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Strategic Investment in Surveillance for Pandemic Preparedness: Rapid Review and Roundtable Discussion

VICTORIA Y. FAN, ELENI SMITHAM, LYDIA REGAN, PRATIBHA GAUTAM, OLE NORHEIM, JAVIER GUZMAN, AND AMANDA GLASSMAN

Abstract

Efforts in pandemic preparedness can be strategically guided by understanding the potential costs and benefits of interventions for surveillance, which we call the "best buys" of surveillance. This policy paper examines the state of knowledge on investing in the "best buys" of surveillance for pandemic preparedness and specifically for respiratory infections. We focus on respiratory infections because of their potential for global spread as well as the World Health Organization (WHO)'s Preparedness and Resilience for Emerging Threats (PRET) initiative initial focus on pandemics of respiratory pathogens. We conduct a rapid literature review to assess the state of knowledge on the costs and benefits of investing in four selected types of surveillance for respiratory infections (laboratory networks, sentinel surveillance, notifiable disease surveillance, and health facility event-based surveillance) considered as "core" surveillance by the WHO's Mosaic Framework (which listed a total of ten types of surveillance). We discussed early results with an expert panel during a CGD roundtable discussion. Overall, cost data on surveillance programs remains very limited. Of the four types of surveillance examined, there are more studies reporting costs for sentinel surveillance than other types of surveillance. Studies did not standardize measures of effectiveness of surveillance, making comparisons across surveillance types challenging. The effectiveness of investments is not easily assessed before a pandemic, highlighting the need for rigorous, independent evaluation of the value and impact of preparedness investments (including for surveillance) on pandemic response. In order to inform future pandemic preparedness and response efforts, more knowledge is needed on the costs and effectiveness of surveillance of respiratory infections and related diseases.

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The Need for Learning What Works for Pandemic Preparedness and Disease Surveillance

Countries are facing urgent policy issues including inflation, debt crises, food insecurity, looming recessions, and severe budgetary constraints, on top of concerns to address pandemic preparedness and response. The severe macroeconomic climate following the worst part of the COVID-19 pandemic means fewer resources are available to countries and donors (Glassman et al., 2023). Further, there is a need for governments and society to learn from the COVID-19 pandemic and past pandemic experiences in order to be ready for the next pandemic, while recognizing that the next pandemic may look and act differently from a COVID- or flu-like pathogen (Glassman et al., 2022). Countries and donors must make hard and smart decisions about how to better invest in pandemic preparedness systems that can nimbly adapt to a range of pandemic threats.

The G20 High Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response (HLIP) report made the case for investing in four key areas including greater globally networked surveillance systems (HLIP, 2021), and leading to the creation of a financial intermediary fund, hosted by the World Bank. In September 2022, the World Bank officially launched this new Pandemic Fund. As of February 2023, there were pledges of US$1.6 billion from 25 donors (World Bank, 2023a). Its first call for proposals was released in early March of 2023 and was due in May 2023, with a focus on surveillance, human resources, and laboratory systems (World Bank, 2023b). In early expressions of interest, countries have asked for more than $5.5 billion in support on these areas, against a hard budget cap of $300 million. Demands greatly exceed the available budget, hence the need for smart investments.

Questions about what to invest in and *how much* to invest in for pandemic preparedness and response are joint questions. How much is needed should depend on the types of investments. While recent cost estimates for pandemic preparedness and response varied greatly, there is broad agreement for the need for more funding on pandemic preparedness and response. Table 1 provides the range of different estimates which each use different methodologies. But we argue that one key element of the variation in global costs can be attributed to the lack of underlying country-level information on costs used for programmatic planning and budgeting—which are in turn used to inform global cost estimates.

To determine what to invest in, economic evaluation as a tool can help to assess both the costs and effectiveness of a given intervention and can be used to help guide strategic decision-making, not only in questions of whether to invest in a general area (such as surveillance) but perhaps more importantly which type of intervention in a given class of intervention (i.e. which types of surveillance within the class of surveillance interventions) should be prioritized. The need to identify

TABLE 1. Cost estimates for pandemic preparedness and response using different definitions and methodologies

Source	Estimate
G20 High-Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response (G20 HLIP, 2021)	$10 billion annually, plus $5 billion to strengthen the WHO and other existing institutions
World Bank and WHO for the G20 Joint Finance and Health Task Force (WHO & World Bank, 2022)	$10.5 billion annually in international financing for minimum priority PPR financing gap
McKinsey & Company (Craven et al., 2021)	$20–$50 billion annually, after initial global investment of $85–$130 billion over two years
Becker Friedman Institute, University of Chicago (Glennerster et al., 2022)	$5 billion annually, after $60 billion up front investment for vaccine production capacity and supply chain inputs
Center for Global Health Science & Security, Georgetown University (Eaneff et al., 2022)	$124 billion over 5 years towards "demonstrated capacity" on JEE indicators
World Health Organization (Clarke et al., 2022)	Ranged from $1.6 billion per year for 139 low- and middle-income countries to improve capacities to $43 billion per year including for R&D

Source: Compiled by authors

and prioritize investments in the most cost-effective interventions, or what we call the "best buys" of pandemic surveillance, is even more pressing given limited funding globally for this area.

This research agenda that calls for best buys in surveillance is part of a broader portfolio of work on value for money, priority setting, and economic evaluation at the Center for Global Development (CGD) in strategically informing policy decisions. CGD's prior working groups on Value for Money in Global Health and Priority Setting in Global Health emphasized the need to select highly cost-effective interventions in addressing health conditions of major public health importance (Glassman et al., 2013; Glassman & Chalkidou, 2012). CGD's work on Millions Saved emphasized proven examples of successes in global health (CGD, 2016), while its work on evaluation has emphasized the need to learn from innovative programs where evidence is yet to be generated (CGD, 2015). The need to invest strategically in programs that both recognize known-knowns (or "what works") and the unknown-knowns (or learning from innovation and implementation) are two sides of the same coin in the translation of knowledge and evidence to policy and programs.

Further, the Disease Control Priorities (DCP) agenda that began with the influential World Bank's World Development Report (1993), led by Lawrence Summers and Dean Jamison helped to define a set of highly cost-effective interventions (World Bank, 1993). In subsequent editions of the DCP, the evidence base on the cost-effectiveness and value for money of health interventions across a variety of disease conditions had expanded substantially (DCP3, 2023).

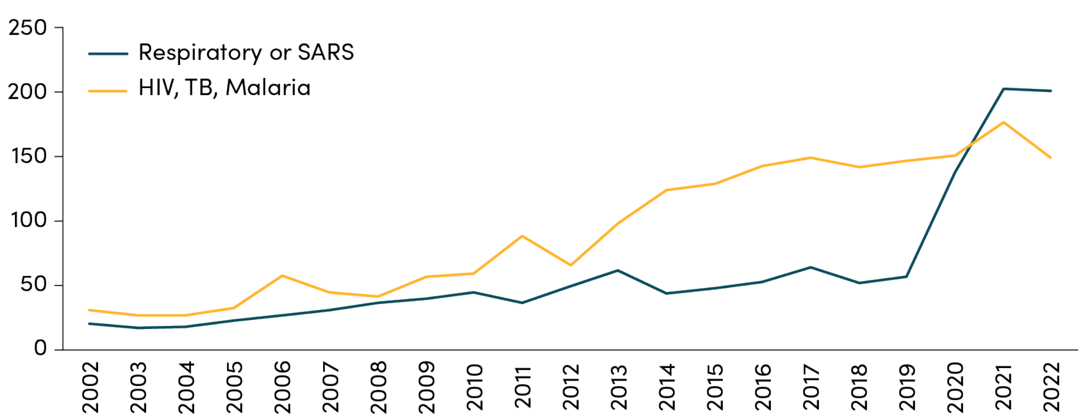
In this paper, we seek to raise the importance of using and generating economic evidence to help guide strategic thinking about priorities in the surveillance of respiratory infections in the broader context of pandemic preparedness. First, we conducted and summarize a rapid literature review on the costs and benefits or effectiveness of selected types of surveillance approaches, using the World Health Organization's Mosaic Framework (WHO, 2023b). Next, we examine a framework that assesses the value of investments in pandemic preparedness and response beyond the limitations of the state of economic evaluations. Finally, we shared early results of the rapid review with an expert panel in a CGD roundtable discussion, thus informing our key policy implications for pandemic preparedness and response investments for surveillance.

Rapid Review of Best Buys for Surveillance for Respiratory Infections

To examine the state of economic evaluation of surveillance for pandemic preparedness, we conducted a rapid review of published scientific literature on the costs and cost-effectiveness of selected types of surveillance for respiratory infections, influenza, and SARS.

From a bibliometric perspective, the evidence base for the cost-effectiveness of respiratory infections including those of pandemic potential remain undeveloped in comparison to the "big three" of HIV, tuberculosis (TB), and malaria. Figure 1 shows the number of studies on surveillance cost-effectiveness for HIV, TB, and malaria compared to (nonspecific) respiratory infections including SARS. The figure reflects the relative lower evidence base of economic evaluations for respiratory infections as a discrete category compared to the "big three". These three diseases were prioritized as part of the Millennium Development Goals during a golden age of development assistance for health.

FIGURE 1: Number of publications in PubMed with selected infectious disease keywords, 2002–22



Source: Authors searched PubMed with keywords of respiratory, SARS, HIV, tuberculosis, malaria, surveillance, and cost-effectiveness

We also examined previous DCP editions for assessments of surveillance for HIV, TB, and malaria, and found that cost data is less forthcoming than that on cost-effectiveness. A notable exception was that studies on tuberculosis had community costs compared to health facility costs per patient (see Annex 1). In contrast, the studies on malaria focused primarily on benefit-cost ratios and did not list programmatic costs for malaria programs including for control or elimination. To our knowledge, a comparable table on the costs of respiratory infections is not available to date, reinforcing the need for better understanding the costs of surveillance programs for respiratory infections.

Rapid Review Methodology

The rapid review was conducted in March 2023 using PubMed and Google Scholar databases and with the following search terms: Surveillance, Sentinel, Laboratory Networks, Notifiable, Respiratory infection, influenza, Covid*, Cost*, economic*, analysis, benefit, monitor*, evaluation.

The four types of surveillance approaches that were included as part of this rapid review were based on their centrality as core types of surveillance in the WHO Mosaic Framework: (1) Laboratory networks, (2) Sentinel surveillance, (3) Notifiable disease surveillance, and (4) Health facility event-based surveillance. Due to limited time and resources, we focused this review to four surveillance approaches which were part of the core set of surveillance types of the Mosaic Framework and had immediate relevance for the Pandemic Fund's first call for proposals, particularly low-income countries. The other six types of surveillance approaches in the Mosaic Framework are: (1) Community event-based surveillance, (2) Investigations and studies, (3) Targeted special population surveillance, (4) Healthcare capacity monitoring, (5) Enhanced clinical surveillance, (6) Pharmaco-vigilance.

TABLE 2. Surveillance approaches and definitions

Surveillance approach	Definition
1. Laboratory networks	Organized networks of laboratories reporting data on specimens tested centrally, with phenotypic and genomic characterization as needed
2. Sentinel surveillance	Involves a limited number of recruited participants, such as health care providers or hospitals, who report specified health events that may be generalizable to the whole population
3. Notifiable disease surveillance	Mandated reporting of notifiable diseases or conditions to public health authorities in a specified and timely manner for effective disease monitoring, control and management
4. Health facility event-based surveillance	Sensitized health workers detecting and reporting conditions and other signals, with verification

Notes and source: "Crafting the Mosaic" (WHO, 2023). The WHO Mosaic Framework classifies ten types of surveillance approaches, with each approach having potentially multiple functions, or what the WHO labels as "domains": Domain I on emerging diseases (labeled by WHO as "Detection and assessment of an emerging or re-emerging respiratory virus"); Domain II on routine respiratory infections (labeled by WHO as "Monitoring epidemiological characteristics of respiratory viruses in interpandemic periods"); and Domain III on intervention effectiveness (labeled as "Informing use of human health interventions").

The inclusion criteria were limited to studies in English on respiratory diseases, for each of the four selected surveillance types, and all papers reviewed had attempted some form of evaluation of the surveillance interventions and included aspects such as, costs (including descriptive, qualitative costs), benefits, requirements need, or analysis. Initially, a total of 262 apers were identified. After the title and abstract screening, 36 papers were read in full, and 25 were then summarized. No papers were excluded based on geography or country income level.

Results from Rapid Review

Table 3 summarizes the results of the rapid review, with Table 3-A covering Laboratory Networks, 3-B Sentinel Surveillance, 3-C Notifiable Disease Surveillance, and 3-D Health facility event-based. While there were few cost-effective analyses or studies with cost analysis, we found several studies that evaluated the surveillance interventions.

The countries represented in the studies were geographically diverse, from Africa (Burkina Faso, Democratic Republic of Congo, Eritrea, Ethiopia, Mali, Madagascar, Rwanda, Sierra Leone, South Africa, Zambia, Zimbabwe) to Europe (Belgium, Georgia, The Netherlands, Portugal, Spain, United Kingdom), and with fewer studies in South Asia (Pakistan), East Asia and Western Pacific (Australia, Vietnam), the Middle East (Yemen), and North America (USA). Notably, we did not find any studies for the high-income economies in East Asia and Western Pacific which had outstanding performance against COVID-19 (Hong Kong, Japan, South Korea, Singapore, Taiwan, and New Zealand) or studies in Latin America, likely due to the English language inclusion criteria.

In general, information on the costs of interventions were limited and not widely available. Measures of effectiveness were not standardized and often qualitative. Of the studies with cost data, there appear to be high start-up costs for surveillance interventions but with large potential spillover benefits. For example, the review of the implementation of health facility electronic integrated disease surveillance and response (eIDSR) in Sierra Leone showed that it provides early detection and reporting of outbreaks, improved collaboration between healthcare facilities and preventive sectors, and increased community participation in surveillance and reporting. Despite the high initial implementation costs, the eIDSR system has low annual direct operational costs, making it a sustainable and feasible approach for disease surveillance in resource-limited settings.

Our review has shown there are multiple papers assessing the effectiveness of sentinel approaches for piloting new surveillance methods in African countries. This strategy is widely regarded as an effective way to establish surveillance systems in regions lacking adequate infrastructure (Root et al., 2020), although the costs of this approach are not well characterized. Recognizing the possible risk of publication bias, the rapid review indicates that sentinel surveillance approaches have potential for strengthening disease surveillance in resource-constrained settings. We caveat that this assessment should not be weighted with higher priority over other forms of surveillance due to the lack of information on other types of surveillance.

Understanding the costs and benefits of laboratories necessitates considering investments through a wide lens and perspective. Conventional economic evaluations with a limited time horizon may underestimate the value of laboratories in surveillance systems and health services. The true benefits would extend far beyond improved surveillance for one disease, meaning it is necessary to consider costs and benefits though direct, indirect costs, and benefits at the patient outcome, public health, and health system level (Fu et al., 2022). High capital costs of laboratory networks and initial implementation and scale-up costs should be weighed relative to larger "spillover" or "horizontal" or "joint" benefits beyond respiratory infections. Projects for surveillance for pandemic preparedness should also incorporate costing of disease surveillance including laboratory networks for multiple diseases that include respiratory infections. The results from this rapid review do not shed light about the ways in which investing in multiple integrated surveillance strategies such as in both laboratory networks and sentinel surveillance can be more effective, representing an area for future research and evaluation.

There are several limitations of this rapid review, in addition to its limited focus on four types of surveillance. The Mosaic Framework's classification of surveillance types does not easily mesh with the general public's understanding of surveillance gained from the COVID-19 pandemic. Other forms of surveillance include testing strategies, wastewater surveillance, genomic sequencing and serosurveillance, as well as social media monitoring. Rapid testing and wastewater surveillance are considered in the Mosaic Framework as "surveillance innovations. Serosurveillance may be part of multiple types of surveillance types in the framework, including "Investigations and studies" for one-off seroprevalence surveys. Media event-based surveillance which includes social media monitoring is classified by the Mosaic Framework as an "enhanced" surveillance approach distinct from the Core surveillance.

The key challenge of assessing the value of different types of surveillance approaches is its modular nature; surveillance involves multiple parts, tools, and interventions as well as multiple actors and organizations that collectively form a "surveillance system", with some systems more integrated and networked than others which are more siloed and fragmented. Even definition of a given type of surveillance may easily include other types of surveillance; for example, those implementing sentinel surveillance will necessarily need to use laboratory networks, and so on.

TABLE 3-A: Summary of a Rapid Review on Selected Core Surveillance Approaches: Laboratory Networks

Surveillance Name	Costs	Benefits	Features or requirements
Laboratory Networks across Europe (Zhao et al., 2014)	• Minimal additional cost for network creation assuming labs are already established. • Potentially large volume-driven cost savings • Total lab set-up costs in the UK £48,859,900	• Quickly adaptable to expand scope including novel pathogens • Improving the quality of patient care • Early detection and enhanced surveillance of public health threats caused by infectious disease	• A network of 14 NHS laboratories to create a Respiratory DataMart System (RDMS)
Lab-based Influenza Surveillance System in Pakistan (Malik, 2019)	• Not available in paper	• Simple and easy to operate, but with little flexibility to integrate with other pathogens and diseases. • Good data quality and timeliness, only 24–48 hours from sample collection to report a submission to the central level. • Acceptability was good, since both private and public sector hospitals and labs are involved	• The system included both private and public sector hospitals and labs. • The surveillance system is 100% donor funded (CDC funding)
Laboratory Networks across Central Africa region (Njukeng et al., 2022)	• Not available in paper	• Laboratory networks for disease surveillance strengthen the quality of laboratory testing	• The Network requires well trained personnel and established organizations
Consolidated Clinical Microbiology Laboratory Compared to Sentinel Network of Laboratories in Belgium (Van den Wijngaert et al., 2019)	• More data is obtained from processing fewer samples, due to the higher analytical capacity of the consolidated lab, without a proportional increase in costs	• Laboratory-based surveillance benefits from increased use of rapid diagnostic testing and increasingly rapid pathogen identification. Advanced detection tools dramatically cut the time to accurate diagnosis and increased the knowledge of epidemiological trends	• One centralized consolidated clinical microbiology laboratory
Clinical Microbiology Laboratory Consolidation across Europe (Vandenberg et al., 2018)	• Volume-driven cost savings of laboratory networks self-evident • The speed, size, and cost of the equipment has decreased, making the required upfront capital investment feasible.	• Improving the quality of patient care • Early detection and enhanced surveillance of public health threats caused by infectious diseases	• A regional scale "microbiology laboratories network" with one large centralized clinical laboratory on a central platform and several distal laboratories

Surveillance Name	Costs	Benefits	Features or requirements
	• Cost of sequencing has reduced by 92%: 0.52 to 0.04 $US per DNA Mb • High-resolution data available at a lower cost means downstream costs for accommodation, analyses, and interpretation. • Reduction in laboratory testing costs (per-capita or per-analysis) remains a clear motivating force to rationalize operations, but CMLs constitute only about 4% of most hospitals' budgets		
Strengthening national and regional laboratory networks across Africa (Best & Sakande, 2016)	• Costs include laboratory renovation, equipment, human resources, reagents and supplies, quality assurance, external quality assessment and accreditation, specimen referral, training, and other costs. • The ability to meet patient care needs, integrated disease surveillance needs and laboratory testing/ reporting with one • health sector computer system will be most efficient and cost-effective for the country	• When used optimally, laboratory testing generates knowledge that can facilitate patient safety, improve patient outcomes and lead to more cost-effective healthcare.	• Effective implementation of National Strategic Plans • Adequate financial support • A national laboratory policy and regulatory framework • Integrated, tiered national laboratory network development • Tiered laboratory network structure • Well-designed, safe laboratory facilities • Supply chain management system • In vitro diagnostic device regulation • Equipment management plan • Quality systems management • Laboratory staffing and Workforce Development • Information management and communication systems • Specimen collection, referral and transport • Biologic risk management, including waste management

Surveillance Name	Costs	Benefits	Features or requirements
Cross-Country Networks for Laboratory Capacity and Improvement (Schneidman et al., 2018)	• Not available in paper	• Cross-country networks are effective in supporting peer-to-peer learning, and have the potential to generate efficiencies in responding to disease outbreaks and in conducting joint research and training	• The East Africa Public Health Laboratory Network was established to bolster diagnostic and disease surveillance capacity. It requires defined governance structures, clear mandates and concrete deliverables
SARI Surveillance System in Portugal (Torres et al., 2023)	• Not available in paper	• SARI surveillance able to early detect the COVID-19 epidemic peak • Sentinel sites included general hospitals so are more likely to be representative of the general population than specialty or tertiary care referral hospitals • All reporting procedures for each hospital are automated and routinely programmed, therefore, minimizing workload and guaranteeing timeliness.	• SARI sentinel surveillance system based on electronic health registries. Requires linkage with laboratory with clinical data.

Source: Compiled by authors

Table 3-B: Summary of a Rapid Review on Selected Core Surveillance Approaches: Sentinel Surveillance

Surveillance Name	Costs	Benefits	Features or requirements
SARI sentinel surveillance in Georgia (Chakhunashvili et al., 2018)	• Not available in paper	• Multi-pathogen diagnostic testing through Georgia's sentinel surveillance provides useful information on etiology, seasonality, and demographic associations. • Findings from sentinel surveillance can assist in prevention planning.	• A surveillance system for SARI was established to provide improved epidemiologic monitoring of influenza and other respiratory disease within the country of Georgia.
Influenza sentinel surveillance system in Zambia (Simusika et al., 2020)	• Mean annual running cost: US$310,000 • US$105 per sample collected and tested	• Monitoring the temporal trends of influenza circulation • Monitoring circulating influenza types • Assessing the burden of influenza-associated illness • Generating isolates to contribute to the annual influenza vaccine • High quality data and flexibility to monitor viral pathogens other than influenza. • High stability over the review period and relatively low cost	• Data generated is not fully utilized as Zambia lacks guidelines on antivirals use and vaccination policy for influenza • Requires dedicated surveillance officer from the National Influenza Center (NIC) • Requires training once a year and supervisory visits to sites were done at least quarterly • System was reliant on external funds
Influenza sentinel surveillance in Rwanda (Nyatanyi et al., 2012)	• Not available in paper	• The surveillance system enabled characterization of the epidemiology and seasonality of influenza for the first time.	• Influenza sentinel surveillance introduced to Rwanda to monitor novel viruses
SARI Sentinel Surveillance in Vietnam (Ka et al., 2018)	• Operational costs are not negligible. • Costs included: the organization of epidemiologic and laboratory trainings, collection materials, transportation costs, laboratory reagents, human resources, and support for supervisory visits.	• Improved Vietnam's ability to collect and analyze data on non- influenza respiratory viruses. Such data can be used to understand seasonality, contribution by various pathogens to respiratory disease burden, and the risk groups of these non influenza respiratory viral pathogens.	• The system builds upon an influenza platform to expand to respiratory viral surveillance. • Requires training for non influenza viral diagnostics and proficiency testing

Surveillance Name	Costs	Benefits	Features or requirements
Influenza surveillance systems in Spain (Torner et al., 2019)	• Not available in paper	• To understand yearly influenza epidemic behavior and to strengthen healthcare resource preparedness.	• Compares two sentinel surveillance systems. Confirms that influenza data from PIDIRAC sentinel surveillance system provides timely and accurate syndromic and virological surveillance of influenza.
SARI Sentinel Surveillance System in Yemen (Alkholidy et al., 2021)	• Not available in paper	• The SARI surveillance system's was useful for detecting trends and signal changes in the occurrence of SARI The SARI surveillance system's flexibility was excellent. The system appeared to be able to adapt easily to changes in the SARI case definition and accommodate changes in data with less effort and minimal costs • The system was simple, stable, and flexible. The system appeared to be able to adapt easily to changes in the SARI case definition and accommodate changes in data with less effort and minimal costs	• Evaluated 4 sentinel sites. Timeliness of the SARI system was poor due to the lack of laboratory components that are essential for sampling • Depends on irregular external financial support • Requires a Disease Early Warning System
Influenza sentinel surveillance system in Democratic Republic of Congo (Babakazo et al., 2019)	• The System allowed monitoring several syndromes under the same platform, increasing cost-effectiveness and avoiding the implementation of vertical surveillance programs. • Adding additional surveillance sites could improve representativeness but would also increase costs.	• Ability to monitor the circulating influenza viruses and temporal trends of influenza circulation, assess the proportional contribution of influenza-associated illness among outpatients and inpatients with ILI or SARI, estimate the national burden of influenza-associated illness and contribute to the regional and global understanding of influenza epidemiology.	• SMS-based system for the transmission of weekly aggregated data • Largely reliant on external funds (> 90%)
Influenza Surveillance Systems in South Africa (Budgell et al., 2015)	• SARI: Annual operating costs: US$500,000–800,000 • VW: Laboratory tests per annum: US$100,000 • Coordination and overhead costs per annum: US$20,000	• Good flexibility and has expanded from fewer than 20 sentinel sites in 2005 to 205 sites in 2012 with little growth in the programme's overhead costs. • Simple and representative	• Compares two surveillance systems. Both substantial investments in human resources and training dedicated personnel or volunteers

Surveillance Name	Costs	Benefits	Features or requirements
Influenza Sentinel Surveillance system in Madagascar (Rakotoarisoa et al., 2017)	• Overall moderate cost • Mean annual cost of the surveillance system, for ILI surveillance: US$ 94 364 • Mean annual cost of laboratory testing of samples: US$44 588	• Data quality for all evaluated indicators was categorized as above 90% • Strong in terms of its acceptability, simplicity and stability.	• The system covers 34 sentinel sites across the country. • Entirely supported by external funding
A sentinel surveillance system in day care centers The Netherlands (Enserink et al., 2012)	• Operating costs for syndromic surveillance: A research assistant and PhD student and costs for designing/distributing software and relevant documentation. • The operating costs for the microbiological surveillance include laboratory expenditures for microbiological analyses.	• Study infectious disease dynamics in the day care setting over a sustained period. The created (bio) databases help assess day care-related disease burden of infectious diseases among children and staff.	• A day care-based sentinel surveillance network for infectious diseases (the KIzSS network)
Global Influenza Surveillance and Response System for respiratory syncytial virus surveillance (Broor et al., 2020)	• It was feasible to leverage GISRS for RSV surveillance with little incremental cost without any significant adverse impact on the functioning of GISRS for influenza surveillance.	• Leverages the existing capacities of the Global Influenza Surveillance and Response System (GISRS) to better understand RSV seasonality, high-risk groups, validate case definitions, and develop laboratory and surveillance standards.	• The WHO piloted a RSV surveillance strategy in 14 countries that leverages the existing capacities of the Global Influenza Surveillance and Response System (GISRS)

Source: Compiled by authors

Table 3-C: Summary of a Rapid Review on Selected Core Surveillance Approaches: Notifiable Disease Surveillance

Surveillance Name	Costs	Benefits	Features or requirements
Notifiable disease surveillance system in Zimbabwe (Chimsimbe et al., 2022)	• Not available in paper	• Identify notifiable diseases early to institute prevention and control measures. • The NDSS links the health information system from the health facility to the national level.	• Notifiable Diseases Surveillance System (NDSS) training required for staff
Notifiable diseases surveillance system in Zimbabwe (Maponga et al., 2014)	• Cost of notifying a single case of a notifiable disease: • Paper based system: US$18.15. • Mobile phone system: US$1.55. • For the paper-based system, 90% of the cost is for transport	• Not available in paper	• Notifiable Diseases Surveillance System (NDSS) training required for staff Paperwork, Salaries, Transport, telephone bills
Notifiable disease reporting Electronic Disease Reporting System in the USA (Boehmer et al., 2011)	• Not available in paper	• Notifiable disease surveillance systems are critical for communicable disease control, and accurate and timely reporting of hospitalized patients who represent the most severe cases is important.	• Used hospital discharge data to evaluate notifiable disease surveillance systems.
Notifiable Disease Surveillance System in Australia (Miller et al., 2004)	• Not available in paper	• The system was acceptable, structurally simple, and that the data collected were actively used by stakeholders.	• The Australian National Notifiable Diseases Surveillance System (NNDSS) is a passive surveillance system that collects information on communicable diseases.
Notifiable disease surveillance system in South Africa (Weber, 2007)	• Not available in paper	• The communicable disease surveillance systems form an integral part of the health system and public health planning and implementation.	• The completeness and accuracy of notification data is insufficient to gauge a true picture of burden of disease in the province.

Source: Compiled by authors

Table 3-D: Summary of a Rapid Review on Selected Core Surveillance Approaches: Health facility event-based

Surveillance Name	Costs	Benefits	Features or requirements
Health facility electronic Integrated Disease Surveillance and Response (eIDSR) in Sierra Leone (Sloan et al., 2020)	• The total economic cost to roll out eIDSR in the Western Area Rural district over a 14-week period was US$64,342 with a per health facility cost of $1,021. Equipment for eIDSR was the primary cost driver (45.5%) followed by personnel (35.2%). • The direct rollout costs were $38,059 (or 59.2%). • The projected annual direct operational costs were $14,091, or $224 per health facility. • Although eIDSR equipment costs are a large portion of total costs, annual direct operational costs are projected to be minimal once the system is implemented.	• Early detection and reporting of outbreaks, improved collaboration between the healthcare facilities and preventive sectors of the ministry, and increased community participation in surveillance and reporting. • Practical and easy to implement and that health facility staff will engage in rapid detection and notification when provided with simple guidance and a clear reporting mechanism • Can be tailored to the specific needs of a country: designed broadly to detect all hazards, or with a particular focus, such as respiratory diseases	• Procurement and setup of electronic devices including tablets, logistics planning and device connectivity • Personnel training using a standardized curriculum covering smart device use, data entry, report submission, and troubleshooting • Intensive follow-up after training to support facilities learning to use the eIDSR app
Event-based Surveillance at Community and Healthcare Facilities in Vietnam (Clara et al., 2018)	• Not available in paper	• Early detection and reporting of outbreaks, improved collaboration between the healthcare facilities and preventive sectors of the ministry, and increased community participation in surveillance and reporting.	• Twenty-four master trainers were trained in August 2016: two from each province and 16 GDPM and Regional Institute staff. A cascade training to lower administrative levels followed the master training. By October 2016, >7,000 persons in 4 provinces were trained to detect, record, and report signals and events, and 52 DHC staff were trained in basic risk assessment. Staff from every district, CHS, and public hospital within each province were trained, achieving 100% training coverage

Surveillance Name	Costs	Benefits	Features or requirements
Event-based surveillance in north-western Ethiopia (Toyama et al., 2015)	• Not available in paper	• This surveillance system was established along with an existing indicator-based surveillance system and was simple to implement	• The cost of establishing the system was minimal, requiring only a brief orientation for the surveillance focal persons and printing and distribution of the rumor logbooks to the HCs".
Cost analysis of an integrated disease surveillance and response system: case of Burkina Faso, Eritrea, and Mali (Somda et al., 2009)	• Over the period studied (2002–2005), the average cost to implement the IDSR program in Eritrea was $0.16 per capita, $0.04 in Burkina Faso and $0.02 in Mali. In each country, the mean annual cost of IDSR was dependent on the health structure level, ranging from $35,899 to $69,920 at the region level, $10,790 to $13,941 at the district level, and $1,181 to $1,240 at the primary health care center level. The proportions spent on each IDSR activity varied due to demand for special items (e.g., equipment, supplies, drugs and vaccines), service availability, distance, and the epidemiological profile of the country.	• This study demonstrates that the IDSR strategy can be considered a low cost public health system although the benefits have yet to be quantified. These data can also be used in future studies of the cost-effectiveness of IDSR	• The proportions spent on each IDSR activity varied due to demand for special items (e.g., equipment, supplies, drugs and vaccines), service availability, distance, and the epidemiological profile of the country.

Source: Compiled by authors

The Value of Investing in Preparedness for Future Response

The rapid review shed light on the limitations in the current state of research and economic evaluations of surveillance for respiratory infections, primarily that most studies did not measure cost. On the outcomes side, measurement of benefits and effectiveness that we found in this review were often qualitative, beyond the number of cases detected and reported and the timeliness of those cases which are arguably features or functions of the system. Future studies of cost-effectiveness of surveillance systems should seek to define and measure effectiveness in terms of timeliness and early detection and response as a defining characteristic of a high performing surveillance system, The reasons for the use of qualitative measures of benefits and effectiveness are not obvious. One possible reason for the lack of measures of surveillance effectiveness, may pertain to the nature of epidemic curve, in which most of the time when surveillance is implemented is during the interpandemic period, i.e. "peace time". Surveillance systems may not be regularly stress tested in response to a severe pandemic, due to the rare nature of severe pandemics. In the interpandemic period, economic evaluations on interventions for pandemic preparedness, and surveillance in particular, appear to lack standard measures of cost-effectiveness, i.e. measures of a dollar per life year averted or quality-adjusted life year. Thus, the pandemic preparedness and response community is challenged to make the case for the long-term value of investing in surveillance, even as economic evaluations, which are generally shorter term, may lack appropriate measures of effectiveness and benefits. To quote Laurie Garrett, "Public health is a negative. When it is at its best, nothing happens: there are no epidemics." (Garrett, 2001)

An alternative framework to assess the value of pandemic preparedness and response may require integrating over both interpandemic (between pandemics) and intrapandemic periods (during a pandemic) to guide strategic investments. WHO recently launched the Preparedness and Resilience for Emerging Threats (PRET) initiative, with an initial focus on respiratory pathogen pandemic preparedness (WHO, 2023a) and consistent with this integrated perspective. The PRET initiative has argued that countries with influenza plans, as part of the WHO Pandemic Influenza Preparedness (PIP) framework—as well as the corresponding laboratory capacities and trained health workforce—in place were more prepared to respond to the COVID-19 pandemic. The initiative cites that African countries with a National Influenza Centre (NIC) were able to scale up COVID-19 testing capacity much earlier than countries without (WHO, 2023d). (See Annex 2 for a selection of WHO's country case studies reportedly able to respond more quickly and effectively to COVID-19 due to previous investments in influenza surveillance.) The extent to which countries were able to leverage existing investments in pandemic influenza preparedness for the COVID-19 response merits rigorous evaluation and research. Preparedness investments are broadly encompassing of not only laboratory and surveillance capacity, but also regulatory strengthening, e.g. regulatory approvals for vaccines (WHO, 2022b).

The value of interpandemic investments in *pandemic preparedness planning* and their importance for the quality and effectiveness of disease surveillance systems and programs for the COVID-19 global response marks an important area of future research. An in-depth, independent evaluation of the PIP is needed, as well as a rigorous country comparison of countries with influenza plans that scaled up testing and surveillance rapidly for COVID-19 during the pandemic. Using rigorous impact evaluation methodologies as well as in-depth qualitative research methods, there is a need for independent third-party evaluation of the value of investing in planning for preparedness and surveillance over a longer period. Evaluation is needed to understand the extent to which countries were able to leverage international influenza surveillance systems and programs during the COVID-

19 pandemic to harness laboratory surveillance infrastructure and build laboratory capacity; utilize influenza pandemic preparedness plans and trainings; expand influenza evaluation projects to include COVID-19 program evaluations; and leverage influenza vaccine partnerships for COVID-19 vaccines (Marcenac et al., 2022).

Policy Considerations for Best Buys in Pandemic Surveillance

On March 31, 2023, CGD convened a panel of experts for a private roundtable discussion on "best buy" interventions for disease surveillance to inform the Pandemic Fund's first call for proposals and presented early findings from the rapid review. The conversation brought together stakeholders across different communities of practice in the areas of pandemic preparedness, disease surveillance, and health information systems. Participants included those from global health agencies (e.g. World Health Organization, Centers for Disease Control and Prevention), international financial institutions (e.g. Interamerican Development Bank, World Bank), national governments (e.g. the White House National Security Council, and the Foreign, Commonwealth & Development Office), private sector (e.g. Ginkgo Bioworks, Deloitte), universities (e.g. Georgetown, Harvard, Seoul National University, University of California at Berkeley), and nonprofit organizations (e.g. ONE, Pour Demain, Vital Strategies, CGD). Individuals reflecting geographic and organizational diversity were selected, although participation from countries was limited due to time difference. See Annex 3 for the list of participants in the roundtable who have consented to share their names.

The roundtable posed several questions for discussion following initial presentations on the WHO Mosaic Framework and the preliminary findings from the rapid review of best buys for surveillance, intended to spark conversation and generate independent and actionable policy ideas for how the Pandemic Fund and its co-investors can make investments in cost-effective disease surveillance systems (see Annex 4). The roundtable discussion was held under Chatham House rules. We draw out five key themes that emerged during the conversation in light of early findings of the rapid review.

1. Bolster evidence on the costs and cost-effectiveness of investments in pandemic surveillance

Costing of surveillance for pandemic preparedness remains an important area for supporting decision-making. Costs will vary by pathogen type, system type, and context. Start-up or initial costs to set up new surveillance systems are not negligible. Further, investments in one surveillance type, or surveillance for one type of pathogen, may have significant potential for "spillover" benefits across surveillance for other pathogens, as well as the health system as a whole.

Despite high start-up costs, a comprehensive, multi-component surveillance system that can detect and stop a pathogen (or multiple pathogens) is clearly cost saving given the large potential costs and losses of a severe pandemic, however rare. Nonetheless, studies that do exist on disease surveillance cost-effectiveness are skewed towards three major diseases—HIV, TB, and malaria—and largely omit respiratory pathogens. Rigorous and independent evaluation on the extent to which investments in those three diseases have had spillover effects to support respiratory pathogen surveillance remains needed. It is also important to consider, however, when investing in surveillance systems for specific pathogens, the opportunity costs for surveillance of other pathogens—investing in one system can result in the neglect of another. This has led to integrated approaches such as PRET, though this can present its own downsides.

Leading national or international public health and development agencies such as the WHO or World Bank should define and develop a framework for measuring the shorter- and longer-term cost-effectiveness and value of investing in surveillance for pandemic preparedness, inclusive of broad types of pathogens such as respiratory infections and diseases with other modes of transmission (eg bloodborne, water borne, vector borne, etc.). As this scope of work requires both an understanding of epidemiology and economics, there is a need to draw on interdisciplinary expertise to develop such a framework. The value of system approaches also needs thought leadership and new metrics, including addressing the value of surveillance vis-à-vis other key policy and programmatic decisions (e.g. antimicrobial resistance and other public health functions).

There are several challenges of cost-effectiveness as a framework for assessing the value of surveillance. As noted earlier, one key challenge is the measures of benefit of surveillance require future development, particularly in interpandemic periods. During an epidemic, the measures of benefit are also skewed to a variety of potential epidemic scenarios depending on the transmission and severity of the disease. A properly functioning disease surveillance system may prevent a small outbreak from becoming a global pandemic, but there is a lack of a counterfactual of what would have happened had the system not detected the outbreak and prevented the disease from spreading. Estimating and providing accurate cost-effectiveness figures for surveillance over the long term proves challenging.

Nevertheless, costs of pandemic preparedness and response investments, including in surveillance, will pale in comparison to the losses of a severe pandemic. Measuring costs can help to inform budgeting and strategic decisions, and if suitable short-term measures of effectiveness of surveillance systems can be developed, cost-effectiveness of multiple surveillance systems can be effectively compared.

2. Focus on timely, reliable, multi-sourced data including mortality

Countries are tasked with detecting and monitoring for influenza, SARS-CoV-2, Respiratory Syncytial Virus (RSV), other respiratory and non-respiratory pathogens, simultaneously and continuously. Such surveillance data needs to be not only integrated and "collaboratively" shared (WHO, 2023c), but also constantly updated and verified to be an effective tool for mitigating and preventing outbreaks.

Using mortality data, often from civil registration and vital statistics (CRVS) systems, as a form of pandemic surveillance has great demonstrated value—to understand the scope and scale of health threats—but remains a neglected area in current pandemic frameworks. COVID-19 shone a brighter light on the difficulties of counting deaths in many countries and therefore measuring excess mortality. Although their timeliness may not as relevant for early warning systems, such mortality data systems are nevertheless important for pandemic response. In addition, measures of pandemic risk and value of investing in pandemic preparedness and response from a long-term perspective hinges on the quality of mortality data, particularly low- and middle-income countries.

In addition to mortality data and disease-specific surveillance data, other sources of data should be explored. Questions about the value of facility-based data compared to community data, as well as passive versus active surveillance remain an area for further assessment, costing, and study. Similarly, the contributions of digital systems and health information systems as a critical part of surveillance systems are not well captured or understood at present. The success of surveillance systems may depend on integration, i.e. the ability of data to flow from local to national to global. Those working in pandemic preparedness and response should also assess the value and investing in centralized data systems compared to federated or decentralized systems and assess the requirements for integrated surveillance systems, whether they are centralized or decentralized.

3. Coordinate across diseases, including in the inter-pandemic period

Another key challenge is to measure joint costs to measuring the value of surveillance given the broad applicability of surveillance to multiple diseases. Calls for investments in surveillance or human resources or laboratory appear to be distinct decisions, when in fact these components are part of an integrated public health system that serves multiple diseases, not only respiratory pathogens. The fragmentation of international resources by disease may undervalue the need to invest in surveillance of respiratory infections. Breakdowns of recurrent costs compared to start-up or capital costs are also not apparent, especially in light of systems that address multiple diseases. Further, the shadow costs of time and the attention of practitioners may not be adequately reflected in existing studies of either vertical interventions or horizontal integrated approaches.

The dichotomy of thinking through investing in pandemic preparedness versus pandemic response is challenging because of the ways in which costs are shared interpandemic. For example, the costs required for response may be larger if investments in preparedness are lower. Put differently, the costs for ramping up workforce requirements for epidemic intelligence and surveillance during response may somewhat compensate for the investments made in workforce development during preparedness.

In developing such preparedness systems, maintaining flexibility is critical, as countries must use routine monitoring and surveillance activities to detect and respond to a range of hazards. Large and small outbreaks should be leveraged to bolster routine disease surveillance. There is a need to better value and invest in flexible systems that can address both routine and emergency issues for a diverse set of hazards and pathogens, especially given that health workers are not disease specific, even as funding flows may be disease specific.

4. Align local and global priorities and cost sharing

From an economics perspective, surveillance priorities for local and national decisionmakers may naturally differ from those of global policymakers. National policymakers struggle to address the tension in aligning priorities for surveillance across local, regional, and international levels. The notion of investing in "what works" may also not be suitable to what local and national authorities need to address pandemic preparedness and response. Thus, standard priority setting frameworks using lists of interventions (Ahazie & Fan, 2023) may be less relevant than ensuring the local implementation requirements are met, such as ensuring small funds or local budgetary authority to local implementation units to purchase necessary equipment, including communication devices (i.e. cell phones) which can be needed for reporting.

Countries ideally determine their surveillance priorities, including through Joint External Evaluations (JEE)s, National Action Plans for Health Security (NAPHS), and other robust, transparent processes to determine what institutional capacities are needed. Yet from a global policy perspective, there is a lack of alignment in terms of who can pay and who benefits for such investments in preparedness. The distribution of costs and benefits of investing in preparedness clearly differ locally and national compared to globally. A cost-effectiveness framework does not fully reflect the challenge of public goods—of who bears the costs and the benefits of the surveillance or other preparedness investments.

5. Create incentives for evaluating surveillance approaches

Rigorous, independent evaluation of past investments in pandemic preparedness can help to inform the long-term value of investing in planning, including for surveillance. Yet insufficient incentives may exist for countries to develop robust national surveillance systems due to the ambiguous cost savings of preventing a pandemic through targeted interventions. Further, incentives are lacking for evaluating surveillance systems and ensuring they meet objectives (which could be addressed by a metrics framework).

Surveillance approaches are not easily evaluated, because they are highly contextual and involve multiple components. Evaluations must consider how specific surveillance approaches fit into an overall national, regional, and global system. Incentives should be built into any investment of pandemic preparedness and response to ensure that evaluations are conducted in order to institutionalize the generation and use of evidence to determine whether interventions achieved their intended goals (Kaufman et al., 2022). Past investigations into how to achieve more value for money have called for improving ex ante budgeting and transparency on spending—evaluating and understanding the cost effectiveness of interventions prior to implementation (Glassman et al., 2013).

So-called gray literature or implementation experience of practitioners and public health authorities in implementing surveillance systems may be excluded from most literature reviews. Such real-world experiences also include investments in preparedness and planning processes resulting in tacit experience of the public health workforce and should not be discounted. The notion that doing is more important than learning may underly the lack of inclusion in formal scientific literature on the experiences from East Asia, despite their positive performance against the COVID-19 pandemic. Learning and improvements in public health and pandemic preparedness and response should be occur through broad sources of knowledge and diverse experiences. Rigorous and independent evaluation should thus also consider qualitative and mixed methods.

Concluding remarks

This policy paper covered three distinct areas pertaining to investing in the "best buys" of pandemic surveillance. First, we used a standard public health methodology of rapid literature review to quickly assess the state of knowledge on the costs and benefits of investing in four selected types of surveillance for respiratory infections. Of the four types of surveillance examined, sentinel surveillance appeared to have more information on the costs, potentially due to publication bias, but should not be viewed as a statement of preference over other forms of surveillance which lacked evidence and cost data. Overall cost data on surveillance in the published literature remain very limited. Further, there is limited standardization across measures of effectiveness of surveillance, limiting comparisons of cost-effectiveness across different types of surveillance, including the other types of surveillance in the WHO Mosaic Framework. Those working in pandemic preparedness and response may consider learning from colleagues working in other diseases such as HIV, and should seek to measure costs and benefits of surveillance of respiratory infections in order to make the investment case.

These limitations of a standard short-term economic evaluation framework do not imply measuring costs and benefits is not needed. We reported on a new WHO PRET Initiative which seeks to use a broader framework on the value of pandemic preparedness and response that integrates both interpandemic and intrapandemic investments. We argued for the need for rigorous, independent evaluation of these interpandemic investments and an examination of the extent to which countries with greater influenza pandemic planning were more prepared to respond against COVID-19.

Finally, the rich discussion from the roundtable highlighted both the importance as well as the limitations of using a "best buy" lens. The need for investing in greater evidence on the costs and effectiveness of pandemic surveillance is clear. Drawing on broad sources of surveillance data is also important for pandemic surveillance. Horizontal or integrated approaches to surveillance that encompass multiple diseases have joint costs and spillovers. The typical frames of "what works" and standard priority setting frameworks should also be considered alongside implementation experiences of real-world practitioners. Finally, rigorous, independent evaluation, including impact evaluation as well as using qualitative methods, can help to understand the contextual variations of surveillance systems.

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Annex 1. Selected cost-effectiveness estimates for tuberculosis with information on treatment costs: compilation from Disease Control Priorities, 3rd edition

Study	Study country	Community cost (2012 US$)	Health facility cost (2012 US$)	% difference in cost per patient
Islam and others 2002	Bangladesh	172.8	259.2	33
Wandwalo, Robberstad, and Morkve 2005	Tanzania	216.1	331.9	35
Dick and Henchie 1998	South Africa	1,296.10	2,073.10	37
Moalosi and others 2003	Botswana	5,135.90	8,543.40	40
Datiko and Lindtjørn 2010	Ethiopia	138	332.7	59
Pichenda and others 2012	Cambodia	639.3	2,131.10	70
Khan, Khowaja, and others 2012	Pakistan	320.83	471.16	32
Okello and others 2003	Uganda	796.52	1,405.63	43
Nganda and others 2003	Kenya	752.65	2,250.51	67
Floyd and others 2003	Malawi	1,040.94	4,477.99	77

Source: Authors compiled from DCP3, p. 267 of Chapter 11

Annex 2. Examples of enhanced country preparedness for COVID-19 due to investments in influenza surveillance

Albania implemented the First Few X Cases and their close contacts (FFX) protocol for COVID-19, following a successful pilot for influenza in early 2020. The data generated through this study helped to produce timely estimates of severity and transmissibility of infection (WHO, 2020).

In **Bolivia**, the systems the country routinely uses for epidemiological analysis of influenza—Severe Acute Respiratory Infection (SARI) case form and the Pan American Health Organization influenza sentinel information systems—acted as models for a national COVID-19 case information system (WHO, 2022a).

Since 2018, **Nepal** has linked its influenza-like illness and SARI sentinel surveillance network with its Early Warning, Alert and Response System to facilitate greater disease surveillance coverage. Nepal's Ministry of Health and Population adapted and expanded its existing epidemiological and laboratory influenza surveillance systems for the COVID-19 response (WHO, 2022a).

South Africa leveraged existing multi-sectoral national outbreak response teams for the COVID-19 response, and rapidly developed a national COVID-19 plan based on its existing influenza pandemic preparedness plan (WHO, 2023e).

Annex 3. List of Participants at CGD-convened Private Virtual Roundtable (March 31, 2023)

Brett Archer, World Health Organization

Stefano Bertozzi, University of California, Berkeley

Victoria Fan, Center for Global Development

Pratibha Gautam, Harvard TH Chan School of Public Health

Amanda Glassman, Center for Global Development

Marelize Gorgens, World Bank

Ramiro Guerrero, Inter-American Development Bank

Javier Guzman, Center for Global Development

Vageesh Jain, Foreign, Commonwealth and Development Office

Rebecca Katz, Georgetown University

Gerard Krause, World Health Organization

Derek Licina, Deloitte/George Washington University

Joshua Mott, World Health Organization

Ben Oppenheim, Ginkgo Bioworks

Jenny Ottenhoff, ONE

Lydia Regan, Center for Global Development

Gina Samaan, World Health Organization

Eleni Smitham, Center for Global Development

Patrick Stadler, Pour Demain

Sally Stansfield, Independent

Note: The names of the individuals are those who consented to include their name as part of the roundtable. Their names included herein does not necessarily reflect the views of the participants or the views of their organizational affiliation. Further, CGD is a nonpartisan, independent organization and does not take institutional positions.

Annex 4. Questions posed at CGD-convened roundtable on March 31, 2023

1. How should a country strategically invest in multi-component surveillance systems and specifically in light of the WHO Mosaic Framework? How should countries prioritize one type over another type of surveillance?

2. What are the notional costs of these different types of surveillance systems? How are costs joint and shared across systems? How are costs distributed by capital costs versus recurrent costs?

3. How are benefits of different surveillance systems measured? How can a cost-effectiveness framework assess the value for money or how much health can be bought with a given system?

4. Are there qualitative or quantitative measures of benefits and costs that can be compared? Do we have a multi-criteria decision analytic framework to help us weigh the pros and cons?

5. How should countries strategically invest across surveillance types for underlying data and health information systems?

6. How will countries develop costed plans for surveillance and pandemic preparedness? How can knowledge on costs of surveillance be obtained and shared as learning across countries rather than rely on private consultants who are not incentivized to share information on costs?