A Global Early Warning System for Pandemics:

A Blueprint for Coordination

ESTHER KROFAH, SUNG HEE CHOE, ALISHA SUD, AND ANNA DEGARMO

About the Milken Institute

The Milken Institute is a nonprofit, nonpartisan think tank.

We catalyze practical, scalable solutions to global challenges by connecting human, financial, and educational resources to those who need them. We leverage the expertise and insight gained through research and the convening of top experts, innovators, and influencers from different backgrounds and competing viewpoints to construct programs and policy initiatives.

Our goal is to help people build meaningful lives in which they can experience health and well-being, pursue effective education and gainful employment, and access the resources required to create ever-expanding opportunities for themselves and their broader communities.

About FasterCures

FasterCures, a center of the Milken Institute, is working to build a system that is effective, efficient, and driven by a clear vision: patient needs above all else. We believe that transformative and life-saving science should be fully realized and deliver better treatments to the people who need them.

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EXECUTIVE SUMMARY

Background

The COVID-19 pandemic has had enormous health, social, and economic consequences. Despite unprecedented advances in medical science that have enabled the development of novel vaccines and therapies in record speed, this pandemic also exposed deep deficiencies in our ability to detect, prevent, and respond to global health threats.

Throughout 2020 and 2021, the Milken Institute brought together global health leaders to build a vision for a coordinated global early warning system to address a key gap in current global disease surveillance efforts. The vision, as outlined in our report "A Global Early Warning System for Pandemics: Mobilizing Surveillance for Emerging Pathogens," calls for the mobilization of a coordinated network of multisector and multilateral stakeholders to collect data, share insights, and respond to signals of early disease outbreaks. This report takes this vision for a global early warning system a step further by identifying its critical components and prioritizing the next steps for action.

At baseline, an early warning system capable of pre-event and early event surveillance must have the elements below:

- Monitor microbe, animal, and human interfaces;
- Provide strategic information on the geographies and animal populations at highest risk of zoonotic spillover to humans;
- Capture traditional and nontraditional sources of outbreak information; characterizes pathogens in pre- and early event settings to provide information on their evolution and risk;
- Capture and integrate human behaviors (e.g., population migration, conflict, and climate events) to better identify potential areas of risk;
- Leverage data collected from historical events and outbreaks for insights (such as on the behaviors and practices that drive spillover);
- Leverage the newest genomic sequencing technologies and most advanced prediction methods; and
- Ensure all data captured are translated into insights to support outbreak response and decision-making.

This same group of experts discussed issues related to data collection and use, incentives, and ensuring adequate financing to sustain an early warning system. Further, we engaged a range of external organizations from across the world to share the vision and gain additional input on the activities and structure of an early warning system. This report, which is informed by these discussions, seeks to offer minimum requirements and recommendations for early warning system governance, data, financing, and incentives for participation. Key takeaways include the following:

Governance

An early warning system must be built on a responsive, agile, and transparent governance model. A governance body must set a clear organizational mandate, establish legal and ethical guidelines around data collection, usage, and ownership, set the terms for global collaborations and partnerships, explore options or create innovative models for sustainable financing, and utilize policy and behavior change strategies to achieve the goals of an early warning system.

Data

Several top-down questions can serve as a starting point for determining the types of data that a robust early warning system should be expected to collect. In this report, we offer a set of minimum data questions that, if answered, can help prioritize emerging microbes and hotspot regions as well as identify areas where clusters of unknown diseases are emerging. Most, but not all, of the data required to answer the minimum data questions are already collected through existing initiatives. An early warning system would build on existing surveillance infrastructure, fill gaps where data do not exist, and aggregate and analyze both traditional and nontraditional data to generate insights.

Incentives

A global early warning system cannot be truly functional without strong political commitment from governments around the world. Indeed, many governments and organizations have invested heavily in pandemic preparedness. But lack of global coordination and leadership across these efforts has given rise to siloed initiatives. At the same time, governments should not be expected to bear this burden alone. Formalizing a global early warning system will require the participation of international development organizations, philanthropies, the private sector, as well as communities and individuals, which collectively bring to the table the resources, data, technologies, and advocacy that will be needed. Just as important, disincentives for participation must also be understood and mitigated. This report offers a starting point for considering potential incentives to drive three areas: data sharing, global collaboration, and sustainable financing and partnerships.

Financing Considerations

Despite recognition of an early warning system as a global good, securing the long-term financing necessary for its implementation will be challenging. As we move further away from the start of the COVID-19 pandemic and other priorities start to regain attention, political will—and along with it, commitments to finance—will wane. While all eyes and ears are on pandemic preparedness now, funding can dwindle as the crisis moves past the acute stage.

Financing for an early warning system must integrate multisector stakeholders. Such integration will lend itself to co-financing and blended financing (that is, the use of public or philanthropic funds to catalyze private sector investment) options for greater and a more sustainable variety in funding sources. It will also foster collaboration among entities and initiatives to coordinate on areas where funding gaps exist. Public-private partnerships (PPPs) can expand opportunities for financial and in-kind resources and provide an avenue for private organizations to contribute to an early warning system. PPPs' structural flexibility—combined with their ability to follow for-profit or nonprofit models, create a new entity or expand upon an existing one, and be established through informal or formal channels—enables initiatives to mobilize and

change without the bureaucratic constraints that independent public-sector, private-sector, philanthropic, or other entities navigate when pursuing new initiatives. Current global disease surveillance efforts could benefit from the creation of an early warning-focused PPP, as multisector partnership lends itself to a range of benefits that would otherwise not be available through collaboration among governments or other entities alone.

Immediate Next Steps

The ideas above and further detailed in this report offer a starting point for mobilizing an early warning system. No single entity can achieve the vision we have outlined by acting alone. Progress toward an early warning system will require the collaboration of countries, development organizations, philanthropies, and the private sector. In addition, timing is essential. We cannot let perfection stand in the way of progress nor wait to solidify the parts of an early warning system requiring further deliberation. It will also be important to leverage existing innovations, data collection methods, and global alliances to realize an immediate impact to help prevent the next pandemic.

Below we highlight some immediate next steps that we see as the most critical and actionable items to continue to build toward an early warning system:

1. Convene and socialize recommendations for an early warning system with political leaders, global health leaders, and existing organizations and networks.
2. Map out organizations and stakeholders "outside the box" of traditional disease surveillance efforts but with a vested interest in a global early warning system. Start early engagement with them to broaden the circle of support and bring new voices to the table.
3. Build consensus around a data governance framework that defines roles, responsibilities, and processes for accountability and ownership.
4. Leverage this blueprint to inform the development of a technology solution that recognizes the synergies across existing and new global efforts.
5. Build a strategy for prioritizing surveillance in hotspot areas and invest in local capacities to conduct data collection and signal reporting activities.
6. Deepen our understanding of the barriers and facilitators to participation by the private sector and develop appropriate incentives accordingly.
7. Design innovative financing mechanisms to support an early warning system that mobilizes private investment.

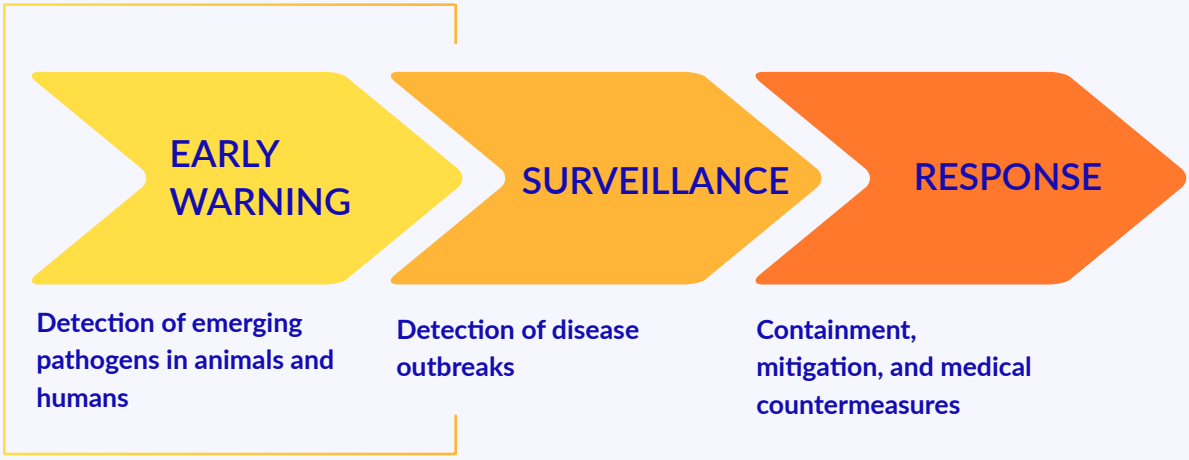
The Milken Institute will continue to advance this vision and we encourage other global organizations that sit at the intersection of the public, philanthropic, and private sectors to take a leading role.

INTRODUCTION

Background

The COVID-19 pandemic has had devastating effects on human health and economies around the world. In the face of this extraordinary global challenge, we have witnessed advances in medical science at unprecedented speeds and scientific collaborations that were once viewed as improbable. We also learned a number of sobering lessons along the way. Chief among them is that despite decades of investment to build public health infrastructure around the world, we are woefully unprepared to deal with pandemics. COVID-19 revealed deep deficiencies in our ability to detect, prevent, and respond to global health threats. Beginning in late 2020, FasterCures, a center of the Milken Institute, brought together a network of global experts in health, finance, data, and technology over several months to identify the areas in which investment may be most impactful in preventing future pandemics. A key takeaway from this work was the need for a globally coordinated early warning system, one that not only has the capabilities to detect pathogens that spill over from wildlife and livestock to humans (see Figure 1), but also helps translate data into action across the whole of society. Many new pathogens are expected to be zoonotic in origin due to land use, food production practices, climate change, and population growth.[1] As zoonotic outbreaks become more frequent, surveillance systems will need to monitor the effects of these changes on animal health and their potential spillover to humans, as well as capture early outbreaks in humans.

Figure 1. Early Warning Alignment in a Pandemic Prevention Ecosystem



The early warning system envisioned in this report would focus on detecting emerging pathogens in animals and humans and capturing outbreaks in humans at their earliest stage.

Source: Milken Institute (2022)

With input from a community of experts, FasterCures outlined an early warning system that could generate insights at the pre-event (an outbreak that occurs before a spillover event) and early event (an outbreak that occurs after a spillover event—the warning period will depend on the type of outbreak, and epidemiological data on incubation periods and rates of disease transmission) stages. The system envisioned would mobilize a federation of multisectoral entities that represent and support localities throughout the world in their early surveillance efforts to track unknown and characterized pathogens. It would link activities at the subnational, national, and regional levels, work alongside existing entities to facilitate connections and fill information gaps, provide a governance framework for data collection and ownership, and ensure a sustainable source of financing for early warning surveillance activities. The full vision is described in FasterCures' June 2021 publication, "A Global Early Warning System for Pandemics: Mobilizing Surveillance for Emerging Pathogens."

To build out a blueprint to implement this vision, FasterCures convened a group of global health experts between July and December 2021 to discuss how this vision could be realized and how to prioritize the next steps for action. Collectively, we identified issues related to data collection and use, incentives for participation, and ensuring adequate financing as starting points. We created working groups to tackle questions and challenges related to each of these three areas and an Advisory Council to oversee the outcomes of the working groups and provide overarching recommendations for the initiative. The working group and Advisory Council members are listed in Appendix A. Further, we engaged a range of external organizations from across the world to share the vision and gain additional input on the activities of an early warning system. This report, which is informed by those discussions, seeks to offer minimum requirements for data collection, potential incentives, and financing considerations that can serve as a foundation for formalizing an early warning system.

Guiding Principles

Through the course of this work, several guiding principles emerged:

1. An early warning system should be viewed as a global public good.
2. Early warning is a collective responsibility. It is not the responsibility of governments and the health sector alone.
3. An early warning system coordination and governance entity must be diverse and representative of all participating countries.
4. All countries must benefit from an early warning system. Benefits should also accrue to the regional and local levels.
5. An early warning system must empower regional and local communities to act quickly to lower the risk of emerging threats.
6. An early warning system should leverage, integrate, and strengthen existing infrastructure and capabilities.
7. The inputs and outputs of an early warning system should integrate into a country's public health system when possible.
8. Sustainability of political commitment, partnerships, and financing must be designed into an early warning system.

Blueprint for a Global Early Warning System

As a starting point, experts agreed that an early warning system capable of pre-event and early event surveillance must have the following elements to predict future outbreaks:

- Monitors microbe, animal, and human interfaces;
- Provides strategic information on the geographies and animal populations at highest risk of zoonotic spillover to humans;
- Captures traditional and nontraditional sources of outbreak information;
- Characterizes pathogens in pre- and early event settings to provide information on their evolution and risk;
- Captures and integrates human behaviors (e.g., population migration, conflict, and climate events) to better identify potential areas of risk;
- Leverages data collected from historical events and outbreaks for insights (such as on the behaviors and practices that drive spillover);
- Leverages the newest genomic sequencing technologies and most advanced prediction methods; and
- Ensures all data captured are translated into insights to support outbreak response and decision-making.

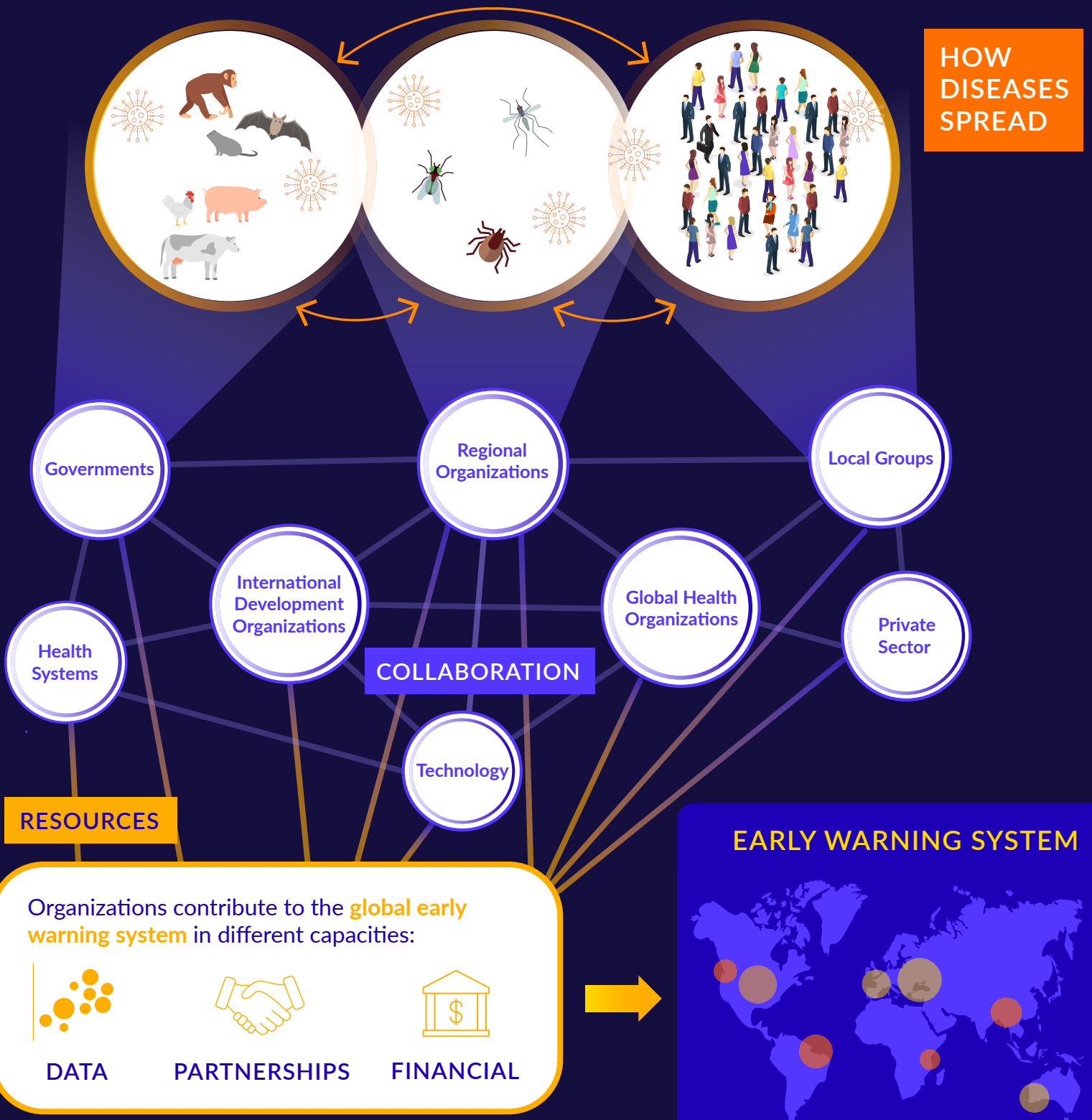
Traditional data refers to longitudinal sampling from humans, livestock, and wildlife (e.g., biologic, epidemiologic, and ecologic samples) to monitor known and emerging pathogenic spread. In other words, it refers to data that are commonly used in surveillance, including laboratory samples, health records, registries, symptom and disease reports (e.g., from health centers or schools), and administrative data sets.

Nontraditional data refers to data that can signal outbreaks that do not come from traditional data sources, such as health centers and laboratories. Sources of nontraditional data can include wastewater samples, human migration patterns, rates of deforestation in high-risk disease spillover hotspots, emerging trends in climate change, geospatial data (e.g., imaging from hospital parking lots), mobile technology, satellite imagery, the internet (e.g., searches and social media), financial transactions (e.g., pharmacy purchase data), and privately held data (e.g., credit card expenditures).

Achieving such a system requires multisectoral and multilateral collaboration—and the right incentives to drive that collaboration. An early warning system must leverage the combined strengths of governments, multilateral organizations such as the WHO, Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE), international development organizations, regional and local community organizations, as well as partners from around the world in data, technology, health, and philanthropy.

Figure 2 visualizes the different components of an early warning system. Starting with the top of the image, an early warning system must focus on the interfaces between animals and humans. Moving from top to bottom, the image captures some of the entities that conduct activities that can support an early warning system. Governments, philanthropies, foundations, international development organizations and banks, and the private sector must come together in new ways to achieve the vision of an early warning system outlined in this report. In addition, there must be strong coordination across the local, subnational, regional, and global levels. The bottom of the figure depicts the culmination of multilateral and multisectoral collaboration—an early warning system that can generate insights to inform local, regional, and global action.

Figure 2. Blueprint of a Coordinated Global Early Warning System



Source: Milken Institute (2022)

COMPONENTS OF AN EARLY WARNING SYSTEM

Governance

An early warning system must be built on a responsive, agile, and transparent governance model. A governance body must set a clear organizational mandate, establish legal and ethical guidelines around data collection, usage, and ownership, set the terms for global collaborations and partnerships, explore options or create innovative models for sustainable financing, and utilize policy and behavior change strategies to achieve the goals of an early warning system. It also includes fostering trust and encouraging direct involvement among participating countries and organizations to lend credibility to its decisions.

To prevent asymmetries in access and value, leadership from the countries in which spillover events and disease outbreaks are most likely to occur must be woven into a strong governance strategy. An early warning system is just as dependent on leadership from subnational and local-level players as it is on high-level global leaders for executing on-the-ground activities like data collection and supporting the coordination of data and disease surveillance response measures. To ensure that all stakeholders are engaged, the governance body must further evaluate how it can empower civil society organizations to advocate for bottom-up change from local and national governments.

Data

An early warning system would build on existing surveillance infrastructure and fill gaps where data do not exist. It would aggregate and analyze both traditional and nontraditional data (as defined on page 6) in order to generate insights.

Several top-down questions can serve as a starting point for determining the types of data that a robust early warning system should be expected to collect on the regional, country, local, and sub-local levels. These questions, and the baseline data sources required to answer them, are outlined in Table 1. By answering these questions, a system can help prioritize emerging microbes and hotspot regions as well as identify areas where clusters of unknown diseases are emerging.

Table 1. Minimum Data Questions for an Early Warning System

	Question	Data Sources
PRE-EVENT	What are the high-risk microbes (viruses and bacteria), and where are they emerging?	Microbe-specific: as defined by class, type (bacteria, viruses, and parasites), and occurrence (endemic, sporadic, and outbreak) data
	Where are the hotspot areas with the highest risk of experiencing animal-to-human disease spillover? What animal hosts are most likely to be involved in spillover? What animal species, especially those close to humans, should be monitored?	Animal-specific: as defined by category (domestic or wildlife), type (aquatic or terrestrial), class, order, family, genus, and species data
	Which high-density hotspots are rapidly changing to be at greater risk of spillover pathways? Which geographical locations where animal hosts reside are facing environmental stressors, including land-use changes and urbanization? What interfaces are driven by human behaviors and practices (such as wet markets and guano caves) that elevate the risk of spillovers?	Ecologic: as defined by climate, deforestation, and mining data
EARLY EVENT	Which viruses are seasonal, and where do they pose the greatest risk? Where are resistant or variant strains of high-risk microbes with significantly different potential impact within animals and humans emerging? What diseases are spiking in animal species, and where are these outbreaks happening?	Epidemiologic: as defined by disease emergence incidence data, case-fatality ratios, and transmission rates Genomic: as defined by sequences by clade/country/territory and the regional distribution of clades/variants Metadata: as defined by the geographic origin of the sample, the age of the host, and the lab at which the sample was sequenced

Table 1. Minimum Data Questions for an Early Warning System (continued)

	Question	Data Sources
EARLY EVENT	Where is the initial emergence of zoonotic pathogens in humans occurring? Where are clusters of unknown disease occurring based on syndromic observations in humans? How unusual is the unknown disease in terms of pattern or severity in humans? What symptoms are being noted, and what drugs are being prescribed by clinicians for unknown disease out-breaks in humans?	Human-specific: as defined by diagnosis/ treatment data (fever of unknown origin) and behaviors associated with viral spillover and spread (e.g., wet markets and guano caves) Nontraditional: as defined by data that include, but are not limited to, internet-based data (e.g., search and social media data), financial transactions (e.g., pharmacy purchase data), privately held data (e.g., credit card expenditures), wastewater testing, and satellite imagery (e.g., to assess movement and behavioral trends, such as a shift in hospital parking lot usage)

Source: Milken Institute (2022)

Given this baseline set of questions, FasterCures, in consultation with the working group, reviewed 12 existing data and technology-focused initiatives (described in Appendix B) to determine those collecting data that can help answer any of the questions above.

As Figure 3 shows, most of the data required to answer the minimum data questions are already collected through these initiatives. However, data from these efforts will need to be aggregated and analyzed, which will require robust data sharing. A strong governance structure, as noted above, will be essential to harnessing the collective insights of these datasets.

Figure 3. Sample of Existing Data Initiatives

	Data Questions	Africa PGI	CREID	DEEP VZN	FAO-OIE-UNEP-WHO	GIHSN	GISAID	GISRS	HealthMap	Premonition	ProMed	UK CPP	WHO Hub	Intelligence Community	Search Engines	Social Media	Wastewater Systems
PRE-EVENT	What are the high-risk microbes (viruses and bacteria), and where are they emerging?	X	X	X			X			X	X	X	X				
	Where are the hotspot areas with the highest potential risk to experience animal-to-human disease spillover?		X	X						X				X			
	What animal hosts are most likely to be involved in spillover?		X	X						X							
	What animal species, especially those close to humans, should we be monitoring?		X	X						X							
	Which high-density hotspots are rapidly changing to be at greater risk of spillover pathways?			X										X			
	Which geographical locations where animal hosts reside are facing environmental stressors, including land-use changes and urbanization?																
	What interfaces are driven by human behaviors and practices (such as wet markets and guano caves) that elevate the risk of spillovers?												X				
EARLY EVENT	Which viruses are seasonal, and where do they pose the greatest risk?	X				X	X	X	X			X					
	Where are resistant or variant strains of high-risk microbes with significantly different potential impact within animals and humans emerging?	X			X	X	X	X	X	X		X					X
	What diseases are spiking in animal species, and where are these outbreaks happening?			X	X					X		X					
	Where is the initial emergence of zoonotic pathogens in humans occurring?	X	X	X	X		X	X		X		X				X	X
	Where are clusters of unknown disease occurring based on syndromic observations in humans?					X			X	X						X	
	How unusual is the unknown disease in terms of pattern or severity in humans?					X			X						X	X	
	What symptoms are being noted, and what drugs are being prescribed by clinicians for unknown disease outbreaks in humans?					X			X						X	X	

Source: Milken Institute (2022)

Incentives

A global early warning system cannot be truly functional without strong political commitments from governments around the world. Indeed, many governments and organizations have invested heavily in pandemic preparedness. But lack of global coordination and leadership across these efforts has given rise to siloed initiatives.

At the same time, governments should not be expected to bear this burden alone. Formalizing a global early warning system will require the participation of international development organizations, philanthropies, the private sector, as well as communities and individuals, which collectively bring to the table the resources, data, technologies, and advocacy that will be needed. Just as important, disincentives for participation must also be understood and mitigated. For example, there is much work to be done to unwind the effects of the inequitable distribution of COVID-19 vaccines and therapeutics, as well as the unequal application of travel bans, such as those imposed after South Africa's reports of the Omicron variant in November 2021. These instances have only served to remind global leaders of the fragility of international cooperation and solidarity.[2]

Participation should initially be linked to an understanding of disincentives and incentives in the following three areas:

1. **Data sharing:** Key inputs of an early warning system are traditional and nontraditional data that can be provided by existing data platforms. Incentives for these constituents to provide access to these data sets in support of an early warning system are critical to define.
2. **Global collaboration:** There is a long tradition of multinational cooperation to advance global health goals, and an early warning system should be no different. However, during the COVID-19 pandemic and other past public health crises, the strength of commitments to global collaboration was put to the test. Incentives will need to be in place to encourage all parties to come to the table.
3. **Sustainable financing and partnerships:** Establishing the path to sustainability will be crucial to mobilizing an early warning system. Other strategic priorities will compete for investment; thus, incentives must encourage sustained financial commitments to early warning-related initiatives.

The incentives outlined in Tables 2 through 4 below are intended to serve as a starting point for understanding the range of drivers around data sharing, collaboration, and sustainable financing in the context of creating an early warning system. The potential effectiveness and feasibility of these incentives will differ by country and will need to be weighed against country- and region-specific factors. They also warrant a deeper discussion and vetting with global stakeholders to ensure that all potential incentives are fully explored.

Table 2. Incentives for Data Sharing

Governments	Philanthropies, Research, and International Development Organizations	Private Sector	Communities and Individuals
Access to cutting-edge genomic sequencing technologies in exchange for national data on sequences of novel/ emerging pathogens Access to technical assistance to set up an early warning system or other disease-related surveillance Access to other diagnostics, therapeutics, vaccines, and medical supplies at accessible price-points, or within tiered pricing structures established to ensure low-cost access to low- and middle-income countries Access to resources to build research capacity and strengthen health systems Increased benefits of stability and innovation in exchange for timely and open access to public-sector data	Serve as a trusted leader in data aggregation and analysis Serve as a champion of global behavior change around data sharing, becoming the "go-to" source for pathogen information, especially when new outbreaks happen Benefits of more diverse data inputs and material resources to achieve organizational mission in exchange for data already collected	Access to grants and public-sector funding to better tackle health-care and scientific challenges in exchange for sharing of data Benefits of integrating with other (e.g., public) data sets to produce richer insights Creation of new or more predictable markets and market opportunities through the exchange of data, potentially increasing access to private capital and investments Mitigate potential for future economic—and profit—losses (e.g., early containment)	Access to tools, training, and economic incentives for individuals at the forefront of potential spillover hotspots and outbreaks—including farmers, food service workers, and local health-care providers Access to insights generated from pooled data that can inform decision making to mitigate risk

Source: Milken Institute (2022)

Table 3: Incentives for Global Collaboration

Governments	Philanthropies, Research, and International Development Organizations	Private Sector
Serve as a voice at the table in the writing of bilateral and multilateral agreements that allow countries to set their own terms around early warning system activities Benefits of recognition of global contributions to public health and safety by the broader international community Benefits of the transfer of best practices from donor countries to help track global progress and inform policy discussions on pandemic prevention using empirical evidence Benefits of donor countries' efforts around early warning system workforce training, facilitated by the global shift to online/virtual courses, trainings, and meetings Benefits of international assistance to contain outbreaks as soon as they are reported	Benefits of building trust with low- and middle-income countries through promoting early warning system data privacy and ownership parameters Benefits of global recognition as a key interlocutor between stakeholders, identifying potential and areas of need Serve as an anchor of international cooperation at the national, regional, and global levels	Access to opportunities to pilot and scale new products and services that could benefit the early warning ecosystem (e.g., cutting-edge disease surveillance technologies, medical countermeasures, innovations in immunizations and epidemiology) Benefits of global profile raising through corporate social responsibility efforts related to an early warning system

Source: Milken Institute (2022)

Table 4. Incentives for Sustainable Financing and Partnerships

Governments	Philanthropies, Research, and International Development Organizations	Private Sector
Benefits of new funding sources to bolster early warning capabilities and overall health system strengthening Benefits of having strategic direction-setting power through collaboration with donor and recipient governments through early warning system board representation and voting rights Increased flexibility and capacity to adapt to evolving funding needs	Benefits of greater overall funding for organizational priorities in the form of complementary resources and external support for an early warning system from development partners and national governments	Benefits of long-term return on investments, manifesting as increased overall productivity, social stability, and corporate growth as a result of contributing to a meaningful effort

Source: Milken Institute (2022)

Financing Considerations

Despite recognition of an early warning system as a global good, securing the long-term financing necessary for its implementation will be challenging. As we move further away from the start of the COVID-19 pandemic and other priorities start to regain attention, political will—and along with it, commitments to finance—will wane. While all eyes and ears are on pandemic preparedness now, funding can dwindle as the crisis moves past the acute stage. The costs to implement an early warning system will be significant (some of the cost categories are listed in Appendix C), though it is important to recognize that such costs are outweighed by the financial and social burdens of an unmitigated pandemic.[3] Although existing data sets and infrastructure will be leveraged, the costs to integrate these capabilities and expand them to the level needed for a robust system will be substantial—this includes investment in infrastructure to ensure adequate health system and laboratory capacity and integration to conduct early warning activities. New investments will be needed as well, particularly to address existing gaps in infrastructure and spur greater innovation in diagnostics, data sharing platforms, and data analytics.

Innovative financing strategies involving many different types of stakeholders across sectors will be needed to ensure the sustainability of the system. This sentiment was shared among other groups concerned with financing to prevent future pandemics, including the G20 Independent Panel for Pandemic Preparedness and Response (the Independent Panel) on Financing the Global Commons for Pandemic Preparedness and Response.[4] Many resource-limited governments will not have the domestic resources to reallocate or mobilize investments without trade-offs in other important areas.

Financing strategies will require a combination of grants and donations, as well as financial investments and in-kind contributions (e.g., technologies, personnel) from the private sector, international development organizations and banks, philanthropies, and foundations. But there are limitations to these sources in terms of sustainability. Grants and donations can support global health programs and initiatives but are not intended to be a sustainable source of revenue. International development organizations and philanthropies will be important sources of funding for specific activities, but a heavy reliance on these contributions can limit budget and spending flexibility and will be subject to fluctuation depending on funder priorities. Private corporations, particularly investors, are a relatively untapped source of funds because of their traditional requirement for a return on investment—and revenue-generation is not something development-focused activities do or can guarantee. Therefore, their role in financing must be thoughtfully and transparently devised to ensure their participation does not undermine efforts to build trust.

Given these considerations, financing for an early warning system must integrate multisector stakeholders. Such integration will lend itself to co-financing and blended financing (that is, the use of public or philanthropic funds to catalyze private sector investment) options for greater and more sustainable variety in fund sources. It will also foster collaboration among entities and initiatives to coordinate on areas where funding gaps exist. PPPs can expand opportunities for financial and in-kind resources and provide an avenue for private organizations to contribute to an early warning system. PPPs' structural flexibility—combined with their ability to follow for-profit or nonprofit models, create a new entity or expand upon an existing one, and be established through informal or formal channels—enables initiatives to mobilize and change without the bureaucratic constraints that independent public-sector, private-sector, philanthropic, or other entities navigate when pursuing new initiatives. The global disease surveillance space could benefit from the creation of an early warning-focused PPP because multisector partnership lends itself to a range of benefits that would otherwise not be available through collaboration among governments or other entities alone.

To facilitate understanding of the range of potential financing mechanisms to support an early warning system, Table 5 lists possible financing mechanisms according to type of funder. These mechanisms are further disaggregated into the types of investments they can fund (e.g., infrastructure, technology, human resources). The private sector, as noted in the table, encompasses a range of for-profit entities, including private equity firms and other financial investors, companies producing goods or services necessary for conducting early warning activities, and insurance and re-insurance agencies.

Table 5. Financing Mechanisms Explored to Support an Early Warning System

Cost Categories	Governments	Philanthropies and Foundations	International Development Organizations and Banks	Private Sector	Governments, Philanthropies and Foundations, and Private Sector
INFRASTRUCTURE	**Revenue collection** including tax restructuring and solidarity levies/ taxes **Project finance/ bond issuance** **Guarantees** to facilitate infrastructure development and health system strengthening **First-loss capital** **Compulsory contributions**	**In-kind contributions** **Grants** **Blended finance**	**Blended finance** (e.g., the US International Development Finance Corporation incorporates funding from multiple sectors to reduce financial risk by providing guarantees to local banks) [5] **Non-concessional loans** **Loan guarantees**	**Revolving loan funds** **Impact-focused equity fund** **Blended finance model utilizing debt and equity in the capital structure**	**Combination of funding and financing within a blended project finance model**
TECHNOLOGY	**Increased investment** toward the development and purchase of technologies **Push-funding mechanisms** to lower the cost of research and development through tax incentives and regulatory changes **Innovation funds**	**In-kind contributions** **Grants** **Program-related investments into impact funds or debt models**	**Equity investments** **Concessional loans** **Grants**	**In-kind technology and data donations** **Impact investing fund for new technology companies** **Low-cost loans** for scaling up data collection activities based on projected revenue from government offtake agreements	**Advanced market commitments/ offtake agreements**

Table 5. Financing Mechanisms Explored to Support an Early Warning System (continued)

HUMAN RESOURCES	**Social insurance tax** to support the execution of sustained surveillance activities	**Debt buy-downs** to fund the development of domestic health programs, including personnel and resources necessary to execute programmatic activities **In-kind contributions** **Grants** **Development impact bonds (end payer)**	**In-kind contributions** **Voluntary contributions** **Assessed contributions**	**Development impact bonds (upfront investors)** where private investors pre-finance social programs and public sector pays investors back if they deliver on programmatic goal	**Development impact bonds/ Results-based funding** **Surge financing** that can be used when risk is identified to deploy increased personnel for data collection/ monitoring
MISCELLANEOUS	**Reallocate domestic finances** for country health system strengthening	**Grants** **In-kind resource donations**	**In-kind resource donations** **Voluntary contributions** **Assessed contributions**	**Grants** **In-kind resource donations**	**Co-financing** among philanthropies, foundations, the private sector, and individual governments to advance health systems and support a shift from external donations toward domestic sources of financing

Source: Milken Institute (2022)

MOBILIZING AN EARLY WARNING SYSTEM

The data, incentives, and finance considerations described above are intended to serve as starting points for establishing the framework of an early warning system. In parallel, it is crucial to consider the coordinating and governing entity that could assume responsibility for mobilizing these activities. There are three potential paths for moving forward. The first is focused on expanding and improving existing structures and organizations. This approach is viewed as the most efficient, in particular because established norms, regulations, and relationships with member countries can be leveraged. The second is focused on taking a transformative approach and building a new effort. The final path combines these two approaches, calling for a new coordinating entity that would bring new voices to an early warning system but still work within the paradigms established by existing organizations.

Option 1: Mobilizing Existing Structures and Organizations

Support for expanding existing structures is often grounded in the difficulties and complexities of securing political will for a de novo effort. Proponents of formalizing an early warning system within existing structures and organizations argue these entities have already laid the groundwork for cooperation that would take too long to replicate. Adding value to what already exists could bring more stakeholders in—rather than be viewed as a competitive threat.

World Health Organization

WHO has the unique ability to shape cooperation among global governments and already conducts indicator-based surveillance for specific diseases, such as seasonal, pandemic, and zoonotic influenza. WHO's capacities, in addition to the FAO's and the OIE's disease surveillance and response work, are detailed in "A Global Early Warning System for Pandemics: Mobilizing Surveillance for Emerging Pathogens." As mandated by the International Health Regulations (IHR)—the legal framework that defines countries' rights and obligations in handling public health events and emergencies that have the potential to cross borders—WHO is responsible for supporting its member states in developing implementation plans and core competencies for surveillance and response activities.[6]

There is strong support for revising the IHR to include an early warning system as an important part of pandemic preparedness. The IHR have not been updated since 2005, and many see the potential to update the IHR to include early warning activities. From a financing perspective, there are potential benefits to revising the IHR as well. For example, the World Bank refers to the IHR to assess countries' pandemic preparedness. If the IHR included requirements to strengthen early warning surveillance capabilities, it provides an avenue for funding. The challenge to this approach ultimately lies in the time it takes to revise the IHR, which may hamper efforts to build upon the momentum created by the current pandemic. The capacity within WHO to support well-resourced early warning system activities may also pose a barrier, especially given that critical functions within WHO for disease surveillance are already under-resourced. Finally, the lack of a clear pathway for WHO to engage with the private sector to leverage new, critical technologies and expertise would undermine its ability to mobilize a multisectoral early warning system with broad participation.

Regional Organizations

Trusted networks on the ground could also be leveraged for early warning. Regional organizations work in the interest of their member states, are agile, and can mobilize members quickly. One can look at the success of Africa Centres for Disease Control and Prevention (Africa CDC) in mobilizing the continent-wide response to COVID-19.[7] The continent's achievement can be credited to a rapid, coordinated response among African leaders, drawing from past experiences with infectious diseases, and proactive engagement of political and other local leaders and community health workers.

The Caribbean Public Health Agency is another example of a regional organization that serves as a trusted public health agency in coordinating surveillance across communities in the Caribbean. Its Caribbean Public Health Laboratory Network (CariPHLN) coordinates surveillance through collaborations with laboratories and health centers across the region. During the COVID-19 pandemic, CariPHLN surveyed laboratory capacities in the area to inform infrastructure needs, educate health and laboratory professionals on safe practices for specimen handling, and maintain regular communication with public health professionals regarding new guidelines and publications.[8]

On the multi-regional front, Connecting Organizations for Regional Disease Surveillance (CORDS) demonstrates how many countries and regions can work together to identify and communicate disease signals. Working through regionally-coordinated partnerships, such as the Mekong Basin Disease Surveillance, the Southeast European Center for Surveillance and Control of Infectious Diseases, and the Middle East Consortium on Infectious Disease Surveillance, CORDS leverages existing surveillance capacities and pre-established, trusted networks to encourage collaboration, promote innovation, build networks, and share information necessary for preventing disease spread.[9]

Option 2: Mobilizing a New Coordinating Entity

Some in the global health community are skeptical that the current international system has the wherewithal to formalize an early warning system, primarily because existing structures are member-state-driven. Proponents of a transformative approach argue that adding bits and pieces to the existing system will not address all issues, such as inefficient bureaucratic processes and the inability to leverage private-sector expertise, among others. Layers of complexity created by long-standing political dynamics would slow down the process of mobilizing an early warning system. Creating a new structure that can fully engage with private-sector partners to attract sustainable investments and financing to underpin the activities of an early warning system was proposed. Gavi or COVAX, which includes robust private-sector, civil society, and government collaborations, are potential models.

Support for creating a new political structure, such as the Global Health Threats Council, as proposed by the Independent Panel, also emerged. The WHO director-general appointed the Independent Panel in response to a World Health Assembly (WHA) resolution calling for an independent review of lessons learned from the COVID-19 pandemic. The council would be led at the head of state and government levels, and the membership would include state and relevant non-state actors. As described by the Independent Panel, the council would help secure high-level political leadership and ensure that attention to pandemic prevention, preparedness, and response is sustained over time. The council would have the ability both to use accountability mechanisms and to provide access to financing.[10]

Option 3: A Mixed Approach to Mobilization

Most support taking an incremental approach that not only would seek to strengthen existing institutions such as WHO but also would create a new mechanism that would include the private sector and civil society. While neither the United Nations (UN) nor any of its family of organizations would serve as a global coordinating center, it is critical that specialized agencies such as WHO, FAO, and OIE are included in the effort because they are essential to the success of an early warning system. Therefore, WHO and other organizations would continue to play a central role, but a new entity would be responsible for the functioning of an early warning system, establishing governance and standards, and overseeing data sharing and operations while ensuring a federated approach to disease surveillance. Coordination and governance would sit outside the UN, and the new entity would create a new governing framework.

The International Civil Aviation Organization (ICAO) is a potential model for this option. ICAO is a UN agency focused on developing the aviation standards and practices by which governments and airlines abide. Similar to the early warning system, ICAO was formed after a global event (in its case, WWII) where a need for common regulations became evident. Under ICAO, the civil aviation organizations of each UN member state are the primary constituents and own responsibility for updating ICAO's operating procedures. These organizations serve as technical bodies to address issues and changes to the group's operating procedures, while additional players—such as civil society and industry—participate in discussions about the creation or revision of standards. A widely accepted benefit of ICAO is its technical and largely apolitical role in instituting air traffic regulations, which has facilitated its ongoing acceptance as a global leader and regulation setter.[11]

RECOMMENDATIONS FOR FUTURE FOCUS

The COVID-19 pandemic has energized commitments around the world to invest in pandemic preparedness capabilities, yet early warning activities—as described in this work—continue to receive significantly less attention than disease surveillance and response activities. Below we highlight three areas in which advocacy efforts from the global health community can help advance an early warning system.

Revision of the IHR

There is broad support for providing input into efforts to amend the IHR to integrate early warning system activities. In response to the ongoing COVID-19 crisis, in December 2021, the WHA—WHO's decision-making body—announced that it would propose a new global convention under WHO's constitution to strengthen pandemic prevention, preparedness, and response. As an important first step, the assembly has established an intergovernmental negotiating body (INB) to draft and negotiate this new provision. The INB met in late February 2022 and authorized negotiations for an international treaty and amendments to the IHR. A working draft with further details will be shared in August 2022, with the aim to submit a final convention for consideration by the 77th WHA in 2024. The WHO director-general will be closely involved in the INB's work, which will also include participation by other UN entities, non-state actors, and other relevant stakeholders, creating an opportunity to inform this process.[12] According to the WHO, non-state actors fall into four groups: nongovernmental organizations (NGOs), private-sector entities including international business associations, philanthropic foundations, and academic institutions.[13]

An Early Warning-Specific Ethical Code of Conduct

As the formal process for updating the IHR gets under way, a potential informal, parallel opportunity exists to begin to outline an ethical code of conduct for early warning activities. The creation of a new code of conduct presents a chance to start fresh and may be a more expedited path to achieving international consensus. A global code of conduct developed outside WHO or an existing entity can either later be adopted by WHO member states or used to establish a framework for global coordination on an early warning system.

An example of a code of conduct established outside formal WHO processes and later adopted by member states is the achievement led by the Honourable Mary Robinson, former president of Ireland, and Francis Omaswa, former Ugandan Ministry of Health official, between 2007 and 2009 to establish the Global Health Workforce Alliance. Under their leadership, an informal body of experts was convened to quickly and efficiently draft a new set of global provisions to address the crisis of a shortage of health workers in low- and middle-income countries at the time. This draft code was ultimately negotiated with WHO member states to enact an official Code of Practice on the International Recruitment of Health Personnel. Following its approval, the code of practice served—and still serves—as an important instrument in the global response to the health worker migration issue by setting out guiding principles and international ethical standards for the recruitment of health workers. While it is technically a non-binding international instrument, it has provided a significant step toward the development of an effective framework of international cooperation on the issue.[14]

The Private Sector

The role of the private sector in solving global health challenges has been inconsistent and ill-defined, as few in the private sector have outlined a strategy for how they will contribute to improving global health (in contrast to climate change, for example).[15]

There is a need for more advocacy to increase engagement of the private sector on global health issues and to address barriers that preclude more private sector participation. In this report, the "private sector" refers generally to industry, technology companies, health-care providers, investors, and other privately held organizations. However, the private sector comprises disparate groups with different motivations for participating in an early warning system. Each of these groups can also make different types of contributions, from data/analytics to diagnostic and technological innovations to financing, and engagement strategies based on these contributions will need to vary. A critical next step toward creating an early warning system will be to deconstruct the private sector to better understand the barriers and facilitators to the groups' participation in an early warning system and to examine incentives more specifically for each type of group.

IMMEDIATE NEXT STEPS

The ideas in this report offer a starting point for mobilizing an early warning system. No single entity can achieve the vision we have outlined by acting alone. Progress toward an early warning system will require the collaboration of countries, international development organizations, philanthropies, the private sector, communities, and others. Below we highlight some immediate next steps that we see as the most critical and actionable items to continue to build toward an early warning system. The Milken Institute will continue to advance this vision and we encourage other global organizations that sit at the intersection of the public, philanthropic, and private sectors to take a leading role.

1. Convene and socialize recommendations for an early warning system with political leaders, global health leaders, and existing organizations and networks.
2. Map out organizations and stakeholders "outside the box" of traditional disease surveillance efforts but with a vested interest in a global early warning system. Start early engagement with them to broaden the circle of support and bring new voices to the table.
3. Build consensus around a data governance framework that defines roles, responsibilities, and processes for accountability and ownership.
4. Leverage this blueprint to inform the development of a technology solution that takes into account existing data and technology efforts and aligns with new global efforts.
5. Build a strategy for prioritizing surveillance in hotspot areas and invest in local capacities to allow for data collection and signal reporting activities.
6. Deepen our understanding of the barriers and facilitators to participation by the private sector and develop appropriate incentives accordingly.
7. Design innovative financing mechanisms to support an early warning system that mobilizes private investment alongside public and philanthropic capital.

CONCLUSION

Timing is essential. We cannot let perfection stand in the way of progress nor wait to solidify the parts of an early warning system requiring further deliberation. A large amount of innovation has occurred in the global health and security space over the course of the pandemic. The governing body of an early warning system should seek to leverage these existing innovations, data collection methods, and global alliances to realize an immediate impact to help prevent the next pandemic.

APPENDIX A:

Consulted Stakeholders

FasterCures appreciates the insights and guidance of the project's Advisory Council and working group members in developing the blueprint for an early warning system.

Advisory Council

Rick Bright, The Rockefeller Foundation, Pandemic Prevention Institute

Dennis Carroll, Global Virome Project and University Research Co.

Steve Davis, Bill & Melinda Gates Foundation

Dylan George, Center for Epidemic Forecasting and Outbreak Analytics, US Centers for Disease Control and Prevention

Chris Graves, Ogilvy Center for Behavioral Science

Peter Jackson, INFEX Therapeutics

Nicole Lurie, CEPI

Vanessa Moeder, Illumina

Jennifer Nuzzo, Johns Hopkins Bloomberg School of Public Health

Sharon Peacock, Wellcome Sanger Institute and University of Cambridge

Mauricio Santillana, Harvard Medical School, Harvard T.H. Chan School of Public Health, and Boston Children's Hospital

Paul Tambyah, International Society of Infectious Diseases

Anupama Tantri, Merck

Oyewale Tomori, University of Lagos

Andrew Weber, The Council on Strategic Risks

Data Working Group

Asia Pacific Society of Clinical Microbiology and Infection

Bioinformatics Institute

Boston Children's Hospital

CEPI

data.org

Food and Agriculture Organization of the United Nations

Foundation for Influenza Epidemiology

Georgetown University

Global Virome Project

Harvard Medical School

Harvard T.H. Chan School of Public Health

Illumina

International Society of Infectious Diseases

Johns Hopkins Bloomberg School of Public Health

National University Hospital, Singapore

Peking University Center for Public Health Preparedness and Response

The Rockefeller Foundation, Pandemic Prevention Institute

Stanford School of Medicine

The Trinity Challenge

University of Lagos

University of KwaZulu-Natal, Stellenbosch University, South Africa

University Research Co.

Data Working Group (continued)

US Agency for International Development

US Centers for Disease Control and Prevention

US Department of Health and Human Services

Wellcome Sanger Institute

World Health Organization, Global Influenza Surveillance and Response System

Governance & Partnerships Working Group

Ateneo de Menila University School of Medicine and Public Health

Bill & Melinda Gates Foundation

CEPI

The Council on Strategic Risks

Jacobs

National University of Singapore

Ogilvy Center for Behavioral Science

Rabin Martin

Ready2Respond

Resolve to Save Lives

US Department of Health and Human Services

World Health Organization

Yong Loo Lin School of Medicine

Finance Working Group

Center for Global Development

Global Fund

Global Health Security and Sustainable Financing for Preparedness, Office of Global Affairs, US Department of Health and Human Services

Merck

The Palladium Group

US Agency for International Development

World Bank

APPENDIX B:

Existing Data and Technology-Focused Initiatives

Africa Pathogen Genomics Initiative

Africa CDC Institute of Pathogen Genomics, through the Africa Pathogen Genomics Initiative (Africa PGI) aims to enhance disease surveillance and public health partnerships through integrated, cross-continent laboratory networks equipped with the tools, human resource capacity, and data infrastructure to fully leverage critical genomic sequencing technologies.

Nearly 140 disease outbreaks are detected annually across Africa. Genomic sequencing technology will provide the scientific evidence needed for health systems to better prevent, identify, and track these outbreaks, thus helping public health experts to stay ahead of novel pathogens and re-emerging diseases.

Centers for Research in Emerging Infectious Diseases Network

The Centers for Research in Emerging Infectious Diseases Network (CREID Network), composed of 10 Research Centers and a Coordinating Center, is a coordinated network operating in regions around the globe where emerging and re-emerging infectious disease outbreaks are likely to occur. Multidisciplinary teams of investigators will conduct pathogen/host surveillance, study pathogen transmission, pathogenesis, and immunologic responses in the host, and will develop reagents and diagnostic assays for improved detection of important emerging pathogens and their vectors.

Discovery & Exploration of Emerging Pathogens—Viral Zoonoses

Discovery & Exploration of Emerging Pathogens—Viral Zoonoses (DEEP VZN), a five-year, approximately $125 million project (pending availability of funds), will strengthen global capacity to detect and understand the risks of viral spillover from wildlife to humans that could cause another pandemic.
DEEP VZN will build and expand on previous work by significantly scaling up the United States Agency for International Development's (USAID) efforts to understand where, when, and how viruses spillover from animals to humans. USAID will share information it gathers with host-country and global partners to develop and implement interventions in communities to reduce the risks of virus spillover and therefore potential outbreaks.

FAO-OIE-WHO Tripartite Collaboration

These three organizations have worked together for many years to prevent, detect, control, and eliminate health threats to humans, originating—directly or indirectly—from animals. Putting the "One Health" vision into practice has been facilitated by a formal alliance between the three organizations. In this context, the FAO, OIE, and WHO acknowledge their respective responsibilities in combating diseases that have a severe impact on health and the economy, particularly zoonoses.

In 2010, the three organizations published a Tripartite Concept Note, describing their collaboration and

objectives in the prevention and control of health risks at the human–animal–ecosystems interface.

Global Influenza Hospital Surveillance Network

The Global Influenza Hospital Surveillance Network (GIHSN) is a network of sentinel hospitals identifying and characterizing acute respiratory infection cases in a systematic way and according to a similar protocol. This network currently consists of 100+ hospitals in 20+ sites worldwide and collects every year data from thousands of cases combining clinical data, virological data, and virus genome sequencing.
The SARS-Cov2 pandemic further demonstrated the value of such a resilient network driven by site empowerment, use of existing local infrastructure combined with capacity building, cross-country open collaboration, and data ownership by sites. Scope has been enlarged progressively to focus on various respiratory viruses including SARS-Cov2. This platform's features are particularly aligned with current pandemic preparedness discussion and are open to opportunities for synergies.

GISAID

The GISAID Initiative promotes the rapid sharing of data from all influenza viruses and the coronavirus causing COVID-19. This includes genetic sequence and related clinical and epidemiological data associated with human viruses, and geographical as well as species-specific data associated with avian and other animal viruses, to help researchers understand how viruses evolve and spread during epidemics and pandemics.

GISAID does so by overcoming disincentive hurdles and restrictions, which discourage or prevented sharing of virologic data prior to formal publication. The Initiative ensures that open access to data in GISAID is provided free-of-charge to all individuals that agreed to identify themselves and agreed to uphold the GISAID sharing mechanism governed through its Database Access Agreement.

Global Influenza Surveillance and Response System

Global influenza surveillance has been conducted through WHO's Global Influenza Surveillance and Response System (GISRS) since 1952.
GISRS is a system fostering global confidence and trust for over half a century, through effective collaboration and sharing of viruses, data and benefits based on Member States' commitment to a global public health model.

The mission of GISRS is to protect people from the threat of influenza by continuously functioning as a:

- global mechanism of surveillance, preparedness and response for seasonal, pandemic and zoonotic influenza;
- global platform for monitoring influenza epidemiology and disease; and
- global alert for novel influenza viruses and other respiratory pathogens.

GISRS currently comprises institutions in 124 WHO Member States.

HealthMap

HealthMap brings together disparate data sources, including online news aggregators, eyewitness reports, expert-curated discussions, and validated official reports, to achieve a unified and comprehensive view of

the current global state of infectious diseases and their effect on human and animal health. Through an automated process, updating 24/7/365, the system monitors, organizes, integrates, filters, visualizes, and disseminates online information about emerging diseases in nine languages, facilitating early detection of global public health threats.

The freely available website "healthmap.org" and mobile app "Outbreaks Near Me" deliver real-time intelligence on a broad range of emerging infectious diseases for a diverse audience including libraries, local health departments, governments, and international travelers.

Microsoft Premonition

Through a network of robotic sensing platforms, Premonition aims to continuously monitor our environment to detect potential pathogens and disease-carrying animals before they cause outbreaks. Robotic smart traps continuously monitor the environment for important types of insects, such as mosquitoes, which both transmit pathogens and collect blood samples from other animals. Meanwhile, Microsoft Premonition's cloud-scale genomic analyses try to identify all the species of organisms and viruses in environmental samples to spot new transmission patterns.

ProMED

The Program for Monitoring Emerging Diseases (ProMED) is an internet-based reporting system dedicated to the rapid global dissemination of information on outbreaks of infectious diseases and acute exposures to toxins that affect human health, including those in animals and in plants grown for food or animal feed.

Electronic communications enable ProMED to provide up-to-date and reliable news about threats to human, animal, and plant health around the world as quickly as possible. ProMED is the largest publicly-available system conducting global reporting of infectious diseases outbreaks.

UK Centre for Pandemic Preparedness

To build on the UK's global leadership role in health protection, a new Centre for Pandemic Preparedness (CPP) will be established as part of the UK Health Security Agency. The CPP is set to become a world-leading hub for all aspects of pandemic preparedness, starting with genomic surveillance of human and animal infections in collaboration with a range of scientific and academic partners, that can be shared around the world.

WHO Hub for Pandemic and Epidemic Intelligence

The WHO Hub will strengthen pandemic and epidemic intelligence through better data, better analytics, and better decisions across all aspects of public health emergencies at national and local levels.
As a global collaboration of partners from multiple sectors, the WHO Hub will enable innovators to co-create tools and use linked data that all countries need to prepare, detect, and respond to pandemic and epidemic risks. The WHO Hub will drive innovations to increase the availability and linkage of diverse data, develop tools and predictive models for risk analysis, improve public health decision-making, and monitor disease control measures and infodemics.

APPENDIX C:

Local, National, Regional, and Global-Level Costs and Activities of an Early Warning System

		Capital Cost *One-time cost*	Recurring Cost *Occurs once per year or more*	Outputs *What each level of the system is accountable for*
Local and National Labs and Sites	**Infrastructure**	• Development of new laboratory facilities • Testing equipment • Office space (new development, initial purchase of space)	• Maintenance of existing laboratory facilities • Testing equipment • Office space (if rented)	• Generates, manages, and reports data to regional coordinating center • Shares de-identified, limited data sets to appropriate regional hubs for analysis and risk identification • Garners community buy-in for sample collections and infrastructure building • Analyzes data for immediate public health and policy response • Assesses local operational and technological capacities, and reports needs to regional coordinating center to inform necessary resource support • Characterizes pathogens and genomic sequences in house, and reports results to regional coordinating center; regional coordinating centers will coordinate support when sequencing technology is unavailable
	Technology	• Data collection technology • Information reporting technology • Security technology for data transfer • Molecular diagnostic technology • Conventional diagnostics • Communication technology • Cloud infrastructure • Software licensing • Population-based civil registration and vital statistics or sample registration system	• Costs associated with ongoing licensing and account ownership • Costs associated with technology modernization and upgrades	
	Human Resources	Training: • Data collection • Information technology • Communications	Personnel:* • Field workers • Surveillance staff • Data encoders • IT support • Field trainers • Volunteers (no cost)	
	Miscellaneous		• Maintenance (facilities, technology) • Transportation • Resource mobilization (shipping, handling) • In-field materials and supplies (e.g., personal protective equipment) • Office supplies	

		Capital Cost *One-time cost*	Recurring Cost *Occurs once per year or more*	Outputs *What each level of the system is accountable for*
Regional Coordinating Centers	**Infrastructure**	• Office space (new development, initial purchase of space)	• Office space (if rented) • Office supplies	• Works with localities to establish community buy-in and ownership of ongoing early surveillance activities • Ensures that financial, human, and technological resources are effectively mobilized to appropriate localities • Leverages data-sharing agreements at local centers • Analyzes data and identifies local risks • Conducts quality assurance and proficiency testing at local labs • Communicates early warning signals with the global coordinating center and relevant localities to inform public health response • Facilitates coordination among human and animal laboratory systems • Provides training in data collection, information technology, communications, specimen collection, handling and referral processes, and biosafety standard operating procedures
	Technology	• Genomic sequencing technology • Data analysis tools • Modeling and risk analytics tools • Data management technology • Data analysis technology • Information reporting technology • Data security technology • Communication technology • Cloud infrastructure • Software licensing	• Costs associated with ongoing licensing and account ownership • Costs associated with technology modernization and upgrades	
	Human Resources		Personnel:* • Development officers • Fundraising/financial management staff (e.g., grant management delivery support) • Partner relations staff • Data encoders • Data managers • Program officers • Quality assurance officers (ensures compliance with scientific protocols) • Epidemiologists • Lab platform experts • Field trainers • IT support (in-country and coordinating center) • Human resources officers	
	Miscellaneous		• Maintenance (facilities, technology) • Travel costs (transportation, hotels, food) • Resource mobilization (shipping, handling) • Lab sample transport and coordination	

		Capital Cost *One-time cost*	Recurring Cost *Occurs once per year or more*	Outputs *What each level of the system is accountable for*
Global Coordinating Center	**Infrastructure**	• Office space (new development, initial purchase of space)	• Office space (if rented) • Office supplies	• Coordinates surveillance and data collection activities occurring at the regional and local levels • Establishes governance and principles for guiding coordinated activities and manages the risk assessment framework • Secures funding from various sources for use throughout the early warning system • Develops data management, security measures, and use standards to maintain a level of trust and value • Standardizes protocols and methodologies for surveillance and data management • Ensures quality control of data • Coordinates with regional coordination centers to build capacity, infrastructure, and training; deploy technical expertise; ensure quality control; and distribute resources to communities • Engages a range of stakeholders for garnering political will and local buy-in • Ensures early warning activities work alongside the UN, WHO, and Global Health Security Agenda efforts • Facilitates coordination among human and animal laboratory systems
	Technology	• Modeling and risk analytics tools • Data management technology • Information reporting technology • Data security technology • Communication technology • Cloud infrastructure • Software licensing	• Costs associated with ongoing licensing and account ownership • Costs associated with technology modernization and upgrades	
	Human Resources		Personnel:* • Board of directors • Scientific advisory group • Legal advisors • IT support • Database operations staff • Fundraising/financial management staff (CFO, COO, grants management) • Country support staff • Partner relations staff • Communications staff • Human resources officers • Administrative support • Monitoring and evaluation staff	
	Miscellaneous		• Maintenance (facilities, technology) • Travel costs (transportation, hotels, food) • Resource mobilization (shipping, handling)	

**Includes salaries, unless otherwise specified*

Source: Milken Institute (2022)

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ABOUT THE AUTHORS

Esther Krofah is the executive director of FasterCures and the Center for Public Health at the Milken Institute. She has deep experience in the government, nonprofit, and for-profit sectors, where she has led efforts to bring together diverse stakeholder groups to solve critical issues and achieve shared goals that improve the lives of patients. Most recently, Krofah was the director of public policy, leading GlaxoSmithKline's engagement with the US Department of Health and Human Services (HHS) and relevant Executive Branch agencies on broad health-care policy issues, including leadership in improving vaccinations and care for people living with HIV. Prior to GSK, Krofah served as the deputy director of HHS' Office of Health Reform, where she led the development of policy positions for significant regulatory priorities, including the health insurance marketplaces. Prior to HHS, Krofah served as a program director at the National Governors Association (NGA) health-care division, working directly with governors' health policy advisors, state Medicaid directors, and state health commissioners on health insurance, health workforce, and Medicaid coverage issues. Before joining the NGA, Krofah worked in consulting at Deloitte Consulting LLP, where she worked with public-sector and commercial clients, including assisting states in developing state-based exchanges. Krofah received a BA from Duke University and a Master of Public Policy from the Harvard University John F. Kennedy School of Government.

Sung Hee Choe is a senior director at FasterCures, a center of the Milken Institute. Prior to joining FasterCures, she was a managing director at Avalere Health. In this role, Choe focused on a broad range of health-care issues, with an emphasis on policies that aim to accelerate access to new treatments and to elevate the patient voice across the care continuum. At Avalere, she also oversaw the firm's content strategy, which involved leading new content development, identifying emerging trends and topics, and building consensus around research initiatives. Before Avalere, Choe spent a decade in the financial services industry, most recently as a vice president at BNY Mellon Investment Management. At BNY Mellon, Choe was the lead health-care analyst for a small-cap growth fund, for which she researched pharmaceutical, biotechnology, and medical device companies to identify investment opportunities. Choe received a BA from Mount Holyoke College and a Master of Public Health from the Milken Institute School of Public Health at The George Washington University. She is also a Chartered Financial Analyst® charterholder.

Alisha Sud is an associate director at FasterCures, a center of the Milken Institute. In her role, she supports

work related to health equity, cell and gene therapies, and building a global early warning system for pandemics. Prior to joining FasterCures, Sud was an analyst at the international strategic advisory firm Albright Stonebridge Group, where she worked with health clients on government affairs and business strategy. Sud received a BA in international development and Mandarin Chinese from the University of Vermont and a certificate in international studies from the Johns Hopkins University School of Advanced International Studies.

Anna DeGarmo is a senior associate at FasterCures, a center of the Milken Institute. In her role, she supports the mobilization of an international initiative to coordinate and elevate pathogenic surveillance. Prior to FasterCures, DeGarmo was a research intern at the Riverside Center for Excellence in Aging and Lifelong Health, where she aided studies focused on reducing caregiver burden and providing effective training for nursing home staff. She did further aging-related work assisting ChooseHome, a program dedicated to providing support and resources for older adults to age in place comfortably. DeGarmo received her BS in kinesiology and health sciences from the College of William and Mary in 2017 and is a Master of Public Health candidate at the Milken Institute School of Public Health at The George Washington University.


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