An assessment of unmet core global health security needs
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The research team traveled to Liberia to ground truth its findings from a cross-ministerial, country-level perspective. In a roundtable setting, partners from the National Public Health Institute of Liberia (NPHIL), Central Veterinary Laboratory, and Forestry Development Authority provided their expert perspective on how well the identified functions and initiatives align with the assessments, experience, and needs in their sector and at a national level. While in Liberia, we also benefitted considerably from attending additional meetings convened through Liberia’s One Health Coordination Platform to learn more about the country’s cross-cutting efforts across public health, forestry, environmental protection, agriculture, and other agencies. We especially thank Tolbert Nyenswah and Sonpon Sieh for their generosity in welcoming us and allowing us to learn from Liberia’s efforts.
PREFACE

The Ebola crisis of 2014-2016 in Guinea, Liberia, and Sierra Leone spurred a substantial rethinking of how the global community must orient itself toward preventing, mitigating, and responding to the impacts of major infectious disease events. Nations, companies, and philanthropies poured billions of dollars into direct Ebola response and into activities and initiatives designed to ensure against another Ebola-like event.

Four years later, we sought to understand where this self-reflection and new-found commitment to global health security has brought us. We looked not to the country level, where abundant programs and assessments are ongoing, but instead to the global stage of actors. Our intent was to capture the systematic initiatives operating worldwide to address the core functions outlined in prominent global health security frameworks. We suspected that behind the many and productive policy and programmatic efforts there remain core capabilities that are insufficiently addressed or not addressed at all at this level. We began with the assumption that progress was abundant yet uneven. We also assumed that the major frameworks themselves might be drawn too narrowly to account for the full scope of outbreak sources—intentional and unintentional spillover or release—and the distinct but complementary capacities needed to address them.

We know of no group that has undertaken an end-to-end review of the primary functions needed for effective prevention through recovery from pandemics, regardless of their origin, and an assessment of which functions are receiving insufficient attention. Any weak link in the global health security system can jeopardize the ability to prevent and manage high-consequence outbreaks. A high-level evaluation, therefore, is necessary and timely. Much of the work needed to build a world resilient to catastrophic health threats is really just beginning; we hope that this assessment will play a role in building the scaffolding to create that world.
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GLOSSARY

Recognizing that many of the following terms have multiple meanings or usages, this glossary provides definitions for the purpose of this report; these have been sourced or adapted from a variety of existing and published definitions.

**Biodefense.** Activities directed to thwart biothreats of intentional or unintentional origin.

**Biosecurity.** 1) Prevention of theft, diversion, or deliberate misuse of knowledge, skills, materials, and/or technologies from the biological sciences. 2) Prevention of the inadvertent release or transport of pathogens from hospitals, laboratories, farms, and other settings.

**Biothreat.** Short for “biological threat;” a biological pathogen or toxin with high-consequence potential for human or animal health or national security.

**Build back better.** The phases implemented after a disaster to increase resilience of nations and communities through integrating disaster risk reduction measures into restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies, and the environment.

**Collective health security.** The reduction of vulnerability of societies to disease threats (generally those that are caused by pathogens or acute toxic exposures) that spread across national borders.

**Detect.** A global health security pillar characterized by systems, policies, and procedures to gather and analyze information, provide early warning, and inform strategies.

**Emerging infectious disease.** An infectious disease caused by a pathogen previously unknown to science, previously unknown to infect humans, or markedly increasing in incidence or geographic range.

**Epidemic.** An occurrence of an infectious disease in a defined population at a level exceeding normally expected incidence.

**Global health security.** A state characterized by sufficient epidemic and pandemic preparedness and capabilities in order to minimize vulnerability to acute public health events that can endanger the health of populations across geographical regions and international boundaries.

**Pandemic.** An infectious disease epidemic that occurs on more than one continent.

**Preparedness.** The knowledge and capacities developed by governments, response and recovery organizations, communities, and individuals to effectively anticipate, respond to, and recover from the impacts of likely, imminent, or current disasters.

**Prevent.** A global health security pillar characterized by systems, policies, and procedures to determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure.

**Recover.** A global health security pillar characterized by systems, policies, and procedures to restore and strengthen normal operations.

**Re-emerging infectious disease.** An infectious disease that had declined in prevalence or impact but which is again becoming a health problem for a given population.

**Respond.** A global health security pillar characterized by systems, policies, and procedures aimed at controlling or mitigating the impact of disease and saving lives.

**Zoonosis.** An infectious disease transmissible between animals and humans.
**ACRONYMS**

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMR</td>
<td>antimicrobial resistance</td>
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<tr>
<td>AU-IBAR</td>
<td>African Union - Inter African Bureau for Animal Resources</td>
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<tr>
<td>BWC</td>
<td>Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction</td>
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<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<td>CCHF</td>
<td>Crimean-Congo hemorrhagic fever</td>
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<td>CDC</td>
<td>U.S. Centers for Disease Control and Prevention</td>
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<td>CEPI</td>
<td>Coalition for Epidemic Preparedness Innovations</td>
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<td>CFE</td>
<td>Contingency Fund for Emergencies</td>
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<td>CORDS</td>
<td>Connecting Organizations for Regional Disease Surveillance</td>
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<td>CITES</td>
<td>Convention on International Trade in Endangered Species of Wild Fauna and Flora</td>
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<td>CP3</td>
<td>Community Pandemic Preparedness Program</td>
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<td>DAH</td>
<td>Development Assistance for Health</td>
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<td>DALY</td>
<td>disability-adjusted life year</td>
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<td>DRC</td>
<td>Democratic Republic of Congo</td>
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<td>EID</td>
<td>emerging infectious disease</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>GHSA</td>
<td>Global Health Security Agenda</td>
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<td>GHSI</td>
<td>Global Health Security Initiative</td>
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<td>GLASS</td>
<td>Global Antimicrobial Resistance Surveillance System</td>
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<td>GLEWS</td>
<td>Global Early Warning System</td>
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<td>GOARN</td>
<td>Global Outbreak Alert and Response Network</td>
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<td>IDA</td>
<td>International Development Association</td>
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<td>IHR</td>
<td>International Health Regulations</td>
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<td>IRR</td>
<td>International Reagent Resource</td>
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<td>JEE</td>
<td>Joint External Evaluation</td>
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<td>NGO</td>
<td>non-governmental organization</td>
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<td>NPHIL</td>
<td>National Public Health Institute of Liberia</td>
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<td>OIE</td>
<td>World Organisation for Animal Health</td>
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<td>PEF</td>
<td>Pandemic Emergency Financing Facility</td>
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<td>PSI</td>
<td>Proliferation Security Initiative</td>
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<td>PVS</td>
<td>Performance of Veterinary Services</td>
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<tr>
<td>R&amp;D</td>
<td>research and development</td>
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<td>REDISSE</td>
<td>Regional Disease Surveillance Systems Enhancement</td>
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<td>RVF</td>
<td>Rift Valley fever</td>
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<td>SARS</td>
<td>Severe Acute Respiratory Syndrome</td>
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<td>UN</td>
<td>United Nations</td>
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<td>U.S.</td>
<td>United States</td>
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<td>USAID</td>
<td>United States Agency for International Development</td>
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<td>WAHIS</td>
<td>World Animal Health Information System</td>
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<td>WEF</td>
<td>World Economic Forum</td>
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<td>WHO</td>
<td>World Health Organization</td>
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**PREVENT**
Determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure

**DETECT**
Gather and analyze information, provide early warning, and inform strategies
RESPOND
Control or mitigate the impact of disease and save lives

RECOVER
Restore and strengthen normal operations
EXECUTIVE SUMMARY
Global health security is the bulwark against catastrophic public health events. Building this security is a timely and urgent challenge for the world as it faces an increasing rate of emergent and re-emergent infectious disease events tied to changing pressures on animals and ecosystems, resistance to antimicrobials, and avenues for intentional dissemination—all with prospects of rapid spread through our highly mobile population. To date, no end-to-end review of the components needed for effective prevention, detection, response, and recovery from major biological events of any cause, nor an assessment to determine those components that are receiving insufficient attention, has been published.

An optimized global health security system is one that effectively implements and integrates core functions and is enabled by collaborations between governments, non-governmental organizations (NGOs), industry, academia, and communities. Many efforts in various stages at subnational, national, and global levels are directed toward contributing to global health security. Some are advanced by international governing bodies and incorporated into formal frameworks through which activities are funded and coordinated. Others are put forth by networks, coalitions, and consortia of stakeholder groups to identify and implement ways of organizing, advocating for, and contributing to new approaches to health security.

Here we present a framework for rethinking global health security in a way that captures, under a single umbrella, functional areas requiring inputs from the healthcare and public health, animal health, agriculture, environmental, law enforcement and counterterrorism, defense, and disaster risk reduction sectors. It also explicitly considers functions needed to defend against events regardless of their source, whether intentional or unintentional.

OBJECTIVES

We sought to provide perspective on the question of how well the global community has situated itself with respect to building defenses against biological threats. Our specific objectives were to:

1. Comprehensively identify the functions needed to optimize global health security against biothreats regardless of cause (intentional or unintentional), including those that may be missing from current constructs; and
2. Determine which of these functions are insufficiently supported by global-level initiatives.

This was a qualitative evaluation designed to identify the broad pillars and core functions needed to prevent and manage major threats to human health security, and to determine which pillars and functions are unsupported or under-supported by global initiatives. We framed our scope by a published definition of “global governance for health” that encompasses health in the context of global organizations across various sectors, as well as the many mechanisms, institutions, and health professionals that contribute to global health strategy and implementation. It includes “those institutions and processes of global governance that do not necessarily have explicit health mandates, but that have a direct and indirect health impact” (e.g., related to environment, food production, trade, etc.).

We identified major existing frameworks (international and U.S. domestic) and reviewed them to identify the pillars and functions that each put forth as imperative for achieving a state of collective health security:

Prevent: Systems, policies, and procedures to determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure.

Detect: Systems, policies, and procedures to gather and analyze information, provide early warning, and inform strategies.

Respond: Systems, policies, and procedures aimed at controlling or mitigating the impact of disease and saving lives.

Recover: Systems, policies, and procedures to restore and strengthen normal operations.
We then identified a list of global initiatives to manage biothreats—operationally-oriented efforts and major financing mechanisms aimed at building capacity or otherwise closing health security gaps in particular functional areas—and mapped them against pillars and functions. Our focus on global efforts does not ignore the utility of regional, bilateral, and country-level efforts, but acknowledges the substantial good that global bodies and mechanisms could offer to all pillars of global health security if they chose to. Using expert input via interviews and three roundtable workshops, we assessed the validity of the pillars and functions we captured; our choice of initiatives; the mapping of the initiatives to the pillars; and our findings and recommendations.

**FINDINGS**

Under the four pillars, we identified 60 functions to which countries must have sufficient access at the country, regional, or global level. We also identified 22 major global health security initiatives. Mapping these 22 initiatives against the 60 functions revealed that response activities clearly emerge as the dominant focus of global health security initiatives, with 16 of 22 notionally or actually addressing this pillar. While effective response mechanisms are requisite, they should not be pursued to the exclusion of functions in other pillars. We found that the following major challenges characterize the landscape:

- **Global initiatives to manage biological threats largely operate independently of one another.** No strategic inter-institutional guiding framework attempts to align all of these global initiatives toward a commonly defined objective or set of goals.

- **Biothreat planning and implementation is dominated by the human health sector.** A tendency to think about biothreats in terms of human health drives planning and implementation processes, even though dozens of sectors are relevant for prevention, detection, response, and recovery.

- **Prevention is scarcely addressed.** The Prevent pillar is at once the most important and most underappreciated, with only seven of 22 initiatives supporting prevention as we define it. Only four of these address the prevention of unintentional sources of outbreaks or incidents.

- **Recovery is all but missing.** Recovery functions remain the most significantly overlooked. Initiatives to meaningfully and systematically advance recovery planning and implementation are almost non-existent. Recovery is supported by only five of 22 initiatives.

- **Cross-cutting functions provide under-utilized entry points for participation.** Several cross-cutting functions needed to support every pillar of the entire global health security enterprise are critically under-emphasized, including community engagement; risk communication and education; research and development in areas beyond surveillance or medical countermeasures; and data and information management.

**RECOMMENDATIONS**

To mitigate these challenges, we offer the following:

1. **Global biothreat initiatives should be more strategically aligned.** Coordination and harmonization will help ensure coverage and synergy. The now-forming Global Pandemic Monitoring Board may be well suited to this activity. The proposed Global Health Security Agenda (GHSA) 2024 Framework is anticipated to reaffirm the need and set the stage for preparedness, and could be upscaled to include additional nations or become a global compact.

2. **Multi-sectoral participation must be recognized as a requisite tenet of the entire global health security enterprise.** Three weaknesses in multi-sectoral participation, if rectified, could provide substantial benefit to the health security of global citizens. These might be effected through a renewed push per the GHSA 2024 Framework development process:

   **Defense and security.** A shifted paradigm toward complete engagement of this sector from the country to the global level is necessary. Efforts from this sector can play a central role in preventing outbreaks in the first
instance, and also in detection, response, and recovery. Law enforcement, military, customs and border control, and other entities can assist with core functions, including protection of critical infrastructure, bioforensics and attribution, logistics of essential services surge, and medical countermeasure distribution and dispensing. The GHSA could leverage existing regional security agreements toward this end.

**Environment.** The environment sector can be leveraged to contribute key information for threat detection and sentinel surveillance, lynchpin capabilities for prevention. It can also help provide intervention options to mitigate disease risks from wildlife and other environmental sources. Donors can coordinate more systematically with relevant sectors to ensure approaches that incorporate the environmental sector are built into programs prospectively in One Health fashion.

**Private sector.** The enthusiasm of the private sector through efforts like the Global Health Security Private Sector Roundtable offers opportunity for its inclusion in biothreat planning and implementation. We recommend the development of aggressive, early, and transparent public-private partnerships. These efforts should begin by defining the many and unique health security functions the private sector is best positioned to provide, and mapping the many potential contributions of it to global health security.

Valuable cooperation across sectors and disciplines is not limited to these three areas. There is a need for better engagement across many others, including trade, travel, and finance as well as with civil protection and disaster management authorities.

3. **Strategic gaps at the margins must be aggressively addressed.** Of the four pillars that define global health security in our construct, two are dramatically overlooked:

**Prevent.** Funders and implementers should embrace Prevent as an area of need and target investments accordingly beyond vaccination efforts designed to contain new outbreaks. Improved prediction and prevention science can be utilized to assess and manage risks upstream of outbreaks, but will require new approaches to address proximal and distal drivers of disease emergence. Building capacity for the functions in this pillar will require sustained investments from donors, including those who traditionally secure and allocate resources for response. The GHSA's next iteration should include metrics that measure prevention of spillover not only in terms of surveillance efforts, but of other behaviors, policies, and practices that minimize that spillover.

**Reccover.** Granting biothreat recovery functions attention similar to that provided for other types of disasters will promote a more systematic understanding of needs and should strengthen functions to prevent, detect, and respond to future risks and impacts. Nascent programs in this area that contribute to global health security should be strongly supported. Proactive collaboration with disaster response and humanitarian aid entities may help anticipate needs, establish coordination channels, and provide opportunities to build back better to strengthen overall systems and support future disease prevention.

The architects of global health security programs, be they countries, major donors, NGOs, or other such entities, are the primary audience for this report. By defining a comprehensive set of core functions for effective global health security, mapped against ongoing initiatives to reveal weaknesses, global commitments can be more strategically informed and directed. The results of this study can allow improved strategic planning and can assist the integration of prospective initiatives into the global health security enterprise in a way that optimizes their utility. Of course, the ultimate goal of all global health security activities is to optimize country-level capabilities, so we hope that the comprehensive identification of pillars and functions will provide national governments the opportunity to refine and message their particular needs via their national planning processes. Many sectors and disciplines beyond the public health and medical communities are relevant and can offer solutions in the form of regulatory policies, industry standards, investments, surveillance networks, and technical innovation. This study provides a foundation for follow-on work that might take the form of designing and ultimately implementing a system of partnerships to meet the identified needs.
INTRODUCTION
The 2009 H1N1 influenza virus, which emerged in Mexico and spread to much of the rest of the world in less than a year, caused the first declared influenza pandemic in more than 40 years. In little more than a year, it caused more than 18,000 laboratory confirmed deaths, although the actual number of deaths is likely closer to 300,000. Yet predictions of its impacts had been even more dire. H1N1’s failure to meet its own catastrophic potential, combined with the relative numbness of developed nations to influenza as a pathogen, may have lessened what might have been dramatic policy shifts.

The 2014–2016 West Africa Ebola crisis was different. Even though any one global citizen was much less likely to know an Ebola victim than an H1N1 victim, the tremendous media coverage, visceral fear of hemorrhagic fever, higher case fatality rate, and shock that the pathogen—previously unknown in West Africa and limited to relatively small outbreaks in deep forests and villages—had emerged at all set up a new era of pandemic awareness.

The emergence and spread of Ebola and Zika viruses reminded us that pathogens know no borders and that all countries and regions will continue to face the threat of high-consequence outbreaks for the foreseeable future. Prior to the appearance of Ebola virus in Guinea, Liberia, and Sierra Leone, national-level infectious disease events that garnered an international response typically emerged following humanitarian disasters or were part of acute but isolated events in an under-resourced setting that required short-term intervention. The response to SARS improved awareness of needed capacity strengthening, but Ebola in West Africa changed the global landscape, provoking a prolonged humanitarian response and transitioning actors from a containment-driven mindset to one of longer-term planning. This drastic shift challenged existing mechanisms for coordination, deliberation, and funding, and forced a recognition of the need to balance response and sustained capacity building.

Developed nations and other entities invested billions in this region to reduce spread of the disease and help prepare for future Ebola outbreaks. The United States alone appropriated an unprecedented $5.4 billion in emergency response funding, about $2 billion of which was directed internationally to the affected areas as well as other nations. As important as these investments were, their impact has had limits. These dollars were primarily allocated to response for the particular Ebola Zaire epidemic in the region, not prevention or recovery efforts for Ebola Zaire or other emerging pathogens.

In the four years since the West Africa Ebola outbreak was acknowledged as a global crisis, the world has mobilized to prepare for what is now the infectious disease normal. The infusion of billions of dollars from the public and private sectors has enabled global partners to better identify risks, research causes, and create policy and programmatic initiatives to manage pathogen emergence. These efforts are targeted largely at epidemic-prone and emerging pathogens. (Endemic diseases and diseases in the elimination pipeline have long been targeted by other initiatives and funding streams.) The work is bearing fruit in establishing collective health security in both low- and high-income countries. All nations, however, remain at considerable risk of disease introduction or emergence. This is true whether emergence occurs through a biological process, intentional deployment of a biological weapon, or unintentional release of biological agents or material. Each country is vulnerable, even those with more advanced health security systems, and country-level vulnerabilities place all in the global community at risk.

Major strategic and operational gaps remain, perpetuating global vulnerabilities in parallel with the growing threat of infectious diseases. The rate of disease emergence and international spread is increasing, the bioterror threat level is rising, and laboratories that handle high-containment pathogens are proliferating in the United States and abroad, which may signal improved detection and containment capacity but may potentially also add to other risks. Emerging disease threats include both novel pathogens—those previously unseen, re-emerging, or found in new geographic regions or demographic sectors—as well as more common pathogens that acquire antimicrobial resistance (AMR). Zoonotic agents alone cause more than a billion human cases of disease each year and constitute the majority of human pathogens (over 60%) and emergent disease events. The relentless encroachment of humans on pathogen reservoirs such as wildlife and their habitats creates enormous technical and political challenges with which governing bodies are only beginning to come to terms. The impacts of outbreaks and costs of response are borne by individuals, governments, local societies, development funders, and industry and others in the private sector. Of course, in addition to pathogens that
jump between animal and human populations, the continued prevalence of non-zoonotic livestock disease threats also destabilizes economic and food security. The approach we took to developing pillars and functions captures these biothreats as well.

Several recent reports have highlighted the high and rising cost of pandemics and the need for coordinated action at country and global levels. Rapid trade and travel facilitates disease spread and escalates economic impacts. These impacts can be substantial: the World Bank estimates a severe influenza pandemic could cost tens of millions of lives and up to 4.8% of global gross domestic product. The expected return on investment for prevention and swift resolution of disease events is high; investing in One Health systems for mitigation could yield savings of an estimated $30 billion in any given year, and potentially more than double if paired with investments in R&D and preparedness. These savings occur through avoided impacts of a severe pandemic (impacts of a once-in-a-hundred-year pandemic have been estimated at upwards of $3 trillion).

The Blue Ribbon Study Panel on Biodefense views biodefense as those activities directed to thwart biothreats, regardless of their origin. Its members wrote in 2015, “Biodefense touches many aspects of society, falling within the purview of national security, homeland security, public health security, and economic security. As such, it requires an enterprise approach—eliminating stovepipes; transcending agency-centric activity; drawing upon stakeholders throughout government, academia, and the private sector across health as well as other disciplines; and recognizing the extraordinary breadth of the challenge—to provide flexible solutions that address the full spectrum of the threat.” We concur that effective biodefense demands this multisectoral approach. We assert that the existence and maturity of activities needed to prevent and respond to high-consequence outbreaks is highly uneven across countries and sectors, and that these weaknesses leave us vulnerable to intentional and unintentional releases of biological agents alike.
In April 2009, a novel H1N1 strain of influenza virus emerged in the Western Hemisphere, spreading from Mexico into the southern United States. While seasonal influenza is endemic around the globe, antigenic shifts that allow a strain to emerge in humans against which we have neither immunity nor vaccine are relatively rare. This strain had never been seen in people or animals, although it contained genes most closely related to H1N1 strains found in pigs. The disease quickly spread worldwide, moving it out of the epidemic category into pandemic.

This was the first influenza pandemic in more than 40 years. H1N1 resulted in more than 60 million cases and 12,000 deaths in the United States. Although its global impact is not fully known, the virus may have caused nearly 300,000 fatalities in its first twelve months and infected as much as one-quarter of the world’s population. Mexico lost nearly $3 billion due to a decline in tourism in the months following H1N1’s emergence. The pork industry lost revenue because the inaccurate naming of the disease as “swine flu” caused consumers to avoid pork products, even though these products posed no health risk, costing the U.S. pork market $200 million.

This outbreak tested numerous elements of global health systems. It tested technological capabilities to rapidly diagnose an unknown disease and then, after the virus was identified, the ability to develop and distribute laboratory assays to detect it. It tested capacity for rapid vaccine manufacturing: one year after the first detection, sufficient vaccine to protect only 17% of the world’s population had been produced. It tested community willingness to accept those vaccines and the effectiveness of risk communication needed to engender public and consumer trust in government recommendations and actions. It tested hospital surge capacity to meet the large influx of patients. It tested political willingness to make decisions about quarantines and border closures. Like all notable outbreaks in the last 15 years, H1N1 revealed both strengths and substantial weaknesses in the global capacity to prevent and respond to infectious diseases.
Every type of outbreak, whether intentional or unintentional, has a cause behind it, usually related to a human action. Intentional outbreaks may result from human decisions to engage in biowarfare, bioterrorism, or biocrimes. Unintentional outbreaks may result from human behaviors that lead to accidental pathogen releases from laboratory, hospital, or other settings. Unintentional can also be used to describe the kinds of outbreaks often referred to as “natural” or which come at us from nature—the spillover of Ebola from bats to people, the spread of highly pathogenic avian influenza from migratory waterfowl to poultry to people, the dramatic increase in the prevalence of antimicrobial resistance. These events are in fact largely driven by anthropogenic activities that facilitate pathogen exposure and which create dispersal and selection pressures that change the natural histories of infectious diseases. Thus, accidents and spillover events (and related issues like antimicrobial resistance) are all captured under the term “unintentional” in this report. The result of this dynamic is that we cannot expect to mitigate the effects of outbreaks by managing their health consequences alone; we must address the risk factors inherent in human behaviors, and this can only be done through equal inclusion of institutions designed to deal with those behaviors.

Absent major intervention, the continued appearance and impact of new infectious diseases of epidemic and pandemic potential in human populations is certain. Bill Gates has repeatedly stated his concern that disease epidemics, be they spillover events or the result of biowarfare or bioterrorism, are the most likely phenomena to kill 10 million or more people globally, with potentially much higher mortality. The World Economic Forum’s 2018 Global Risks report ranked the spread of infectious disease as among the top 10 high-impact concerns for the world.

Our vulnerability to these threats is a function of how ready we are as a society to meet them. From initial pre-event awareness through dynamic post-event recovery, have we fostered capabilities in communities and countries that enable a baseline competence that reduces or at least manages these inherent vulnerabilities? Have we done so regardless of the source of outbreak, and yet with special consideration for the unique activities that those different scenarios may demand?

**Information gathering and analysis**

This high-level evaluation was designed to identify the pillars and core functions needed to prevent and manage major biological events, and to determine which pillars and functions are unsupported or under-supported by global initiatives. The evaluation addressed needed functional capacity regardless of origin (i.e., human, animal, or environmental origin; warfare or terrorism; or accidental/unintentional release). It drew from preparedness approaches in both international and U.S. domestic health security spheres. We examined expert and institutional sources from the peer-reviewed and gray literature, and from health security frameworks and related government documents; solicited expert opinion via roundtable discussions; attended and participated in meetings and conferences of relevance domestically and abroad; and directly consulted with experts across a range of settings from public health, animal health, security, environment, development, and industry (see Acknowledgements). Information capture and evaluation were enriched by a series of country case studies and ministerial perspectives, including through consultation with experts in Liberia. Findings were incorporated into a comprehensive table of global health security pillars and functions. Based on our research and judgement, and with the feedback of the experts described, we determined which functions are, in general, insufficiently addressed by the listed initiatives based on considerations including scope, mandate, funding, and geographic coverage that point to their relative emphasis and attention in the health security community.
Key definitions

Acknowledging that there are different definitions of “health security,” we generally approached our assessment through the lens of “collective health security,” or the reduction of vulnerability of societies to infectious disease threats that spread across national borders. Indeed, the reduction of risk—a function not only of vulnerability but also of threat and consequences—poses even further opportunity for intervention, and it was the reduction of risk in which we were most interested. A closely related definition of “global health security” also framed our view: activities supporting epidemic and pandemic preparedness and capabilities at the country and global levels in order to minimize vulnerability to acute public health events that can endanger the human and animal population health across geographical regions and international boundaries. Our assessment was organized around the pillars Prevent, Detect, Respond, and Recover, defined as:

**PREVENT**
Systems, policies, and procedures to determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure.

**DETECT**
Systems, policies, and procedures to gather and analyze information, provide early warning, and inform strategies.

**RESPOND**
Systems, policies, and procedures aimed at controlling or mitigating the impact of disease and saving lives.

**RECOVER**
Systems, policies, and procedures to restore and strengthen normal operations.

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IDENTIFICATION
OF CORE SUPPORT FUNCTIONS
“...nations across the world, including the United States, have failed to invest in the necessary infrastructure and capacities. By sacrificing prevention and preparedness, nations have inevitably compromised the ability of public health systems to respond rapidly to health threats.”

– National Academies of Sciences, Engineering, and Medicine 2017

Central to an optimal state of global health security is the assurance that each nation is capable of carrying out a set of critical functions. To build a comprehensive set of such functions, we reviewed a suite of legal instruments, frameworks, tools, guidance documents, and other sources in and outside of the health sector, and interviewed subject matter experts. We gathered each function into a table (Table 1) organized by pre-determined pillars.

One characteristic that makes the framework presented here unique is that it is not sector-specific. Our framework captures, under a single umbrella, functional areas requiring inputs from the healthcare and public health, animal health, agriculture, environmental, law enforcement and counterterrorism, defense, and disaster risk reduction sectors. It also considers functions needed to defend against events regardless of their source, whether intentional or unintentional.

Capturing pillars and core functions relevant to all sources of disease introduction necessitated combining some major functions that might otherwise be viewed as distinct. For instance, under “Prevent,” we collated activities that might, under different rubrics, fall under “Awareness” or “Protection” pillars. As with many frameworks, some functions could reasonably be placed under multiple pillars; in general, we have captured these as cross-cutting functions instead.

Governments and public health researchers have expended considerable capital to identify the spectrum of capacities needed to function well within and across countries to ensure optimal health security capability. This optimal capacity is now generally viewed by the global health security community through the lens of the Prevent-Detect-Respond triad seen in major human health security frameworks, including the Global Health Security Agenda (GHSA). Launched in 2014, the GHSA has defined goals for disease prevention, detection, and response and has gained high visibility and traction in assessing and strengthening country capacity for health security. To ensure alignment with ongoing efforts, we build on this existing structure, expanding it to include upstream prevention aspects and a dedicated recovery pillar consistent with building blocks for One Health operations presented in the World Bank’s 2018 Operational Framework for Strengthening Human, Animal and Environmental Public Health Systems at their Interface.

The pillars and functions in Table 1 are designed to be undergirded by a backbone of existing functional health systems. That is to say, these functions are necessary but not sufficient to achieve global health security. They can also reinforce overall health systems strengthening.
TABLE 1: PILLARS AND SUPPORTING FUNCTIONS FOR GLOBAL HEALTH SECURITY

<table>
<thead>
<tr>
<th>PILLAR</th>
<th>MAJOR ELEMENTS</th>
<th>FUNCTION</th>
<th>CROSS-CUTTING FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREVENT</td>
<td>Awareness, Prevention, and Protection</td>
<td>Systems, policies, and procedures to determine, assess, avoid, mitigate, and reduce threats and risks by reducing vulnerability and exposure</td>
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<tr>
<td>DETECT</td>
<td>Surveillance and Detection</td>
<td>Systems, policies, and procedures to gather and analyze information, provide early warning, and inform strategies</td>
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<tr>
<td>RESPOND</td>
<td>Response</td>
<td>Systems, policies, and procedures aimed at disease control and saving lives</td>
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<tr>
<td>RECOVER</td>
<td>Recovery</td>
<td>Systems, policies, and procedures to restore and strengthen normal operations</td>
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</table>

In general, “prevent” refers to components that thwart the introduction of the disease; “detect” includes those components that contribute to finding and identifying disease; “respond” comprises components that aim to contain and control disease; and “recover” addresses re-establishment of a disease-free status and normalized operations once a disease has been controlled. All functions may occur simultaneously and some functions may carry over from one pillar to the next during an outbreak. Functions should be addressed jointly by public health, healthcare, animal health, agriculture, environmental health, law enforcement/counterterrorism, and defense sectors. EID = emerging infectious disease.
Table 1 presents several unique elements:

**Prevention as a multi-dimensional concept.** Pathogens are opportunistic in terms of their ability to survive and spread. The distinctions between unintentional and intentional sources of pathogen release therefore become somewhat superficial once they begin to spread. The main distinction among outbreaks are the human-mediated factors that shape disease risk and the appropriate interventions needed to mitigate this risk. “Prevent” in this construct captures prevention of epidemics at their source before pathogens spill over, bioweapon development and deployment, and laboratory-based and other pathogen release incidents. This column delineates the numerous functions needed to prevent each of these originations, emphasizing certain functions, particularly in the defense sector, that are either not explicitly seen in global health security frameworks or whose representatives are not routinely represented at the decision-making table.

– **Unintentional.** Prevention of unintentional sources encompasses pathogen emergence from its origin into people (i.e., transmission via contact with the natural reservoir or host species for a pathogen, contaminated food or water, etc.), as well as sources such as accidental release from laboratories. While prevention is an element of several frameworks in name, it typically refers to prevention of disease spread or impact in human populations, rather than prevention of initial pathogen emergence in a novel host, including humans. The GHSA and the Joint External Evaluation (JEE), designed to assess country implementation of the International Health Regulations (IHR), do state their intention to foster behaviors, policies, and practices that minimize spillover, but also indicate that the impact of these efforts would be measured by strengthened surveillance systems. Unless surveillance information is acted on with risk reduction practices, this is not prevention—this is detection. Many of the leading factors that appear to drive risk of emergence and spread, such as problematic land use change and environmental conditions, food acquisition and production practices, and global trade and travel, fall far outside the purview of the health sector. In addition to those factors that enable transmission and geographic movement of pathogens, pathogens may be inadvertently released as a result of a breach in laboratory/hospital biosecurity protocol or biohazardous waste management practices, or from the unintentional release from a bioweapon. The GHSA and JEE incorporation of biosafety into their Prevent categories (and as part of the larger IHR core capacities) is relevant to preventing such unintentional transmission.

– **Intentional.** The prevention of intentional acts, whether carried out or sponsored by states or non-state actors, is a core consideration in the Prevent pillar. The Prevent column in our construct explicitly includes defense-oriented functions. The GHSA and JEE do address biosecurity, one critical element of prevention, but do not cover the many diplomatic and defense functions necessary to achieve comprehensive security from intentional biothreats. Some of these exist outside of the health sector domain, such as counter-proliferation. While this may be justified in the context of those documents’ purposes, we include them in our own framework for the reasons described earlier, and in the hope that they will engender honest discussion about where further engagement of the defense sector could be most beneficial.

**Recovery as a pillar.** After the cavalry has come and gone, communities and nations must somehow resume their former health improvement and economic growth trajectories. How can this recovery be achieved when communities, workforces, economies, and governance structures have been diminished or even decimated, particularly in already-fragile states? Recovery is a complete outlier captured neither in the JEE nor the GHSA. This is significant given the chains of disruption that in the recent past have been triggered by epidemics and pandemics. In the animal health community, steps are outlined by the World Organisation for Animal Health (OIE) for countries or sub-national zones to restore trading freedom after a country’s return to a disease-free status. The World Bank Operational Framework, as well as U.S.-based policies and guidance such as the National Biodefense Strategy and the Department of Homeland Security Threat and Hazard Identification and Risk Assessment process, stress recovery in their constructs. Any global health security framework should do the same.
Animal and environmental considerations as integral to a complete framework. The importance of a One Health approach that recognizes human-animal-environment health connections is often stated, but to the extent that it is actually seen, it tends to be concentrated at the human-livestock interface, largely omitting wildlife and the environment. Because human health is a function of the health of animals with which we share our environment, addressing health security holistically requires inclusion of all of these components.

Cross-cutting functions as foundational. We identified seven functional areas that transect the pillars. These represent critical functions throughout the continuum of prevention through recovery. These are not specific to any one sector, and often require multisectoral and multidisciplinary involvement to be optimized. They must operate not only during emergencies but also between emergencies.

- **Governance.** The success of collective health security at a country level is predicated on the strength of the governance that underlies it. Leadership to ensure strategic focus and prioritization, policy to provide structure, statute and regulation for the legal backbone, and enforcement to ensure effective implementation must all be in place.

- **Resource allocation and coordination.** Resources (whether funds, training, in-kind personnel, supplies, or others) may be useful for any given function. However, many resources can be optimized to ensure they contribute to overall system strengthening, avoid unnecessary duplication and, importantly, ensure necessary allocation of resources for priority and gap areas. This is especially important for coordination across sectors, as resource support sources and priorities may vary, and there may be opportunities to refine existing investments (e.g., in environment or livestock) to generate shared benefits both for their specific sector and more broadly for health security.

- **Community engagement.** Engagement at the community level is a crucial underpinning of local and global health security. The local community must be involved from the start and throughout implementation activities. Workforce development, emerging threat detection and reporting, trust establishment, and risk reduction opportunities are all a function of community-level capability and implementation. Health security approaches must be designed with these end users in mind, including building in assessment and understanding of knowledge, attitudes, and practices in communities.

- **Risk communication and education.** An analysis of recent Ebola, Zika, and yellow fever outbreaks demonstrated that emergency risk communication is a vitally important element of public health. Effective risk communication can enable success in each pillar. Although some avenues of risk communication will take shape based on the characteristics of a given pathogen, general principles, when applied correctly and in a sustained fashion, are needed and useful across pillars. Pathways for message delivery can transect public and private sectors; for example, employers offer central communication channels that reach large segments of the general population and are often a trusted source of information and a direct provider of services for employees and communities, which can help avert unnecessary costs resulting from fear-based aversion actions.

- **Workforce development and sustainment.** Because outbreaks may rapidly escalate to the point at which they overwhelm already-limited systems, strong public health systems supported by a trained workforce are critical to timely detection, trace-back, containment, and treatment. Addressing critical workforce deficiencies can mitigate vulnerabilities. Developing and sustaining a workforce for health security will require multi-year and likely multi-decade commitments, and can drive huge value if conceived as part of strengthening overall health systems to tackle all challenges. Local communities can also contribute to the workforce as the eyes and ears on the ground as a critical source of information for threat detection. Support for national and regional training programs and other paths to career opportunity will help generate a flow of skilled workers who, with additional supports, might be incentivized to remain in country.
– **Data and information management.** The effective generation, collection, sharing, analysis, and storage of data and information related to global health security must underpin evidence-based planning and response. This function applies not only to activities around surveillance data, perhaps most often considered in a data management context, but to every function across the pillars.

– **Research and development.** Collaborative research and development (R&D) is a force for enhancing health security. Health security is enriched by long-term partnerships between institutions with different capacities, including those that form while addressing a specific research objective. A 2011 report by the Center for Strategic & International Studies on the value of U.S. military research laboratories around the world notes the ability of these laboratories to attract productive international and local research partners, in part because of their longevity in a region and trust established with the host country. This trust built on research partnerships can be invaluable in a health crisis, and its value is evident across all pillars. Identification of drivers of disease, expansion of surveillance sites, and contributions to community resilience can all grow from R&D collaborations.

Some might view such a comprehensive framework as operationally unwieldy; we issue it here, however, for a few reasons. The impacts on human and animal life, the environment, and the economy are felt regardless of the pathogen source, and across many sectors. The U.S. National Biodefense Strategy approaches the problem just as comprehensively, and the global community should similarly acknowledge the need for a more universal, less health discipline-specific and sector-specific, framework. Further, outside of highly targeted activities like personnel surety and intelligence collection (designed to prevent deliberate use of an infectious agent) or efforts to establish biosurveillance early warning systems that stem spillover events at their source, most investments will produce benefits regardless of outbreak source.
Policy-wise, there is value in viewing the necessary functions collectively to determine how best to allocate resources among them. Politically, there is value in demonstrating to decision-makers the benefits of investments whether viewed through security or more traditional public health lenses. Table 1 helps to place security concerns and skillsets into health terms, and in this way may help make synergies between sectors more apparent. While in practice it may at times be necessary to make distinctions—and, indeed, sometimes there will be no overlap—we saw value in joining these capacities to demonstrate the overwhelming mutual benefit of these sectors working together.

Figure 1 reimagines Table 1 not as a sequence from left to right but as a circular flow of capability. The pillars that comprise the scaffold can also be viewed as phases of management for outbreaks. But the phases are not really discrete: the dynamic situations that outbreaks present require the Prevent through Recover pillars to be viewed as continuous, concurrent, and overlapping for any high consequence outbreak, not as a chronological process specific to preventing, detecting, responding to, or recovering from a particular outbreak. Sufficient established capacity is required to perform needed activities between emergencies, as well as to address more than one crisis at a time.
IMPLEMENTATION

EFFORTS FOR CORE SUPPORT FUNCTIONS
“Global health governance requires the constant ‘vertical’ exchange between engaged actors from the national, regional and global levels, and ‘horizontal’ exchange between institutions and organizations with very different goals and stakeholders – indeed an extraordinary challenge for network governance.”

– Kickbush and Szabo 2014

Governance and Legal Frameworks

Fortunately, much of the global mechanics needed to support core functions for health security is already in place. Various governance frameworks and international legal instruments specifically or indirectly address global health security and/or weapons of mass destruction. These represent significant global commitments, whether legally binding or voluntary, that countries and in some cases other stakeholders have committed to and that often come with substantial financial investment. The list is constructed based upon our defined scope of functions needed to address prevention, detection, response, and recovery.

These are globally-endorsed agreements with scopes encompassing health security. Of course, there are other important constructs not included here. Policies for industry groups, such as the International Air Transport Association, may also be relevant and expressly address infectious disease risks. Others, such as the UN Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES), the FAO/WHO Codex Alimentarius for food safety, the UN Framework Convention on Climate Change, and the New Urban Agenda may be relevant for the spread of disease, but have not formally emphasized biothreats in the context of global health security. Some governing bodies address health security indirectly, e.g., recent resolutions under the Convention on Biological Diversity (CBD) noting the drivers of disease emergence and the need for integrated biodiversity and disease risk monitoring.

Governance Frameworks and Legal Instruments

- 2005 International Health Regulations (IHR) and WHO Monitoring and Evaluation Framework (including the Joint External Evaluation [JEE])
- Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BWC)
- Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (CWC)
- World Organisation for Animal Health (OIE) Terrestrial and Aquatic Animal Health Code (and the OIE Performance of Veterinary Services [PVS])
- Sustainable Development Goals
In addition to international agreements, other forms of governance may be highly relevant, such as review boards that approve large-scale funding for development projects, research programs, or investments. Industry groups may also introduce binding or voluntary best practice guidelines or industry standards to manage risks. In addition, convening groups such as the JEE Alliance have helped join stakeholders to promote a shared vision of the GHSA. The JEE Alliance’s stewardship of the JEE tool ultimately led to adoption of the tool by WHO to assess gaps in country capacity to meet the IHR, in addition to the regular self-reporting by countries.

The major frameworks cited above each address, in some fashion, the global need to achieve a state secure from the threat of high-consequence pathogens. Overseen by voting countries that constitute their governance bodies, they drive much of the overall focus for implementation initiatives and often financing. Such governance and legal frameworks are fundamental to the strength of any of the pillars. These relevant governance and legal frameworks cover many sectors, including health, security, agriculture, environment, and disaster risk reduction. Some are designed for specific purposes, such as the treaty mechanism for verification and compliance on use of weapons of mass destruction under United Nations (UN) Resolution 1540. A major challenge of operating within UN structures is that their strict sector-specific mandates leave some needs unaddressed. While recent agreements aim to coordinate between particular institutions on specific topics (e.g., FAO/OIE/WHO Tripartite Collaboration), these are primarily high level, lack the provision of guidelines, policies, or investments for countries to work together on coordinated efforts, and ultimately have not translated to routine global coordination and country-level operations. Individual sectors are still responsible for achieving their individual commitments; incentives to work across institutions are lacking, contributing to limited application of a One Health approach in global and country operations despite broad support for such an approach. The decision-making, obligations, and reporting for each institution operate through separate channels, without regard for completeness of coverage and gaps in practice. The UN General Assembly has taken up health only four times in its history, otherwise relying on the mandates and activities of individual UN agencies. An inter-UN agency coordination approach was taken during the global avian influenza crisis (2003–2009) and again during the West Africa Ebola epidemic, but this approach has not been sustained in terms of facilitating a comprehensive, multisectoral approach within the UN system to assist countries in preparing for future threats.

Other international governance bodies also have a role in accountability for global health security. For example, an Independent Oversight and Advisory Committee for WHO’s Health Emergencies Program, established in 2016 as part of WHO reforms, has eight members sourced from country ministries of health, funders, and other UN agencies. In addition, in April 2018 the WHO and World Bank launched a Global Preparedness Monitoring Board with a goal to advance “system-wide preparedness” for health emergencies. It is a successor to the UN Secretary-General’s Global Health Crises Task Force, which was created in 2016 in response to the West Africa Ebola outbreak. While its specific monitoring systems and scope have not yet been defined, its leaders have expressed intent to engage beyond the two founding institutions.

Overall, the specificity of international agency mandates leads to diverging agendas and potential gaps in implementation and associated financing for global health security. In general, the public health community has driven the major metrics, assessments, and investments going into global health security. Because of this, we suspected that certain functions and, in some cases, entire pillars, were not being captured by the deliberative planning, assessment, and implementation processes for global health security. In addition, some of those that are captured may not be sufficiently emphasized or systematically addressed and therefore may not translate into effective action. These areas of coverage and gaps are the subject of the sections that follow.
“In a global health climate characterised by the need to demonstrate outcomes, it is difficult to ‘sell’ prevention and preparedness. Governments should acknowledge that health security has a cost with no immediate apparent outcome, but that such investment is irreplaceable in the face of an imminent health emergency.”

— Kluge et al. 2018

Financing

Country and external donor financing constitutes an important resource for developing health security infrastructure. An estimated $37.4 billion in development assistance for health (DAH), a broad metric for all health spending and not specific to health security, was allocated in 2017. In low-income countries, this assistance constituted a large portion of health spending (approximately one-third) but, at an average of $122 per capita, the shortfall in adequate resources leaves countries vulnerable to disease outbreak and spread. At the same time, this is not just an issue of absolute dollars, but of what functions are (and are not) funded and through what mechanisms.

The majority of global health resources for infectious diseases are dedicated to combatting specific endemic infections, namely HIV/AIDS, malaria, and tuberculosis. In 2017, $9.1 billion (24.2% of total DAH) was allocated for HIV/AIDS. This financing is essential to address a critical public health issue, and speaks to the high cost of ongoing infection when a disease emerges and becomes established in human populations. Yet funds committed to infectious diseases other than HIV/AIDS, malaria, and tuberculosis collectively received only 3.9% of DAH in 2016, despite contributing to a third of total disease burden in low- and middle-income nations.

Pandemic preparedness funding has been short-term, ad hoc, and dispersed to single countries or regions or through specific response mechanisms. While annual reported spending for global pandemic preparedness has doubled over the past decade, the level of funding for pandemic preparedness still contrasts starkly with financing for pandemic response and is vastly outweighed by that of disease-specific programs. There is also poor coordination and clarity to track and optimize dedicated resources for health security; for example, officially reported DAH for pandemic preparedness as part of health systems strengthening in 2017 was estimated at only $204.2 million, with over 80% of funds channeled through WHO, but this estimate does not capture wider health security investments being made at country and regional levels. Short-term funding spikes during recent avian influenza, Ebola, and Zika epidemics further signal that health investments and systems remain largely reactive and sporadic, and that associated recovery efforts are limited. Determining the long-term return on investment of current and future funding is notoriously challenging, given the lack of established baseline measures of pandemic probability and impact and the potential for spillover and spread; however, risk mitigation may have extremely high potential return on investment.

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8 Here, measured by Disability-Adjusted Life Years (DALYs), a common metric of health status that encompasses the impact of poor health, disability, and early death.
Significant resources have been allocated to certain global programs directed toward health security (Table 2). While some of these support capacity building and system strengthening that will enable core operational functions, most are highly specific in scope and objectives. Examples of major investments branded as epidemic and pandemic preparedness financing include initial funding to CEPI for the development of vaccines against three prioritized pathogens and resource mobilization mechanisms established through the WHO and World Bank for emergency response (the Contingency Fund for Emergencies and the Pandemic Emergency Financing Facility, respectively). The GHSA is notable in its support for consistent and coordinated epidemic prevention, detection, and response, mobilizing resources from an extensive network of donor countries for capacity assessment and country operations.

Some of the investments in Table 2 do fill gaps highlighted in past recommendations (e.g., for R&D). However, these, too, are focused on certain countries, specific diseases, or single-outbreak approaches, and are heavy on response. Funding of global initiatives for health security occurs largely through public health sector channels. Yet investments from or in other sectors could be highly relevant: e.g. biodiversity monitoring initiatives that can detect and report wildlife disease events, or livestock investments that build in biosecurity in food production operations. But such investments are relatively lacking, and to the extent that they exist, have not been optimized for health security.
### TABLE 2. MAJOR GLOBAL-LEVEL FINANCIAL RESOURCES MOBILIZED FOR GLOBAL HEALTH SECURITY (FUNDING RECEIVED OR REQUESTED)

<table>
<thead>
<tr>
<th>Program</th>
<th>Funding source(s)</th>
<th>Year(s)</th>
<th>Funding level</th>
<th>Prevent</th>
<th>Detect</th>
<th>Respond</th>
<th>Recover</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEPI</td>
<td>Wellcome Trust, Gates Foundation, Japan, Germany, and Norway</td>
<td>2017–22</td>
<td>$560 million (as of 2017)</td>
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<td>Vaccine development; $1 billion target for first 5 years</td>
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<tr>
<td>Contingency Fund for Emergencies</td>
<td>WHO member contributions (17 countries have contributed to date)</td>
<td>2015–20</td>
<td>$69 million received (as of June 2018); $100 million target for 2018–19</td>
<td>🚒🔍🔍🔍</td>
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<td>Separately funded component of the WHO Health Emergencies Program; rapid response to health emergencies: up to $500,000 mobilized within 24 hours; $21 million utilized in 2017 in 23 countries</td>
</tr>
<tr>
<td>Gavi</td>
<td>Governments, Gates Foundation, private sector</td>
<td>2016–20</td>
<td>$9.2 billion in donor contributions and pledges</td>
<td>🚒🔍🔍🔍</td>
<td></td>
<td></td>
<td></td>
<td>Immunization delivery (includes health system strengthening aspects)</td>
</tr>
<tr>
<td>GHSA</td>
<td>G7 nations</td>
<td>2014–22</td>
<td>&gt;$1.44 billion</td>
<td>🚒🔍🔍🔍</td>
<td></td>
<td></td>
<td></td>
<td>GHSA itself does not allocate/appropriate funds; support is allocated by countries under the principles of GHSA to advance prevent, detect, and respond capacities</td>
</tr>
<tr>
<td>Pandemic Emergency Financing Facility (PEF)</td>
<td>World Bank</td>
<td>2017–22</td>
<td>$320 million (Class A pathogens: $225 million, Class B: $95 million); separate cash window</td>
<td>🚒🔍🔍🔍</td>
<td></td>
<td></td>
<td></td>
<td>Surge financing (insurance window + cash window) in response to activation criteria (outbreak size, spread, and growth); premiums and bonds financed by donor governments</td>
</tr>
<tr>
<td>Pandemic Preparedness Plans</td>
<td>World Bank IDA18 Replenishment</td>
<td>2017–20</td>
<td>Dependent on client country requests</td>
<td>🚒🔍🔍🔍</td>
<td></td>
<td></td>
<td></td>
<td>Support to 25 IDA countries to develop frameworks for governance and institutional arrangements for multi-sectoral health emergency preparedness, response, and recovery</td>
</tr>
<tr>
<td>WHO Health Emergencies Program</td>
<td>WHO member states</td>
<td>2016–20</td>
<td>$485 million requested for 2016-17 (73% funded)</td>
<td>🚒🔍🔍🔍</td>
<td></td>
<td></td>
<td></td>
<td>Core budget for essential functions, plus an appeals budget that covers additional work in response to acute and protracted health emergencies</td>
</tr>
</tbody>
</table>

* To the extent that Gavi covers Prevent it is for the specific prevention of yellow fever spillover through vaccination in high-risk areas; does not address drivers

Examples of global-level health security programs with significant funding or intention to mobilize significant resources. Because funding mechanisms and use vary, and to avoid double-counting from donors and recipients, listings reflect reported funds issued, received, or requested at a global level. Funds may contribute to regional or country-level programs (for example, GHSA funding directed to the U.S. Centers for Disease Control and Prevention (CDC) global health programs or the U.S. Agency for International Development (USAID) Emerging Pandemic Threats program). Under the PEF, Class A and B denote different groupings of pathogens for insurance payout levels; the cash window can be mobilized rapidly separately from the insurance mechanism, including as a funding stream to respond to non-Class A or B pathogens. While the allocation of regional and domestic financing is important for sustaining country-level operations for health security and preparing for disease introduction, these allocations occur at a single country or regional level and on short-term budgetary or project bases, and are thus not captured here. IDA=International Development Association, the World Bank’s lending arm to the poorest countries.
A response-heavy approach to biothreats is characterized by resource allocation to curb disease spread once outbreaks have already occurred, costing both lives and money. Despite this, Table 2 reflects a clear bias toward response. Additional analyses demonstrate the same. Of the nearly $6 billion mobilized from donors over the 14 months of the Ebola epidemic, 79% was allocated for response, 18% for recovery, and 3% for R&D. Even R&D financing during and immediately after epidemics is largely subject to a narrow focus on biomedical innovation primarily for medical treatment and control measures in the context of major epidemics, rather than for wider threats and broader solutions. This surge financing includes upscaling of efforts for known pathogens when outbreaks manifest in new ways, such as via spread in urban populations; for example, investment in treatment and control of Ebola, which had caused outbreaks previously two dozen times, rose 942.7-fold after the West Africa outbreak. Previous R&D efforts to create an Ebola vaccine had been cut short due to lack of funding and interest, an issue that has also affected other “priority diseases” for public health.

Funding streams are typically highly specialized and, if not coordinated, may result in duplication of efforts or may not result in functional capacity. For example, screening capacity under Detect may require laboratory equipment procurement, supply chains, staff training, and infrastructure improvement—all of which may be funded by separate initiatives. Similarly, capacity to screen for particular pathogens may not provide the agility necessary to respond to a wider range of known and novel diseases, and having sophisticated laboratories to detect disease will do little to stem outbreaks if capacity is not in place for field epidemiological investigation and implementation of control measures. At the same time, too, suitability of investments, while well meaning, may in some cases be misunderstood. For example, high biosafety-level laboratories (e.g., BSL-3 and BSL-4) are often high-profile investments, but the BSL designation simply indicates extent of precautions to protect against staff exposure or release of dangerous pathogens, not the extent of diagnostic capacity.

The true costs of disease emergencies are often incompletely or inconsistently captured, with line items varyingly included in impact calculations. Yet estimates point to extremely high direct response costs to donors and societies and cascading economic disruption to other services and sectors (e.g., transport, tourism, education). From 2014 to 2017, more than $8 billion in emergency funding was spent by international health, development, and other donors for response and recovery to the Ebola and Zika crises, in addition to widespread societal disruption and billions of dollars of economic losses to local governments and industry operating in countries with heightened transmission. Despite long-term health and economic consequences from epidemics, commitment to long-term funding wanes all too easily: as of January 2018, less than a third of total pledges announced by donors at the International Ebola Recovery Conference in 2015 had materialized, and the U.S. Congress diverted over $500 million in Ebola recovery funds to the Zika response.

The role of financing in creating incentives, or disincentives, for long-term capacity strengthening and risk reduction for health security is relevant to the support of functions across pillars. Insurance for epidemic and pandemic risks is relatively new and currently emphasizes assistance to countries for response and recovery (with payout once outbreak events reach certain triggers) or to industry for business continuity. If countries and donors are protected against the economic damages from outbreaks, such as through global insurance mechanisms, they may have little incentive to invest in upstream prevention. However, future iterations of insurance mechanisms could encourage safer practices, with precedent from other sectors in insurance encouraging risk reduction. Examples include lower insurance premiums for safe driving records or the use of smoke detectors, and the effect of workers’ compensation plans driving safer employer practices. Shifting incentives to prevention and detection may have a remarkable effect on how we handle pandemic risk. Some investments recognize from the onset the importance of being implemented alongside investments in other pillars to optimize coverage, though to date this has not translated to continuity or coordination in investments.
Financing coordination channels have recently been established through the WHO’s Strategic Partnership Portal\textsuperscript{42} and at Georgetown University within the Center for Global Health Science and Security’s Global Health Security Funding Tracking Dashboard\textsuperscript{43}. Incentives to align investments, however, are still not formalized and any such alignments are dependent on the will of individual donors. Relevant investments and funding needs from other sectors to contribute to global health security functions also go largely unaccounted for. Funds committed to pandemic preparedness were recently added to the annual DAH tracking report, which may help increase visibility of preparedness resources (or the lack thereof) in global health.\textsuperscript{32}

Funders are increasingly using upward changes in JEE and PVS scores as indicators of improved capacity.\textsuperscript{27} However, investments for selected capabilities under each sector’s assessments should be considered in the context of overall health security functions to ensure continuity between programs and to optimize the effectiveness of funding and efficiency of its use. As antimicrobial resistance increasingly challenges our ability to control known diseases, leading to the need for higher-cost second- and third-line treatment regimens, new infectious diseases are also looming on the horizon. Investments should be structured for long-term efficiency and effectiveness and multi-hazard preparedness.
“Despite efforts by the United States and a few other countries, there are still big holes in the world’s ability to respond to an epidemic. Other countries may be more likely to step up if they see an overall plan and understand their role in it.”
— Bill Gates 2015

Initiatives

The governance structures described in the previous section create a structural and leadership platform from which to build and sustain global health security functions. Indeed, many structures have been developed and many initiatives are now underway to implement these functions.

The following are global-scale initiatives operating in the health security mission space, what we term “global initiatives to manage biothreats”:

- Australia Group for chemical and biological weapon proliferation
- Coalition for Epidemic Preparedness Innovations (CEPI)
- Community Pandemic Preparedness Program (CP3)
- Gavi, The Vaccine Alliance
- Global Antimicrobial Resistance Surveillance System (GLASS)
- Global Early Warning System (GLEWS) for major transboundary animal diseases, including zoonoses and Global Animal Disease Information System (EMPRES-i)
- Global Financing Facility
- The Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund)
- Global Health Security Agenda (GHSA)
- Global Health Security Initiative (GHSI)
- Global Partnership Against the Spread of Weapons and Materials of Mass Destruction (Global Partnership)
- International Reagent Resource (IRR)
- Proliferation Security Initiative (PSI)
- World Bank Pandemic Emergency Financing Facility (PEF)
- World Economic Forum (WEF) Epidemics Readiness Accelerator
- World Health Organization Contingency Fund for Emergencies (CFE)
- World Health Organization Global Influenza Programme
- World Health Organization Global Outbreak Alert and Response Network (GOARN)
- World Health Organization Health Emergencies Program
- World Health Organization R&D Blueprint for Action to Prevent Epidemics
We recognize the value of initiatives at other levels, from local to regional to national, but have not included these in our assessment. The sheer number of initiatives would be too great and the information capture too challenging for the scope of this study. Regional and sub-regional initiatives for response and capacity building are critical efforts and include programs like those managed by African Union Interafrican Bureau for Animal Resources (AU-IBAR), Connecting Organizations for Regional Disease Surveillance (CORDS), the Gulf Co-op Council, and Mekong Delta Surveillance. The World Bank’s Regional Disease Surveillance Systems Enhancement Project (REDISSE) in West Africa is notable in that it represents a large-scale regional initiative with both development donor and country commitment and investment. The FAO Emergency Centre for Transboundary Animal Diseases provides crucial support against the threat of cross-border animal health emergencies, and the USAID Emerging Pandemic Threats program is strengthening capacity to examine pathogen spillover risks from wild and domestic animals to humans, but cover only ~30 countries and are based on project funding. The U.S. CDC Field Epidemiology Training Program and its veterinary counterpart are also implemented in many countries, but are predominantly funded bilaterally. Bilateral programs—that is, programs funded by a single country to a single country—were similarly excluded from analysis because of the limitations in our scope. While such programs are often critical to advancing health security goals and can lay the groundwork for sustained and even larger investment from donor countries, such programs can also bring challenges of coordination and resource provision, hindering progress in addressing the very problems they seek to mitigate.

Given these limitations, and because the purpose of the current study was to help advance globally sourced solutions to health security, our list of initiatives was limited to those that could be defined as global. We viewed “initiative” as something global in architecture and/or oversight but designed to support the consistent development of local-, country-, or regional-level capacities or provision of something that could be disseminated based on global need rather than a specific geographic scope. Some of these initiatives were developed specifically to implement legal frameworks, whereas others were expressly developed to fill gaps in governance. While differing in their technical and geographic scopes, funding sources, timescales, and implementing institutions, the listed initiatives are recognized widely and routinely included in multi-donor planning meetings, have mobilized funding at significant scales (i.e., tens of millions to billions of dollars), or are firmly established in international institutions and the international biothreat and public health research, academic, or service delivery communities.

Within these parameters, we assessed the extent to which current global initiatives address the identified functions shown in Table 1. Table 3 reveals the relationships between the initiatives and pillars defined in this report. In addition to reviewing published information about each initiative, we have used our own experience and judgement as well as that of outside experts to determine placement into categories. Designations indicate that an initiative addresses a pillar per its stated mission or the judgement of the authors; it was beyond the scope of this study to assess whether it is successfully doing so.

Some of these are dedicated programs implemented primarily through one institution, while others are based on partnerships. Notably, GHSA is in this latter category. “Agenda” is perhaps a poor descriptor of what the GHSA actually is: a partnership of 64 nations, international organizations, and non-governmental stakeholders that facilitate collaborative capacity-building efforts around biological threats. Each of the listed initiatives may also have many sub-initiatives that operate at different scales (e.g., country or regional) and may cut across pillars and sectors to some extent. Other conceptual and operational initiatives not included in this list may benefit global health security in important ways, but to date are not systematically recognized in global health security planning. More such efforts will hopefully take hold through public-private cooperation and be included in future updates of Table 3.
## TABLE 3: MAPPING OF GLOBAL HEALTH SECURITY INITIATIVES TO PILLARS

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Prevent</th>
<th>Detect</th>
<th>Respond</th>
<th>Recover</th>
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<tbody>
<tr>
<td></td>
<td>Unintentional</td>
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<tr>
<td>Australia Group</td>
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<td>CEPI*</td>
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<td>CP3</td>
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<tr>
<td>Gavi†</td>
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<td>GLASS</td>
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<tr>
<td>GLEWS‡</td>
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<tr>
<td>Global Financing Facility</td>
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<tr>
<td>Global Fund</td>
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<tr>
<td>GHSA†</td>
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<tr>
<td>GHSI</td>
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<tr>
<td>Global Partnership</td>
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<tr>
<td>International Reagent Resource</td>
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<td>OIE WAHIS</td>
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<tr>
<td>Proliferation Security Initiative</td>
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<tr>
<td>World Bank PEF‡</td>
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<tr>
<td>World Bank Pandemic Preparedness Plan</td>
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<tr>
<td>WEF Epidemics Readiness Accelerator</td>
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<td>WHO CFE</td>
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<td>WHO Global Influenza Programme</td>
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<td>WHO GOARN</td>
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<tr>
<td>WHO Health Emergencies Program</td>
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<td>WHO R&amp;D Blueprint</td>
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</table>

* It was beyond the scope of this study to assess whether the initiatives are successfully supporting the pillars. Thus, a checked column does not necessarily mean the effort is actually occurring or occurring in a way that impacts health security.

* Committed to funding through Phase 2 investigational stockpiles; not funded for Phase 3 or linked to a system for procurement, distribution, or dispensing.

† To the extent that Gavi covers Prevent it is for the specific prevention of yellow fever spillover through vaccination in high-risk areas; does not address drivers.

‡ Predominantly focused on risk monitoring and information alerts for Rift Valley fever in livestock.

§ Addresses prevention in the sense of containing outbreaks; attention to and capacity for spillover risk management is extremely limited.

‖ Disbursement of funds only applies to select viruses.
Liberia’s context as a resource-limited, high-biodiversity country targeted for natural resource and economic development presents potential for intensifying contact with wildlife through changing forest access, modernized hunting techniques, movement of and contact with wildlife through wildlife trade, and agriculture without adequate biosecurity. At the same time, the country faces limited human and veterinary medical services (possibly as few as 50 medical doctors and five veterinarians) and poor electricity, supply chain, sanitation, and transport infrastructure.

Ebola revealed weaknesses in public health systems for both routine and emergency functions that left Liberia vulnerable to known and novel disease epidemics. Among these were chronic capacity gaps further identified during the country’s JEE in 2016, including poor capacity for zoonotic disease surveillance, in part due to an extremely limited animal health workforce.

Liberia has subsequently embraced a One Health approach as part of its strong post-Ebola commitment to local, national, and global health security. The country has developed a national One Health Coordination Platform with strong leadership from the government of Liberia and support from WHO, USAID, U.S. CDC, and other partners. Under its associated Governance Manual, the Platform rotates host institutions on a time-specified basis. It is currently hosted at the National Public Health Institute of Liberia, with a designated Director and Coordinator. Signatories come from 36 agencies, ranging from the authorities responsible for animal health, education, and civil society organizations such as religious leaders. If fully implemented, the collaboration that could come from the participation of the 36 stakeholders may provide pathways to identify shared priorities and deliver clear and consistent information that can support optimal delivery of functions such as risk reduction and management, threat and disease detection, and risk communication. The vice president of Liberia serves as Chair, helping to convey its importance in the global landscape and promote an inclusive, equitable approach across sectors.

Country-level models like this can inform tailored approaches for the unique context of a given country and its stakeholder needs. The Platform has flexibility to convene needs-based Technical Working Groups on broad topics (e.g., surveillance) and disease-specific objectives (e.g., rabies). It also mobilizes participants in ways that encourage multisectoral approaches from the onset of assessments, priority setting, and implementation initiatives, including in its National Action Plans for Health Security and Antimicrobial Resistance. This may ultimately help to ensure that strategies are not biased to a limited set of conventional approaches. While limited familiarity or capacity in some sectors (notably, defense and environment) may be an initial barrier to complete implementation of the Platform’s potential in Liberia, it holds significant promise for the promotion of alignment among sectors. One Health approaches are already being embedded into some national operations, including weekly Integrated Disease Surveillance and Response reporting for priority diseases in humans and animals from all of Liberia’s 15 counties, and in building diagnostic capabilities for diseases notifiable to the OIE and WHO.
BUILDING RESILIENCE TO BIOTHREATS

AND SUPPORT FUNCTIONS IN NEED OF ATTENTION
This evaluation has revealed fundamental elements of global health security that remain unaddressed or under-addressed by the global community:

**FINDING: GLOBAL INITIATIVES TO MANAGE BIOLOGICAL THREATS LARGELY OPERATE INDEPENDENTLY OF ONE ANOTHER**

No governance effort nor strategic inter-institutional guiding framework attempts to align the global initiatives toward a commonly defined objective or set of goals. Implementation efforts and associated financing tend to tackle particular objectives—vaccine development incentivization; vaccine delivery; regional surveillance; diagnostics; training; reporting—and while such dedicated efforts are necessary, there is no overarching effort to coordinate them, ensure that they align with a designated set of goals, and see that they operate under a strategic framework to ensure all needed functions, regardless of sector, are in place to achieve them. This has both benefits and drawbacks. On one hand, a flexible structure leaves room for innovation, is not expressly limited by a specific set of priorities set by the judgement of only one authoritative group, and does not impede entry into working on pillars and functions. On the other, without it, the global health security landscape is highly fragmented, with disparate approaches and timelines, chronically under-resourced areas, and gaps in operational capacity. Without a shared framework, monitoring remains challenging and accountability limited.45

The Towards a Safer World initiative, a collaborative of experts established during the H5N1 avian influenza pandemic (2003–2011) through the UN System Influenza Coordination office and cutting across disciplinary and technical agencies, advocated for a whole-of-society and whole-of-government approach to prepare for pandemics and other major health disasters. It aimed to apply lessons learned from pandemic preparedness to other types of emergencies and threats. Following the H1N1 pandemic, the initiative took a light touch to keep the network of experts connected and up to date on global health security issues through a web-based platform. This inter-sector scope, however, was not formally adopted by UN agencies for the long term, despite strong support from many in the community. This is a testament to the predominance of the sector-specific approach and insufficient interest in financing coordination of prevention and preparedness efforts. Bill Gates has argued that the “world does not fund any organization to manage the broad set of coordinated activities required in an epidemic” and has suggested that the world needs a system coordinated by a global institution that is given enough authority and funding to be effective.22 Whether the solution lies in a global institution or simply a mechanism for global alignment, we would extend this thought beyond those activities required “in an epidemic” to all the activities that should occur before it, and that must occur after it.

Conceptual and operational initiatives outside of formal UN-led structures are also emerging as a positive force in global health security planning. For example, the World Economic Forum (WEF) is working in partnership with over 80 corporate, technical, academic, donor, government, intergovernmental, and NGO partners to enhance public-private partnerships to effectively prepare for and respond to outbreaks. As part of this, the WEF’s Epidemics Readiness Accelerator is strengthening essential public-private cooperation in five areas of work (travel and tourism, supply chain and logistics, data innovations, communications, and legal and regulatory); the WEF is also advancing other global health security activities, including helping companies understand the types and magnitudes of risks and impacts they may face from outbreaks. More such efforts will hopefully take hold through public-private cooperation.
FINDING: BIOthreat planning and implementation are dominated by the human health sector

There seems to be a natural tendency to think about biothreats in terms of their consequences; and at that, of the single end consequence that worries us the most: our own health. This view then effectively drives the reverse engineering all of the structures and decisions that must occur before those human health consequences ensue, and the forward engineering of response actions tailored to that human health need. Areas like defense, environment, and animal health are often treated as needs outside of human health security frameworks, and direct partnerships are not often established. It is the central term “health” in the moniker “global health security” that has come to dominate the conversation around high-consequence pathogens, which is itself a symptom of this mindset, and which dramatically influences the nature of investment. This is true globally and, in many cases, nationally. While WHO has a valuable role in guidance and standard setting, we see a persistent gravitation toward holding WHO responsible as the sole organization for global health security planning and implementation, even though the myriad functions needed to do so reach beyond WHO’s remit and, in some cases, technical and surge capacity. At a parallel U.S. level, the National Biodefense Strategy will be administered by a steering committee at the Department of Health and Human Services; and yet sixteen departments and agencies with wide-ranging responsibilities created that strategy.

Many initiatives are driven or owned by the health community rather than by multilateral partnerships (e.g., oversight of the JEE by ministries of health and WHO, and guidance of CEPI by WHO’s R&D Blueprint). While this health sector leadership does not exclude potential inputs from other sectors, it does not promote their systematic inclusion. The IHR is a health framework, and as such the lead on its implementation naturally falls to ministries of health. The IHR and other health-oriented frameworks like it are typically developed only by the health sector. Absent the resources or empowerment to manage their existing mandates or be aware of the relevance of their own activities to other sectors, non-health sectors are not likely to come to the table.

For decades preceding the advent of the pandemic-inspired global health security push, there existed more traditional security-oriented activities in biowarfare and bioterrorism. These were first the superpower offensive bioweapons programs, followed by their cessation per the BWC and the concomitant development of threat reduction and counterproliferation policies and programs to thwart any future bioweapons development. These efforts were designed within the diplomacy and defense spheres of influence, wherein the rhetorical triad was not “prevent, detect, respond” but more akin to “counterproliferation, nonproliferation, and consequence management.”

The approach that has largely come to dominate U.S. federal policies with respect to biothreats—one that recognizes their sources in nature, in human intent, or in human error—was also built into the GHSA. GHSA was not about global health—it was about global health security which, while lacking a standardized definition, clearly differentiated it from other global health programs in areas like maternal-child health or malaria. The term “security” could be viewed in two lights in the GHSA: one with respect to securing human health from high-consequence pathogens, and the other with respect to securing the pathogens themselves from misuse. Both of these, but especially the latter, necessitate the involvement of other sectors that work in or toward security, such as defense, law enforcement, border control, customs, counterterrorism, and diplomacy.

Efforts to create bridges between the health and security communities should acknowledge that some in the health world will be wary of those from the defense world, and vice-versa. Building on initial military and health sector collaborations that were crucial in the response to the West Africa Ebola crisis, the Indonesian Government in collaboration with WHO hosted a meeting in 2017 to promote the sectors’ collaboration to strengthen health security and advance implementation of the IHR. The meeting identified the need for development of guidance on national-level collaboration between military
and civilian health sectors, including the role WHO can play in supporting countries in their implementation. These advances should be promoted and sustained and also considered for other segments of the military beyond health services (and for other sectors), and should attend to both logistical coordination as well as tackling broader biothreats on the horizon (e.g., new developments in synthetic biology). Finding common ground to emphasize shared objectives for capacity and outcomes, and perhaps framing benefits in terms of securing human and global health, may help. The GHSA loosely provides a vision and associated frame for global health security through its dedicated action packages, though it leaves an overarching coordination piece to individual donors. Multiple national and global defense/security actors contribute in some fashion to the GHSA, for example under the Global Partnership, Interpol (a founding member of GHSA), and the many national-level funders from defense and related ministries. The equitable participation of the defense and security sectors was certainly the vision of the GHSA. But their presence has waned in international global health security fora according to experts. Although defense and security must be part of the global health security solution, “Around the world you don’t often see ministers of foreign affairs or defense or their delegates at these meetings.”47 Yet the defense sector can contribute to many functions, regardless of the origin of the threat; it can similarly receive benefit to its own operations by collaborating with sectors like environment, agriculture, health, and finance. Such partnership can enable defense to better understand global threats, develop mitigation strategies, and inform risk analyses that ultimately inform what national and global biodefense priorities should be.

Actions and investments from many additional sectors are clearly needed. The engineering sector, for instance, is widely appreciated for improving sanitation to address water- and vector-borne disease risks. Engagement with sectors of trade, travel, and finance as well as with civil protection and disaster management authorities is similarly highly relevant. This can build on existing initiatives, especially as some sectors outside of health are already providing funding at significant levels; for example, an analysis of projects financed or undertaken by members of the Global Partnership under the BWC indicated that 13 country partners reported contributions totaling >$470 million for capacity building programs.49 Ensuring investments are coordinated or considered with global health security targets in mind can help optimize their multisectoral impact. Governments could also capture revenues from multiple sectors, such as through taxation, to finance pandemic preparedness efforts.19 The recently established multisectoral National Action Plans for Health Security, which help act on the findings of the JEE and other assessments toward implementation of IHR core capacities, recognize this potential for multi-sectoral resourcing and aim to bring finance ministers, agriculture, military, security, and other sectors to the table. Planned costing exercises, however, still remain largely in the health sector.

Finally, One Health is not yet an implementation reality. As discussed, the contributing causes of epidemics and pandemics span widely beyond the human health sector. Without systematically considering risks that contribute to disease emergence from livestock, other domestic animals, and wildlife, and the role of environmental factors as related risks, we will perpetually be left with limited options for disease prevention at the source of disease threats. The siloed approach to disease risk management contributes to the lack of accounting for these negative externalities; a more integrated approach could anticipate and reduce risks from the onset. The institutions that frequently bear the costs of responding to disease events, such as development banks and global foundations, are well placed to address this fundamental issue given their wide-ranging lending lines and technical expertise. This can be done through direct investments in One Health projects that build in dedicated mechanisms for collaboration and incentives for relevant sectors on specific objectives (e.g., REDISSE), as well as by applying a One Health approach to project design, implementation, and evaluation phases. Processes such as safeguard policies, which assess possible adverse impacts of projects, can be enhanced to include public health threats beyond their current scope of environmental and social risks to also help target the drivers of disease to identify risk factors and mitigate negative externalities.16
Since late 2016, in response to the killing of a local chief by the Congolese armed forces and internal conflict along ethnic and political fault lines, 1.5 million people have been internally displaced in the Grand Kasai region of the Democratic Republic of Congo (DRC). Most of the displaced live in makeshift arrangements in their own or other communities, and they lack food and basic health and education services. Approximately 42% of households in this region are food insecure and, across the DRC, about 7.7 million face the risk of imminent famine; over one-third of those at risk are in Kasai.48

This crisis in southern DRC bookends the more limited but high-profile crisis that occurred in the north: on May 8, 2018, an outbreak of Ebola virus disease was declared in the Bikoro region of Equator province. Spread of the disease to Mbandaka, a city of almost 1.2 million, raised the specter of an uncontrolled epidemic that could spill into neighboring countries and markedly raise the death toll. Substantial funding was quickly mobilized, an experimental vaccine and 332 technical experts were deployed, and, on June 12, the last confirmed case was discharged from a treatment center. In total, 58 cases and 27 deaths were attributed to Ebola, but loss on the scale of the 2014 epidemic in West Africa was averted. As this report went to press, the virus had emerged again in DRC in other locations.

Though these crises—the Kasai conflict and the Ebola outbreak in Bikoro—occurred in distinct areas of the country, they represent on-the-ground challenges for national governments and indicate the need for resilience throughout the prevent-to-recover cycle.

Currently, much of the south and east of DRC is considered a “risk” or “deteriorated” area and, in addition to the 2018 Ebola outbreaks, there have been sporadic monkeypox cases and a recent widespread cholera epidemic, all with the risk of famine as a backdrop. These examples highlight the multiple simultaneous threats to security (i.e., food, health, and social and political) presently facing the DRC. Further, the disruption of agriculture, looting and destruction of health facilities and schools, and compromised access to water and sanitation due to conflict show that reinstating healthcare and establishing health security will require security support beyond that of the health sector alone.
**FINDING: PREVENT IS SCARCELY ADDRESSED**

The Prevent pillar is at once the most important and most under-appreciated. Only seven of 22 initiatives support our definition of prevention. This pillar is complicated by two sub-categories: unintentional (preventing spillover and spread in human populations by managing risk drivers, and preventing accidents with biological agents); and intentional (preventing development and use of bioweapons). Only four of 22 initiatives address prevention of unintentional release.

The counterterrorism-oriented functions of this pillar are far better addressed than those that are EID- or accident-oriented. This to some extent reflects the reality that counterterrorism efforts are relatively well defined and approachable through existing diplomatic and defense channels. Preventing EID events is perhaps perceived as less defined or less approachable, but perhaps only because we have not been willing to systematically identify and address the drivers of spillover, develop the research base to anticipate spillover events, and proscribe interventions. In our construct, Prevent is not about limiting outbreaks before they become epidemics or pandemics. Such containment during response efforts to reduce potential for spread and impact is indeed critical when outbreaks do happen. But also important is reducing the likelihood and frequency that outbreaks happen in the first place by preventing the emergence of pathogens at their source. It is this prevention of initial emergence—essentially, the containment of pathogens to their natural hosts—that is so needed to shift the paradigm from one of response to one of prevention (Figure 2).

Despite repeated lessons from HIV/AIDS, SARS, H7N9 avian influenza, Ebola, Zika, and many other infectious diseases, there is surprisingly little attention to diseases on the horizon as compared to other threats to the health and well-being of people and the planet. Ebola in West Africa was unexpected because it had never been reported there before, but reports published after the West Africa Ebola outbreak began showed that Ebola virus antibodies were present in suspected Lassa fever patients in Sierra Leone as early as 2006–2008, suggesting previous circulation of Ebola viruses in the region. Upstream detection and prediction may be technically challenging, but how many opportunities to do so have been missed simply because we did not try? If paired with subsequent risk reduction, these offer real potential to curb the frequency of outbreaks. We acknowledge that some activities that begin with outbreak response—such as biosurveillance, laboratory diagnostics, and emergency operations management—may indeed work toward prevention or containment of future outbreaks if they are sustained. This reality to some extent, then, blurs the line between response and prevention. But even if these activities were sustained, other areas of prevention remain in need of support.

One of these is R&D. The WHO R&D Blueprint priority pathogens all have close environmental or animal health links, but efforts to develop countermeasures for these pathogens are typically targeted to humans. Even while livestock health is becoming increasingly integrated into health security, and the OIE PVS tool helps identify capacity gaps therein, most livestock development assistance is not optimized for reinforcing functions for health security (such as those that target risk reduction in areas like land use planning or animal husbandry). Investment and standards in environmental health have primarily been focused on reducing pollutant and other chemical exposures. Capacity and resources in environment/forestry sectors are typically severely under-developed at the country level. As a result, wide gaps remain related to wildlife and vector-borne diseases, as well as the environmental factors that may be associated with risks.
Epidemics and pandemics are often spoken of as inevitable. It is true that we usually cannot know what we have prevented from happening, but this truth does not obviate the need for prevention research and implementation. The value of prevention is well recognized in other sectors, such as reduced speed limits to prevent traffic fatalities, fire-resistant building materials and sprinklers to prevent and slow the spread of fires, earthquake-proof building codes in high-risk fault lines to prevent building collapse, and building restrictions in high flood-risk zones to prevent the loss of homes and other assets. Incentives, too, exist for risk reduction practices in other mission spaces; for example, lower car insurance rates are offered to drivers without accident and speeding histories.

Some promising prevent-oriented programs have been funded by individual countries, such as those supported by USAID (the Emerging Pandemic Threats program and in particular the PREDICT project) and the U.S. Department of Defense (through the Defense Threat Reduction Agency and the Defense Advanced Research Projects Agency). Analysis reveals that certain species are more common sources of viral zoonoses than others (i.e., bats, rodents, non-human primates) and that habitat loss and exploitation of wildlife are convergent drivers of both species declines and viral spillover risk along with other drivers including agriculture intensification and food industry changes.\textsuperscript{51,52} In addition, environmental factors like rainfall anomalies are positive predictors of climate-sensitive disease outbreaks such as Rift Valley fever.\textsuperscript{53} Climate and weather systems maintained and financed by other sectors can be leveraged by the health security community to anticipate places and people and other animals at greatest risk for spillover events.
Mauritania faces two critical risk factors for vector-borne disease: climate change and urbanization. While intensifying drought and desertification present threats to health and livelihoods in the central Sahel region, coastal erosion and the potential for flooding increase pressure on the growing coastal cities of this second most rapidly urbanizing country on the African continent.

Vector-borne diseases—those caused by pathogens transmitted through mosquito and tick hosts, primarily—are highly responsive to environmental change, including local changes in temperature, humidity, and precipitation, as well as larger-scale changes in land use due to agriculture and urbanization. Recent cases suggest three vector-borne diseases that may respond to climate change and urbanization: Rift Valley fever (RVF), Crimean-Congo hemorrhagic fever (CCHF), and dengue fever. RVF, which causes abortions in livestock and fever, eye damage and, rarely, death in humans, has shown both range expansion and an increase in the number of cases in Mauritania over the last decade. CCHF, which can emerge from a tick-livestock cycle, has a high case-fatality rate (>30%) and has been reported in Mauritania as recently as late 2017. Dengue, transmitted to people through mosquito bites, is present throughout tropical and subtropical regions of the world; it was first reported in Mauritania in 2014.

While these diseases present problems primarily for local communities, the recent cases highlight the broader threat of these diseases to Mauritania and to the region. After the 2014 Ebola epidemic, WHO heightened its monitoring of hemorrhagic diseases, and RVF and CCHF both figure prominently in emergency response plans and are included in the WHO R&D blueprint. The distribution and frequency of both diseases are likely to change as livestock move in response to the availability of food and water in a changing climate. Further, the potential for introduction of these diseases into cities and for altered routes of transmission (e.g., hospital-associated) should be considered in the context of routine movement into cities, including the provision of food products for these burgeoning populations. Finally, with the recent introduction of dengue into the capital city of Nouakchott, an increasing burden of disease in this and other growing cities is a near-term challenge that should be proactively managed.

Urban margins—areas of cities with dense human populations, inadequate infrastructure, and irregular access to water and sanitation—are fertile breeding grounds for vectors and the diseases they transmit, and monitoring and possible prevention mechanisms for introductions (particularly of RVF, CCHF, and dengue) into large- and intermediate-sized cities of Mauritania should be considered as a disease surveillance priority. A comprehensive development approach to urban and water infrastructure, coupled with increased human resources for health and agriculture, including entomological surveillance, will be needed to mitigate the vector-borne disease risks posed by climate change and urbanization in Mauritania.
FINDING: RECOVERY IS ALL BUT MISSING

Initiatives to meaningfully and systematically advance recovery planning and implementation are extremely limited. The entire pillar of Recover is not captured by the major extant frameworks, nor are its functional areas nested within Prevent-Detect-Respond. They thus remain the most significantly overlooked.

Disaster recovery efforts are a mainstay for management of many natural hazards such as floods and earthquakes. Post-disaster recovery in such situations tends to emphasize rapid rehabilitation and reconstruction. But for epidemics, prior capacity is typically limited, with little existing platform on which to build. A true focus on building capacity in ways that “build back better” is generally missing for recovery from disasters that result from biological hazards.

Addressing the long-term burden of disease is the most obvious need for recovery efforts, as seen with the Ebola Survivors projects in West African nations, which focus on issues like healthcare services and research on long-term complications, skills retraining, and stipends to address livelihood impacts and social marginalization. Their very existence is a testament to the lasting impacts of outbreaks, but outside of these programs, support for disease survivors of infectious disease outbreaks is not routine. Nor is health system recovery in the aftermath of bio-disasters, including rebuilding the health workforce which may have suffered huge loss of lives of personnel, reactivation of health services which may have suffered as a result of the emergency, and addressing the overall weaknesses of the system. By effectively addressing lessons learned, investments in recovery could prevent repetitive spending on response reflected in activities like construction of short-term treatment centers, ad hoc animal and ecological surveillance, and the medical supply and healthcare worker influx that often accompany large outbreaks but are frequently not sustained long-term at national levels post-crisis.

The global health security governance community must decide whether recovery is a priority for them and if it is, it should be built into the frameworks, and initiatives in turn must be developed to address it. Recovery has high potential to leverage and optimize investments from other sectors (e.g., energy, education, supply chain development) in ways that benefit future emergency and routine operations. It is also crucial that recovery reinforce functions in the other pillars to address hazards, exposures, and vulnerability in order to avoid repeated devastation. As with other functions, resilient recovery requires coordinated action from a range of sectors in preparation for, during, and following biothreats. Recovery must not merely be based on the return to “normal” but must include prevention activities that prevent future outbreaks or at least mitigate their effects.
In 2017, an epidemic of plague hit the island of Madagascar. Although cases occur annually—Madagascar is a major focus of plague, routinely accounting for one-third of all cases worldwide—this epidemic represented a more than five-fold rise in the number of seasonal plague cases. In total, 2,348 cases and 202 deaths were attributed to the epidemic.

Agricultural communities in Madagascar are at highest risk of exposure to the bacterium Yersinia pestis, the etiologic agent of plague that cycles between fleas and rats and routinely spills over into humans in close contact. However, plague in the 2017 epidemic differed in important ways from seasonal plague. First, unlike the typical concentration of cases in the rural highlands at the center of the country, this epidemic was concentrated in urban areas, including the capital of Antananarivo. Second, rather than transmission through its usual flea-to-person route, the pathogen was transmitted person-to-person through the respiratory route. These two factors fueled the epidemic and posed the threat of wider transmission.

On November 25 of that year, the Madagascar Ministry of Health declared an end of the urban pneumonic plague outbreak, although rural bubonic cases continued to be detected. The epidemic was curtailed by an effective response that included contact tracing and free treatment, supported in part by $1.5 million in WHO emergency funds. However, as noted by Bonds et al., international responses can quickly fade, without the needed pivot to stabilize the economy after fear-associated closures of businesses and reduction in transport and tourism, maintain essential healthcare capacity and risk awareness campaigns that were established during the epidemic, and scope long-term development investments in the health, agriculture, and urban resilience sectors.

Plague is an example of an endemic disease with pandemic potential, demonstrated by three high-mortality pandemics in the years 541, 1347, and 1894. Even though it is easily treated with currently effective antibiotics, pneumonic plague is highly contagious and invariably fatal without timely treatment. Investing in basic public health services, including urban sanitation and vector control programs, should be a priority to prevent the recurrence of a plague epidemic of this scale.
BUILDING RESILIENCE TO BIOTHREATS

FINDING: CROSS-CUTTING FUNCTIONS PROVIDE UNDER-UTILIZED ENTRY POINTS FOR PARTICIPATION

The cross-cutting functions described in Table 3 are not relegated to the bottom of the table because they are unimportant—in fact, the opposite. They are architectural elements of the entire structure, without which it collapses. A few deserve special mention here as critically under-resourced.

While our analysis focused on global initiatives, the ultimate capacity for and return from the core functions is embedded within communities. This includes functions related to workforce, detection and reporting, and risk reduction opportunities. Functional approaches must therefore be designed with the motivations of the community and its wider constituents in mind (e.g., private sector entities, media, local government, and other leaders).

The private sector has been relatively untapped by governments and major global efforts. The development of strategic public-private partnerships across all four pillars is in its infancy. Yet the areas that require public-private cooperation, as well as the benefits that the private sector could provide, are many, and are directly tied to communities. Business continuity helps each business but also society in general. Local businesses and large corporations alike have roles to play and a particular incentive to contribute to well-functioning societies to minimize business disruptions and may be engaged in novel ways to mobilize resources and convene sectors. Employers are a pivotal entry point for workforce development, risk communication, and pandemic prevention and preparedness. They are embedded in communities and often already involved in multi-sectoral initiatives in their own operations throughout a business’s lifecycle.

Risk communication, both for operations within and between institutions and with the public, must underlie all decisions to support awareness of risks and needs and to build the trust of all stakeholders. It also can provide entry points for relevant sectors to ensure correct and consistent messaging and practical solutions. In terms of workforce development and sustainment, the intensive resources required of international responses to epidemics provide a strong rationale for considering ahead-of-time investments in workforce-building for basic public health and medical capacity, including community health workers, that can prepare for and deliver both emergency and routine health services. This investment is generally far more limited than the intensive resources poured into international responses to epidemics, which themselves do not typically support the building of long-term workforces.

Global R&D initiatives are largely focused on biosurveillance, biodetection, and medical countermeasure development, omitting an important evidence basis for all of the other functions, notably among upstream prevention and recovery. Finally, information sharing is still deficient across sectors and disciplines and often among different levels of reporting (e.g., from point of care to national and international levels). Optimizing these, especially the latter, is now a major focus of Integrated Disease Surveillance and Response reporting for implementation of the IHR by countries in the African region (and is being expanded to other regions). However, in general, multisectoral data sharing and interpretation, particularly for diseases before they appear in humans, are not routinely conducted for pandemic threats.
BOX 8: WHERE DOES THE PRIVATE SECTOR FIT IN?

The private sector has suffered significant losses from recent epidemics and pandemics. Declines in tourism following disease-related travel advisories or disruptions to supply chains and workforce threaten business continuity and have considerable impacts on businesses. Companies thus have an incentive to invest in and promote healthy populations and the functions that support stable operations.

New channels are being formed for the private sector to link into pandemic resilience efforts, such as the GHSA’s Private Sector Roundtable. The private sector represents a diverse group of entities in terms of industries and scale. Viewing private entities beyond their role in corporate and social responsibility can provide new pathways for their participation at local, national, and regional levels. The human resources required to build and sustain both basic and surge functions are not yet addressed in a sustainable way, particularly at the national level, and the inputs of the private sector are clearly situated to help address this. Further, employers can implement risk reduction policies such as providing reliable food sources to alleviate wildlife hunting pressures, providing education to workers on zoonotic disease risks, and requiring use of personal protective equipment in high-risk settings to prevent disease transmission and spread to employees. As zoonotic and non-zoonotic diseases can both impose high economic and health security impacts, there are important incentives for many industries to reduce risks. The predominance of the informal or “gig” economy and other aspects of changing workforce paradigms will require new ways for disseminating risk communication and management approaches; links between the private and public sectors can help enable the tools needed to do so which, in turn, can reach countless numbers of people.

Multilateral development banks have committed to mobilizing upwards of 35% increased financing from the private sector within three years, and the World Bank has launched an initiative to maximize private sector financing by considering private financing options, and encourages use of public sector finance to provide an enabling environment. This has great potential to strengthen capacity for some aspects of health security (e.g., private networks of veterinarians), though financing incentives must be in place to engage with the public sector to ensure ongoing contribution to public good. The PEF is facilitating new public-private partnerships through the development of pandemic risk itself as a market, with pandemic catastrophe bonds being assumed by private insurers, with premiums financed by donor governments.
CONCLUSIONS
AND RECOMMENDATIONS
The global health community should address future threats to health security comprehensively based on deeper understanding of prevention and remediation of human security. Simply taking the International Health Regulations to a next step would be too weak and too narrow an adjustment.”

– Chen and Takemi 2015

The global commitment to building the capabilities needed for an optimal state of global health security is strong. Yet the system in place is not yet at the point where the capabilities—the foundation—fully support the pillars, which in turn do not yet fully support a ready and resilient global health security structure. In general, the system still tends toward reactivity rather than proactivity, toward response rather than prevention. Efforts to counter global biological threats can be characterized largely as ad hoc responses to known diseases, with limited attention to horizon scanning and drivers of emergence of new and unknown diseases (what WHO calls “Disease X”).

Despite the reality that pandemic readiness is a function of the strength of all pillars, globally-organized efforts are primarily directed toward response, with 16 of 22 initiatives notionally or actually addressing this pillar. After-action reviews tend to target response failures, perpetuating this response-oriented mindset. Some might argue that global initiatives are naturally better suited to response than to prevention or recovery, and therefore that limiting our study to global initiatives unsurprisingly biased the results toward response. We strongly question this notion. Global institutions shape priority setting, investment incentives, and best practices that inform where countries emphasize their capacity and activities. That prevent and recovery implementation approaches may require context-specific tailoring, and require participation from and in some cases reliance on some sectors not currently involved in global health security efforts, should not preclude the global community from putting its weight behind efforts to aggressively address and invest in them if global health security is a development goal that extends beyond the health sector.

The global community has regularly generated response initiatives in reaction to outbreaks, and it was our intent to ask, what opportunities to address other fundamental areas might it be missing? The response bias precludes emphases on the other pillars that could provide encouragement, guidance, and cover for countries to take on activities toward those pillars at the national level. It also results in resource-intensive measures to contain outbreaks once an emergency has occurred, in many cases costing lives and leading to widespread societal and economic disruption. Most resources are mobilized downstream once emergencies occur. New major financing mechanisms—notably the WHO CFE and the World Bank PEF—allow resources to be mobilized when a certain trigger is activated. These mechanisms are important for assisting countries in outbreak response to avoid large-scale, international epidemics and potential pandemics or to provide insurance against their economic impacts; the CFE, specifically, provides resources for response to disease outbreaks as well as health emergencies that result from other disasters. However, response infrastructure should build on or lead to investments for resilience across prevent-detect-respond-recover. It should capitalize on opportunities for risk mitigation and early threat detection. In the long run, as demonstrated by the high costs of the recent Ebola and Zika outbreaks, relying on response results in huge loss of lives and damages, poses unsustainable financial costs, and represents missed opportunities for cost-saving risk reduction upstream. The imbalance would naturally be mitigated in a relative sense by a greater emphasis on addressing the other pillars. More importantly, the required investment levels would in absolute numbers go down in the long run if preventive efforts were the fundamental
priority for global health security efforts. Initiatives should also be in place to capture prevention and early warning inputs and celebrate success stories of outbreak prevention.

The gaps and limitations described in this report may provide a roadmap for choosing and prioritizing additional areas of investment of human and fiscal capital, ideally in concerted fashion. The work could take the form of designing a system of partnerships to meet the need, and ultimately implementing such a system. This would allow the community of stakeholders to move beyond ad hoc approaches, and instead operate as a more integrated and systematic global network dedicated to global health security capacity. This will require coordination across sectors, including in the design and tracking of assessment tools, action planning, investments, reporting, and promoting effective and efficient use of resources to ensure functions are sufficiently covered.

The global community can engage productively in all of the pillars. Indeed, the very attention of global entities to these pillars would be a huge step that could then support and create downstream activity from regional or national actors. The opportunity now waits in those areas of global health policy and implementation that are addressed insufficiently or not at all.

We believe this study provides a novel lens through which to view needs and opportunities for global health security. Our multidisciplinary findings, especially around the limited attention to date on systematic prevention and recovery, support a more comprehensive approach than is reflected by current health security efforts. We hope that the detail herein is a useful catalyst for further policy discussions and meaningful routes of entry into other sectors. This initial report can be followed up with expanded analyses to precisely map and track specific initiatives, new programs that will complement existing efforts and fill critical functional gaps, and new governance, implementation, and financing structures to ensure their coordination. These findings can be used to empower governments and international agencies to strengthen capacity for coverage of functions along the entire prevent, detect, respond, and recover spectrum of activity defined in the core functions framework. They can directly inform ongoing global initiatives to manage biorhythms and future iterations of capacity assessments, as well as orient prospective initiatives to spaces in the global health security landscape for contributions with optimal impact. Between the relative calm after the West Africa Ebola outbreak and the appearance of the next major biothreat—all too certain a short window—lies opportunity to do so.
RECOMMENDATIONS

While additional research will help inform more precise evidence-based preventions and interventions, several activities can be implemented now to strengthen and reinforce global efforts for global health security.

1. **Global biothreat initiatives should be more strategically aligned**

Coordination and harmonization of dozens of parallel initiatives will help ensure coverage and synergy. While alignment with IHR is important for the health community and some have called for harmonization of multiple standards within it, the relevance, entry points, incentives and ownership for other sectors must also be considered and made apparent. This is admittedly challenging without resources dedicated to coordination to establish working relationships between sectors at all levels, especially the sectors that may have limited capacity and resources (and thus may not be conducting the functions they are best served to address).

All of the needed sectors must be at the table to enable whole-of-society preparedness and promote independent thinking, monitoring, and accountability. One of the most important roles of the global community is to identify functional needs agnostic of sector and then create a framework that guides players to focus their initiatives in a way that is mutually beneficial and synergistic with the many other initiatives operating in the global health security mission space. At a country level, National Action Plans for Health Security offer a platform for integrating multisectoral inputs and identifying shared goals as well as integrating prevention of health emergencies into other sectors’ national action plans, such as those for climate change, biodiversity, and urbanization. Related processes, such as WHO’s recent multisectoral resource mapping and prioritization workshops, can also help bring stakeholders from various sectors together. However, the long-term success of implementing shared priorities will require new ways of working together and likely new mechanisms for financing multisectoral initiatives. The Global Pandemic Monitoring Board, taking shape now, could potentially bring all of these elements together to ensure coverage and coordination of core functions for health security. And the proposed GHSA 2024 Framework, in which more than 40 partners will reaffirm the need and set the stage for preparedness, could be upscaled to include additional nations or become a global compact. To support translation to country action, establishment of a Global Fund-like entity for global health security, which could be used to fund countries directly to implement their costed National Action Plans for Health Security, could help more systematically and sustainably provide a pathway for needed One Health capacity strengthening.

2. **Multi-sectoral participation must be recognized as a requisite tenet of the entire global health security enterprise**

The participation of many sectors and disciplines in the public and private spheres is vital to achieving a state of global health security. Yet the health sector dominates all others, despite the reality that preventing, detecting, responding to, and recovering from major biological events must employ the efforts of many public sector ministries and private sector industries. Our review has identified three glaring weaknesses that, if rectified and considered in the context of disaster risk reduction or management, perhaps through a renewed push per GHSA 2024 Framework development, could provide substantial benefit to the health security of global citizens:
Defense and security

Important investments in counterproliferation and counterterrorism have not yet been institutionalized as a co-equal in the fight for health security. Law enforcement, military, immigration control, and other entities can assist with core functions, including protection of critical infrastructure, bioforensics and attribution, logistics of essential services surge, and medical countermeasure distribution and dispensing. The GHSA “Biosafety and Biosecurity” action package is the most explicit in this purpose, with targets ensuring “that especially dangerous pathogens are identified, held, secured and monitored in a minimal number of facilities according to best practices; biological risk management training and educational outreach are conducted to promote a shared culture of responsibility, reduce dual use risks, mitigate biological proliferation and deliberate use threats, and ensure safe transfer of biological agents; and country-specific biosafety and biosecurity legislation, laboratory licensing, and pathogen control measures are in place as appropriate.”60 This acknowledgement of security is much less evident in the IHR and OIE regulations, and the effort to encourage partnerships among previously distinct sectors was therefore an important specific contribution of the GHSA. All of the action packages can, in fact, be implemented with security in mind if the defense and security sector is considered one among equals. Doing so will require complete engagement of this sector’s representatives at the global and country levels. The GHSA could leverage regional security agreements, such as the North Atlantic Treaty Organization, to address biothreats through the 2024 Framework development process.

Environment

The close link between encroachment on wildlife and ecosystems and disease emergence makes the environment sector a critical partner that has yet to be integrated into health security efforts. This sector can be leveraged to contribute key information for threat detection and sentinel surveillance to enhance disease prevention, as well as intervention options to mitigate disease risks from wildlife and other environmental sources. For example, climate and weather systems and biodiversity monitoring financed by other sectors can be leveraged by the health security community to anticipate places, people, and animals at greatest risk for pathogen spillover events and address risk drivers upstream. In general, there is a continued need to apply (not just talk about) One Health approaches. Donors can more systematically coordinate with the environmental sector to ensure multisectoral approaches are built into programs prospectively. Working through existing channels and reinforcing dual capacities for emerging and endemic diseases may show immediate value and promote sustainability. These efforts can align with and advance many existing intergovernmental and non-governmental environmental organizations’ efforts to explore biodiversity and ecosystem “mainstreaming” for health.

Private sector

We echo the call to “map the potential contributions of the nongovernmental sector to global health security and identify opportunities to catalyze multisectoral partnerships among the US government, private, and social sectors that will harness new allies, innovations, and investments to bolster pandemic preparedness.”61 Engagement of the private sector as a partner in preparedness is critical both for early detection and to minimize potential impacts of reported disease on trade and travel, as well as reduce disruption in other facets of society. Global initiatives with multi-national corporation participation, such as the Private Sector Roundtable, can be followed up with more local activities at country and community level where private sector entities are embedded and business continuity may be integral for both companies and wider society. Incentives to reduce risks, such as incorporating economic vulnerability from pandemic risks into country credit ratings, which has been proposed as a strategy to incentivize pandemic preparedness,62 should be explored. Others have called on financing institutions to take steps to limit upstream risks to reduce potential liabilities. This can occur, for example, by incorporating emerging infectious disease risk in development project safeguards or partnering with industry to promote alternatives to high-risk practices to reduce risk and impact potential negative externalities.63 Such approaches could tie into risk reduction efforts in the environment sector as well. We recommend the development of aggressive, early, and transparent partnerships between government agencies charged with global health security and the private sector. The private sector’s unique health security functions should be defined, mapped to global health needs, and fiscally supported.
3. Strategic gaps at the margins must be aggressively addressed

Of the four pillars that define global health security in our construct, two are woefully under-addressed:

**Prevent**

Implementers should embrace Prevent as an area of need and target investments accordingly. Prevention programs could potentially tie into existing and sustained programs in place on the ground, such through Community Health Worker networks, which feature front-line public health workers with trusted relationships and strong understanding of the communities they serve, and by broadening the scope of other initiatives currently focused on specific communicable diseases (e.g., Roll Back Malaria partnerships). Some innovative approaches have been proposed to target gaps in Prevent, such as the Global Virome Project, which would enhance surveillance and characterize mammalian viral diversity to inform the global health community about potential risks and guide the development of preparedness measures in areas like spillover risk reduction and vaccine and therapeutic inputs. The use of modeling and risk profiling and prioritization to predict disease emergence is still in its infancy, particularly with respect to incorporating elements of human behavior and risk drivers outside the health sector. Improved prediction and prevention science will require new approaches and financing to sectors that at present have limited health security engagement to address proximal and distal drivers of disease emergence. It will require factoring outbreak risk and risk reduction into land use planning, climate action, food production practices, anti-terrorism sanctions, and trade and travel. The GHSAs' next iteration should include metrics that measure prevention of spillover not only in terms of surveillance efforts, but of other behaviors, policies, and practices that minimize that spillover.

**Recover**

Health threats should be managed as a continuum, from Prevent to Recover to Prevent. During Recover, the main focus should not only be to return to “normal” but to prioritize the instillation of policies, plans, and activities to Prevent. Best practices for recovery are extremely limited for biothreats. Granting these functions attention similar to that available with other types of disasters will promote a more systematic understanding of needs and should strengthen functions to prevent, detect, and respond to future risks and impacts. Financing must be sustained through the recovery phase, eliminating rapid shifts to the next outbreak that leave a debilitated country primed for another biothreat event. There is increasing recognition that humanitarian and development agencies must collaborate, recognizing the underlying vulnerabilities to hazards in conflict and fragile states and the need for sustained engagement to promote stability. Nascent programs in this area that contribute to global health security should be strongly supported.
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