skills development), as well as laboratory and IT infrastructure. Weaknesses in monitoring and evaluation, and feedback, also need to be tackled as they are essential for quality improvements and assurance, and the creation of learning systems.

There remain significant knowledge gaps across a plethora of issues related to disease surveillance, ranging from optimal configuration, processes to efficacy of its various components. Consequently, there is a need to continue to build the evidence base, based on applied research, in the field of integrated surveillance. This will necessitate investment in further research across a range of topics; such as the role of NPHIs in IDS, multisectoral evaluations of IDS, barriers and opportunities to developing IDS systems, the value of integration of certain sectors (e.g., One Health and non-health sectors), strengthening indicator-based surveillance (IBS), event-based surveillance (EBS),, and electronic integrated disease surveillance and response (eIDSR), and the understanding of the influence and impact of different country contexts and challenges at the implementation level.

Finally, as many of the issues stem from challenges at the interface between sectors, it follows that multisectoral surveillance networks and 'communities of practice' are needed to bridge these interface divides. There is clearly value and a lead role for NPHIs as system enablers. The development of a NPHI in each country is a complementary investment for supporting and enabling stronger disease surveillance systems.

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# APPENDIX 1: SURVEY QUESTIONNAIRE (ATTACHED)

# APPENDIX 2: LEVEL OF AGREEMENT AND PROPOSED ADDITIONS TO THE IDS DEFINITION AND IDS PRINCIPLES (BY IDS TYPE)

| No. | How well does the definition describe IDS | IDS maturity | What can be added to the IDS definition | Other IDS principles to be included |
|---|---|---|---|---|
| 1 | Not at all well | Partial IDS | Adding ''integration of different data sources and surveillance systems | - Independency / Integrity from government<br>- General Data Protection Regulation (GDPR) |
| 2 | Not at all well | Fully Developed | IDS implies integration across all topic areas in the public health field, which many stakeholders in our country feel is not needed or realistic. IDS should be prioritized by topic area to inform appropriate public health action. As well, the 'use of a single infrastructure' may also not be needed (and not conducive) to the use of varied data sources (e.g., IDS using a One Health approach) where the data may be coming from the Ministry of the Environment and the Ministry of Agriculture, for example. | Adding in concepts of 'simplicity', 'Acceptability', 'flexibility' |
| 3 | Not at all well | Partial IDS | The notion of a single infrastructure does not make sense. It is essential to have all the information from the different surveillance systems. But the notion of having to pass through a single data model doesn't make sense for all data and monitoring. unless ''infrastructure'' means something other than information system | It should probably be made clear that this should cover all the dimensions necessary for understanding the epidemic: the cases, the contacts, their diagnosis, their possible hospital course, their vaccination status, but also their health in general (comorbidities), vulnerabilities.... |
| 4 | Not at all well | Partial IDS | -Missing data protection and legal issues.<br>-Data sources are very different, and not possible to integrate in one single system. | Data protection and legal foundation is missing, GDPR. |

| | | | | |
|---|---|---|---|---|
| 5 | Somewhat | Fully Developed | Analyze, inform policies to respond quickly to a public health event | Data Quality |
| 6 | Somewhat | Partial IDS | Support decision making | One-Health Joint |
| 7 | Somewhat | Fully Developed | According to the definition of surveillance in our Integrated Disease Surveillance and Response (VIDR) manual, I would add the continuous and systematic collection of data and the timely dissemination of given to decision-makers for action | The principles that we can incorporate are the continuous training of technicians, monitoring and evaluation, as well as permanent supervision. |
| 8 | Somewhat | Partial IDS | IDS should allow to provide quick and informative outputs tailored to different groups of stakeholders | Resilience/flexibility |
| 9 | Somewhat | Partial IDS | Territorial-based information that allows the integration of information on the local structure of the health system and the social, economic and environmental determinants | Yes, the population-based information should include social and economic denominators that allow for the establishment of indicators and correlations on inequities related to the diseases that are the object of integrated surveillance |
| 10 | Somewhat | Partial IDS | It is not about gathering information alone, but also should include analysis and probably use of the data. | Multisectoral = One Health |
| 11 | Somewhat | Fully Developed | Most important is that integration of data, and that collaboration between data owners are well functioning. A single infrastructure is not always the only way to organize this. | Integrity and privacy for the individual |
| 12 | Somewhat | No IDS | Needs to include the purpose of the integrated surveillance e.g., to influence public health policy or behavior, not only ''disease '' but '' indicators affecting health '' ''gather'' is process orientated , could we use ''curate evidence '' for transparent and collective decision making | Human resource capacity important component to be included |
| 13 | Somewhat | Fully Developed | Other approaches to surveillance, such as population-based, sentinel, syndromic, or laboratory-based surveillance, are not captured in this definition | It is comprehensive |

| | | | | |
|---|---|---|---|---|
| 14 | Somewhat | Partial IDS | The description is fairly adequate but somewhat unrealistic even in high-income countries. | The idea that you can specify 1-4 USD per capita for IDS is questionable. I would rather link it to a certain fraction of healthcare spending |
| 15 | Somewhat | Partial IDS | The surveillance information is used for public health action | Governance and leadership at all levels is a critical component for effective surveillance |
| 16 | Somewhat | Partial IDS | We may not be able to link all key surveillance systems on a single infrastructure. This means we should maintain a number of standalone systems and platforms that will still provide valuable insights for public health action even though they are not part of the IDS system. | Information governance and data security - the acceptance of these systems by the public will depend on the degree of assurance that they have about the security and confidentiality of their data. |
| 17 | Somewhat | Partial IDS | Not necessarily using a single infrastructure taking operation aspects into account<br><br>Could be using single / multiple infrastructures | N/A |
| 18 | Somewhat | No IDS | Lines of responsibility for multi sector agencies. Use of one health concept identifying key stakeholders. Also outline responsibilities for data flow to avoid silos. Outline how the information will be utilized clearly by various sectors. | N/A |
| 19 | Somewhat | No IDS | Integration is not always possible within the same information system and does not seem absolutely necessary to us every time. Do not see this as a wall-to-wall solution for all diseases or themes. | N/A |
| 20 | Somewhat | Partial IDS | The focus on ''single'' infrastructure is rather difficult. It is not completely good to have everything in a ''single'' system because this would be far too complex. It's the disconnectedness of players that is important. Also, the definitions miss the different levels local/regional/state/national level. | N/A |

| | | | | |
|---|---|---|---|---|
| 21 | Somewhat | Fully Developed | The system may not be using a single infrastructure, but what is important is that the data is interoperable, accessible for decision making. The other parts of the definition are correct | N/A |
| 22 | Somewhat | No IDS | This should also include gathering of information from different sectors, sources and platform for an early warning system and response | N/A |
| 23 | Somewhat | Partial IDS | This single infrastructure should have possibility for analyzing and modeling of data. | N/A |
| 24 | Somewhat | Partial IDS | N/A | yes |
| 25 | Somewhat | Partial IDS | N/A | Capacity enhancement |
| 26 | Somewhat | Fully Developed | N/A | IDS must be adequately supported that's captured in the financing |
| 27 | Somewhat | Partial IDS | N/A | Supported regulation for health staff<br><br>Capacity enhancement |
| 28 | Somewhat | Partial IDS | N/A | N/A |
| 29 | Somewhat | Fully Developed | N/A | N/A |
| 30 | Somewhat | No IDS | N/A | N/A |
| 31 | Somewhat | Partial IDS | N/A | N/A |
| 32 | Somewhat | No IDS | N/A | N/A |
| 33 | Somewhat | Partial IDS | N/A | N/A |
| 34 | Somewhat | Partial IDS | N/A | N/A |
| 35 | Somewhat | Fully Developed | N/A | N/A |
| 36 | Somewhat | Partial IDS | N/A | N/A |
| 37 | Very well | No IDS | -'Across different sectors, agencies and organizations.''<br>-'' For the purpose of disease control and prevention as well as maintaining the public well-being'' | -Principle: Goal oriented<br>-Benefit: Specific methods are governed by the goal<br>-Requirement: IDS's goal should be established by a consensus among stakeholders and leading agency. |

| | | | | |
|---|---|---|---|---|
| 38 | Very well | Partial IDS | And helps to provide up to date and useful date to healthcare sector specialists to further utilize it. | Strong management meaning that it will be used for its purpose and improve the capacity of public health sector to control, prevent from and respond to. |
| 39 | Very well | No IDS | In the context of my country, there is an extreme failure in terms of governance and coordination / multisectoral and inter-institutional collaboration; thus, the establishment of a ''single infrastructure'' is an objective which can only be achieved in the medium or even long term unless there is a radical change in the legislation with a great political will in the direction of IDS | Adequate legislative framework |
| 40 | Very well | Partial IDS | I would add the ultimate goal of that combination, that is: "A combination of active and passive systems that use a single infrastructure to gather information on multiple diseases or behaviors of interest to optimize responses in Public Health" | Equity and Guarantee of Access |
| 41 | Very well | Partial IDS | The definition is comprehensive | Continuous strengthening and improvement |
| 42 | Very well | Fully Developed | Risk assessment and decision making for timely response | Governance, Training and maintenance of human talent in health" |
| 43 | Very well | Partial IDS | Data must be analyzed and used as evidence to formulate health policies in order to identify interventions that can improve the quality of health of populations | N/A |
| 44 | Very well | Partial IDS | Integration of people, data and systems | N/A |
| 45 | Very well | Fully Developed | N/A | Criteria related to the development of human resources |
| 46 | Very well | Partial IDS | N/A | Political commitment that really prioritizes surveillance |
| 47 | Very well | Fully Developed | N/A | Data analytics for prompt and evidence-based response and decisions making. |
| 48 | Very well | Partial IDS | N/A | Cross disciplinary collaboration and analysis |

| | | | | |
|---|---|---|---|---|
| 49 | Very well | Fully Developed | N/A | Systems interoperability |
| 50 | Very well | Partial IDS | N/A | Data standards |
| 51 | Very well | Partial IDS | N/A | N/A |
| 52 | Very well | Fully Developed | N/A | N/A |
| 53 | Very well | No IDS | N/A | N/A |
| 54 | Very well | No IDS | N/A | N/A |
| 55 | Very well | No IDS | N/A | N/A |
| 56 | Very well | Partial IDS | N/A | N/A |
| 57 | Very well | Fully Developed | N/A | N/A |
| 58 | Very well | No IDS | N/A | N/A |
| 59 | Very well | Partial IDS | N/A | N/A |
| 60 | Very well | Partial IDS | N/A | N/A |
| 61 | Very well | No IDS | N/A | N/A |
| 62 | No response | Partial IDS | N/A | N/A |
| 63 | No response | Partial IDS | N/A | N/A |
| 64 | No response | Partial IDS | N/A | N/A |
| 65 | No response | Fully Developed | N/A | N/A |

# APPENDIX 3: ADDITIONAL PRINCIPLES TO THE MORGAN ET AL. PAPER

The Europe and Central Asia and South Asia regions did not propose any additional principles in Morgan et al.'s 2021 paper[7] published in The Lancet. For other regions, respondents suggested several principles to be incorporated into the principles set out in the article. These principles have been summarized in the table:

| | |
|---|---|
| Principles set out in the article | Population |
| | Laboratory confirmation |
| | Digital data |
| | Data transparency |
| | Adequate funding |
| Suggested principles to be added by respondents | An adequate legislative and regulatory framework |
| | Data integrity and confidentiality. |
| | Resilience and capacity building |
| | Governance and political engagement |
| | Flexibility, simplicity and acceptability |
| | Control and evaluation |
| | Interoperability and multisectorality |
| | Interdisciplinary collaboration and analysis |
| | Equity and guaranteed access |
| | Permanent monitoring and data management |
| | Capacity building and development of human talents in health |

[7] 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.