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The Role of Noncommunicable Diseases in the Pursuit of Global Health Security

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Noncommunicable diseases and their risk factors are important for all aspects of outbreak preparedness and response, affecting a range of factors including host susceptibility, pathogen virulence, and health system capacity. This conceptual analysis has 2 objectives. First, we use the Haddon matrix paradigm to formulate a framework for assessing the relevance of noncommunicable diseases to health security efforts throughout all phases of the disaster life cycle: before, during, and after an event. Second, we build upon this framework to identify 6 technical action areas in global health security programs that are opportune integration points for global health security and noncommunicable disease objectives: surveillance, workforce development, laboratory systems, immunization, risk communication, and sustainable financing. We discuss approaches to integration with the goal of maximizing the reach of global health security where infectious disease threats and chronic disease burdens overlap.

Keywords: Noncommunicable diseases, Public health preparedness/response, Global health security, Pandemic preparedness

Introduction

The ongoing COVID-19 pandemic has revealed the importance of noncommunicable diseases (NCDs) to health and economic outcomes. Within a few months of the pandemic's emergence, disproportionate rates of hospitalization, intensity of care, and death were documented for COVID-19 patients with preexisting cardiovascular disease (CVD), hypertension, diabetes, chronic respiratory disease, or cancer.[1-12] Prevalent NCD risk factors, such as obesity and tobacco use, have been implicated in the progression of and susceptibility to COVID-19 infection.[13,14] During both of the world's most recent pandemics, influenza A H1N1 and COVID-19, obesity has been a shared predictor of pathogen virulence and pandemic burden.[15] The convergence between noncommunicable pathologies and infectious outcomes represents a critical switch point in the dynamics of epidemic outbreaks. The underlying health of a population is an aspect of key factors that determine the course of pandemics—ie, their severity and transmissibility—and our ability to plan and respond to them.

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In 2005, the World Health Organization introduced the International Health Regulations (IHR) 2005—a diverse set of approaches to reduce the impact of international public health emergencies through improved country capacity to detect, assess, report, and respond to health security threats.[16-17] In 2014, the Global Health Security Agenda (GHSA) emerged as a joint initiative among multiple countries to further support implementation of the IHR.[18] However, despite the syndemic relationship between communicable and noncommunicable conditions worldwide and despite growing recognition that integrated health systems are important to health security objectives, NCD aspects of health security are not part of IHR- or GHSA-related preparedness approaches. In a world of overlapping disease risks, where NCDs can no longer be siloed away as an independent circumstance from pandemic outcomes, pandemic prevention strategies might benefit from incorporating select NCD elements as part of an integrated approach to health systems.

The objectives of this conceptual analysis are twofold. First, we outline a theoretical framework to inform the relevance of NCDs to global health security efforts, using an application of the Haddon matrix to outbreak preparedness. Second, we identify 6 technical areas in the IHR and GHSA that represent opportunities for integrating health security and NCD objectives. We present an approach for integrating applicable NCD components into these technical areas, with the goal of maximizing the reach of global health security where infectious disease threats and chronic disease burdens overlap.

Convergence of Infectious Diseases and NCDs—The Haddon Matrix

The relevance of NCDs to outbreak preparedness can be understood using the Haddon matrix,[19] a tool developed in the 1970s to provide a conceptual framework of the circumstances before, during, and after an emergency event. When applied to disease outbreaks, the Haddon matrix classifies 3 event phases (preevent, event, postevent) across 4 interacting elements: host population, disease agent, physical environment, and social environment.[20,21] As summarized in Table 1, NCDs play a role across all elements of outbreak preparedness and response, affecting a range of factors including host susceptibility, pathogen virulence, and health system capacity for addressing emergent and ongoing health threats. Because epidemics tend to occur against a baseline of chronic conditions, our understanding of epidemics has expanded to include the notion of syndemics—simultaneous elevations of 2 or more different diseases resulting in accelerated morbidity.[22-24] Syndemics represent a shift in the global health security landscape, as planning for outbreaks

Table 1. Application of the Haddon Matrix to Integrate NCDs with Outbreak Preparedness and Response

	Host (Population at Risk)	*Disease Agent (Pathogen Virulence)*	*Physical Environment (Health System)*	*Social Environment (Budgets, Policy, Political Prioritization)*
Pre-outbreak	NCDs and their risk factors increase population susceptibility to pathogens; better NCD care, vaccination coverage, and appropriate risk communication increase host resilience	n/a	NCD-focused care is interlinked with and strengthens the primary care infrastructure	Budget priorities reflect dual disease burden; including NCD elements in health security initiatives can reinforce community trust and facilitate political cooperation
Outbreak	NCDs increase population susceptibility; infections can have immediate NCD sequelae, requiring treatment for both; understanding high-risk populations helps target interventions	NCDs can increase pathogen virulence, increasing adverse outcomes in affected populations	Health systems structured around NCD control and primary care can provide the infrastructure for medical response during outbreaks (staff, supply chains, healthcare access)	Community trust established through integrated health systems/NCD strengthening prior to an outbreak can facilitate emergency response during an outbreak
Post-outbreak	NCDs continue to affect population susceptibility; NCD burden may rise due to clinical after effects of infection	Understanding the role of pathogens in NCD complications can inform interventions	Health systems evolve to accommodate dual disease burden	Budget and policy priorities reflect dual disease burden

Abbreviation: n/a, not applicable; NCD, noncommunicable disease.

must now take place in a context where contagious diseases are no longer the dominant threat to health in low- and middle-income countries (LMICs), and where NCDs increasingly shape national public health priorities.

Host Population and Disease Agent

Chronic diseases increase host susceptibility to infection. At the population level, this may have a direct effect on the potential size of an outbreak, serving as a predictive factor for transmission.[25,26] Underlying NCDs (eg, heart disease, diabetes) and their risk factors (eg, obesity, tobacco use) can also influence the severity of an outbreak by increasing pathogen virulence in affected persons. For example, a metaanalysis of 6 studies has linked preexisting cardiovascular disease to increased COVID-19 severity.[27] A separate metaanalysis of 6 studies has found that COVID-19 progression is exacerbated by hypertension, diabetes, chronic obstructive pulmonary disease, and cerebrovascular disease.[28] Diabetes has been shown to play a role in determining disease outcomes during the current COVID-19 pandemic,[29-33] during the 2009 outbreak of H1N1,[34] during the 2003 outbreak of severe acute respiratory syndrome (SARS),[35] and during outbreaks of Middle East respiratory syndrome.[36-38] Diabetes worsens outcomes in endemic infectious diseases including malaria,[39] tuberculosis,[40] mucormycosis,[41] and overall infections in developing countries.[42] A metaanalysis of 65 studies established that preexisting hypertension and diabetes were significant factors in determining the severity of dengue and West Nile virus infections.[43] During the 2014-2016 Ebola outbreak, a higher mortality rate was documented in older patients, representing a possible concentration of undiagnosed chronic conditions in this population.[44] Correlations between infection outcomes and chronic conditions such as hypertension and diabetes have been recorded for Middle East respiratory syndrome,[45] avian influenza H7N9,[46] and H1N1.[47] A leading NCD risk factor, tobacco use, has been implicated by numerous studies as a shared risk factor for increasing severity and progression of infections.[48-51] Smoking has been shown to worsen illness from COVID-19 infection in a metaanalysis of 11 studies,[13] possibly by increasing the expression of molecules in the lungs that COVID-19 uses to attach to and infect cells.[52] Obesity, a condition affecting pulmonary function and inflammatory response,[53] is independently associated with COVID-19 complications,[54] particularly in younger patients.[30] In H1N1, obesity aggravates not only individual patient outcomes but has been shown to increase the duration of viral shedding, intensifying transmission at the population level.[55]

In a reverse effect, infectious disease agents may independently add to the chronic disease burden both during and after outbreaks by generating new NCD manifestations in affected patients. Within the Haddon matrix, this can generate postevent implications, reflecting increased morbidity not only during active public health emergencies but also thereafter. For example, acute cardiovascular disease (CVD) complications have been observed during COVID-19 infection[56-60] in older adults[61] and younger patients.[62] After recovery from COVID-19, lingering myocardial inflammation has been documented in a majority of patients in a study using MRI (magnetic resonance imaging) followup.[63] Influenza illness is a recognized trigger for heart attack and stroke,[64-66] and SARS coronavirus infection during the 2003 outbreak was linked to a short-term increased risk of stroke[67] and to long-term alterations in lipid metabolism.[68] Endemic infection with hepatitis B or C virus causes a majority of liver cancers.[69] A systematic review of 10 articles has documented the significance of CVD complications from Zika virus in adults,[70] which can occur in addition to the more widely reported neurological and cardiac consequences of the infection in infants.[71,72] Persistent CVD complications also occur from Chagas disease,[73] chikungunya,[74] dengue,[75] and tuberculosis,[76] and the precipitating role of malaria in chronic renal disease has been known for decades.[77] The added risk of NCDs with infectious etiology implies that emergency response efforts must have readiness to address both types of illness, with a possibility that continued NCD care might be needed beyond the outbreak recovery period.

Physical and Social Environments

As described by Barnett et al,[20] the physical environment in which outbreaks occur is defined by health infrastructure elements like health facilities and staffing, whereas the social environment is represented by sociopolitical, policy, and resultant budgetary factors that shape a country's health system. The physical and social environments are interdependent. In the context of outbreak preparedness, NCDs affect both of these environments through their influence on national health policy priorities, budgets, and expenditures. The growing burden of NCDs in LMICs has also motivated shifts in the direction of global health policy, as evidenced by the expanding focus on NCD prevention and access to care in the 2030 Sustainable Development Goals.[78]

Health systems in lower-income countries are often unprepared to address the dual disease burden of infectious and chronic diseases in their populations.[79-81] Access to healthcare staff, resources, and medications, which may already be scarce, can become increasingly inadequate.[82-84] Focusing on epidemic containment during outbreaks can detract from the capacity to address underlying NCDs, draining resources for overall care. Even in high-resource countries like the United States, healthcare delivery during outbreaks can change in structural ways, such as shifting toward virtual care,[85,86] modifying triage practices,[87,88] and reducing care for nonepidemic patients.[89]

During nonemergency periods, health systems in lower-income countries have responded to the growing demand for NCD care by integrating new health system elements such as primary care,[91,92] NCD surveillance,[81,92] and nonphysician health staffing.[92,93] Provision of essential care through community health workers (CHWs) has been a cost-effective

Table 2. GHSA and IHR Focus Areas with Relevance to NCDs

GHSA/IHR Technical Area	*Sample Areas of Work*	*Crosscutting NCD Activities*
Immunization	Maintain and improve vaccination coverage for vaccine-preventable illnesses	Integrate HPV, HBV, and influenza vaccination in community vaccination plans
Laboratory systems	Include a set of 10 core diagnostic tests in national laboratory capacities, including 6 predetermined infectious disease assays	Incorporate up to 4 core assays relevant to NCDs
Risk communication	Strengthen communication engagement with affected communities; develop a systematic approach to addressing perceptions, risky behaviors, and misinformation	Include information on preventable NCD risk factors in communications to communities
Surveillance	Strengthen health surveillance systems; use surveillance data to identify emerging public health events	Include NCD indicators in existing surveillance systems, including syndromic surveillance and population-based surveys; enforce NCD additions to the Integrated Disease Surveillance and Response Plan
Sustainable financing	Mobilize resources; engage national policy stakeholders	Financing through taxation of NCD risk factors such as tobacco use; coordinate shared procurement mechanisms for essential medicines and supplies
Workforce development	Train health workforce in outbreak prevention and response; develop epidemiologic knowledge across the health workforce spectrum including physicians, veterinarians, laboratory scientists	Include NCD curricula in FETP training; include NCD prevention approaches in CHW training

Abbreviations: CHW, community health worker; FETP, field epidemiology training program; GHSA, Global Health Security Agenda; HBV, hepatitis B virus; HPV, human papillomavirus; IHR, International Health Regulations 2005; NCD, noncommunicable disease.

approach to NCD prevention and control in some LMICs.[94] In another instance of adapting to the rise in NCD needs, lower-income countries, such as many East Africa countries, increasingly incorporate civil society initiatives in addition to or instead of governmental action.[92] Some national approaches to health system development have migrated toward a regional approach to increase efficiencies of scale. Efficiency gains from regional aggregating of medication procurement have been observed in East Africa and the Caribbean,[95] and in staff training and health financing in Southeast Asian countries.[96] The increased use of regional approaches to health systems development adds a new aspect to the physical and social environments for global health security efforts.

Integrating NCDs Into Technical Areas for Action

As health systems in LMICs evolve to adapt to the increase in NCD burden, improved integration between NCD and infection-containment initiatives can help build capacity in emergency preparedness by strengthening the foundation of health systems.[97-99] Along with the recognition that such integration facilitates the efficient distribution of human and financial resources,[100] NCDs merit a distinct place in the global health security formula.

The GHSA is organized around 8 major areas for action (called action packages) to advance the objectives of the IHR.[101] These include antimicrobial resistance, biosafety and biosecurity, immunization, laboratory systems, surveillance, sustainable financing, workforce development, and zoonotic diseases. There are 2 main tools for evaluating progress toward IHR implementation: the Joint External Evaluation (JEE), a voluntary external assessment under the IHR Monitoring and Evaluation Framework,[102] and the mandatory IHR State Party Self-Assessment Annual Reporting (SPAR) tool.[103] The assessment areas covered by JEE and SPAR mostly overlap with the current set of GHSA action packages, but not all action packages are equally suited to assimilate NCD-related components. We identified 6 GHSA action packages—surveillance, workforce development, laboratory systems, immunization, risk communication, and sustainable financing—that are well positioned to incorporate NCD interventions and described aspects of NCD efforts that could be integrated into each area (Table 2).

Surveillance

Public health surveillance—the collection and analysis of population health data—is a principal action area of health security. Within the Haddon matrix, NCD surveillance applies to the preevent, event, and postevent periods of the

host population element. It tracks underlying comorbidities in the population before an outbreak, helps identify high-risk groups for vaccination during an outbreak, and informs chronic health complications and long-term health effects after an outbreak. Although GHSA and IHR have traditionally focused on the surveillance of epidemic-prone diseases, the rising burden of NCDs has provided a strong incentive among health policymakers in LMICs to include coverage of NCD indicators in health surveillance programs. Population-based surveys in LMICs are already evolving toward a single information framework covering both communicable and noncommunicable conditions.[104] For instance, the addition of NCDs into existing surveillance systems of village populations has been described in studies from India[105] and Gambia.[106] The Integrated Disease Surveillance and Response plan—a strategy formulated by the World Health Organization to improve the flow of infectious disease data in LMICs[107]—has been endorsed, albeit with limited implementation, by multiple African countries.[108] While the Integrated Disease Surveillance and Response plan did not include NCDs at the time of its inception in 1998, it has since been revised to include reporting of priority NCDs, specifically hypertension, diabetes, mental health, and malnutrition.[109] Expanding implementation of this plan would represent a step toward a more comprehensive approach to public health surveillance.

Syndromic surveillance—in which data are obtained from patients at points of care rather than population surveys—is particularly suited to NCD integration as it allows the tracking of comorbid conditions that can influence epidemic outcomes in real time. In Mozambique, existing data collection tools have been successfully adapted to include tracking of NCDs in addition to communicable diseases in a hospital setting.[110] In India, primary care registries have been successfully applied toward diabetes surveillance.[111] In areas with limited patient access to care facilities, syndromic surveillance may be facilitated by mobile digital technologies[112,113] or community healthcare workers.[114,115] Overall, the collection of NCD data points in existing health surveillance tools represents a significant opportunity to converge health security goals and local health needs, yet remains underutilized. Actionable items for integrating NCDs in the area of surveillance include adding indicators related to NCDs to existing surveillance systems and tracking such indicators in IHR monitoring and evaluation tools such as JEE and SPAR.

Workforce Development

IHR and GHSA call for strengthening workforce capacity in applied epidemiology in every country. This objective involves training health professionals in supporting national public health systems and managing local public health events. Within the Haddon matrix, workforce development applies to the preevent period of the physical environment element, where staff readiness is an important part of the health infrastructure. The field epidemiology training program is a mechanism for training applied epidemiologists globally,[116] which has been a platform for strengthening public health competencies in LMICs for over 60 years.[117] Countries have the flexibility to customize training programs to meet local priorities and can establish specialized tracks that focus on NCDs, laboratory, veterinary, or other courses of study.[118] NCD areas of study within these programs have become increasingly common,[119,120] and a survey of 57 programs estimated that over half offered training in NCD control.[121] High interest in NCD-related curricula in many countries suggests that an actionable item for integrating NCDs in the area of workforce development is to expand country field epidemiology training programs to include practice and instruction on topics like obtaining and analyzing local NCD surveillance data.

Another workforce development approach is training CHWs who can help bridge gaps in healthcare access in LMICs.[122] CHWs are at the front lines of response to infectious disease outbreaks, immunization events, and preventive services. Incorporating appropriate NCD training for CHWs can contribute to improved diagnosis and management of basic chronic conditions like hypertension, but this resource for addressing NCDs remains underutilized in many countries.[123,124] The need is largely unmet in low-resource settings, where task sharing between CHWs and other healthcare providers could enhance basic preventive services such as lifestyle modification and CVD prevention.[125-127] There is mounting evidence that elements of chronic disease management can be shifted to CHWs through appropriate training.[128-130] Training in CVD prevention can be successfully applied to other healthcare providers as well, including physicians[131-134] and nurses.[135,136] In primary care, training in standardized treatment protocols is a way to expand CVD prevention when staff resources are limited.[137,138] Incorporating NCD prevention in training initiatives for healthcare providers is another action item for NCD integration in the area of workforce development.

Laboratory Systems

Infection control is contingent on efficient pathogen identification. Within the Haddon matrix, laboratory systems strengthening applies to the preevent, event, and postevent periods of the physical environment element. The JEE refers to a set of 10 core diagnostic tests as a threshold for essential laboratory capacity in countries.[139] These include 6 assays critical to the detection of epidemic-prone diseases: polymerase chain reaction testing for influenza virus, virus culture for poliovirus, serology for HIV, microscopy for *Mycobacterium tuberculosis,* rapid diagnostic testing for *Plasmodium spp*., and bacterial culture for

Salmonella enterica serotype *Typhi*. The remaining 4 tests can be selected by individual countries, lending flexibility to include assays related to NCDs.

Laboratory capacity, a foundational element of health security, can be weakened in LMICs by workforce and infrastructure limitations.[140-142] Broadening laboratory capacity beyond a singular focus on infectious pathogens to include chronic disease testing capabilities creates a path forward to filling gaps in comprehensive care[143,144] while avoiding duplicate testing and supply chain costs.[145,146] For example, a standardized national laboratory logistics system in Ethiopia, designed to meet the supply needs of individual laboratories, greatly reduced patient wait times for tests from multiple months to less than a day.[147] Integrating biochemical testing for key chronic conditions into plans for laboratory strengthening could promote whole-patient care as well as economies of scale, but selection of appropriate NCD indicators can be complicated because some are better suited to clinical rather than laboratory testing. Malcolm et al[148] discussed testing for 3 indicators that may, in some circumstances, be candidates for inclusion in the set of core JEE diagnostic tests in resource-limited environments: creatinine for kidney disease, cholesterol for dyslipidemias, and hemoglobin A_{1c} for diabetes.

Immunization

As the workhorse of infection control, immunization is an important component of GHSA. In the JEE, this technical area emphasizes tracking of national immunization coverage for epidemic-prone diseases such as measles. Adding a focus on vaccination against infectious pathogens that result in chronic conditions represents a unique opportunity to deliver NCD preventive services through national immunization networks. Presently, several vaccines can be used to reduce select NCD risks. These include the human papillomavirus (HPV) vaccine for the prevention of cervical cancer, the hepatitis B virus vaccine for the prevention of chronic liver disease and cancer, and the seasonal influenza vaccine that can prevent acute CVD complications provoked by influenza. Given the role of infections as a causal agent of NCDs, NCD control in some parts of the world, particularly Africa, depends on infection control throughout the life cycle.[149] Where African countries are experiencing a significant burden from cervical cancer and other HPV-related conditions, HPV vaccination can be both effective and cost-saving.[150,151] In countries and regions with relatively high burdens of liver cancer, such as China, Southeast Asia, and sub-Saharan Africa, the hepatitis B vaccine has been shown to reduce chronic liver disease in immunized cohorts.[152-156] In Taiwan, a higher rate of influenza vaccination was shown to reduce CVD in high-risk populations.[157] Including HPV, hepatitis B, or influenza vaccinations in community immunization plans is an approach to integrating NCD elements in the technical area of immunization, where these can complement health security goals by building upon and expanding vaccination outreach initiatives in vulnerable areas and among adults.[120]

Risk Communication

The technical area of risk communication refers to establishing channels for communicating disease risk and disease containment approaches with the public, with affected communities, and between public health actors. Within the Haddon matrix, risk communication applies to the preevent and event periods of the physical environment element, where it represents the development of infrastructural capacity for distributing public health information. Increasing the availability of dedicated staff and improving communication training resources can help to improve risk communication objectives, as demonstrated during the 2003 SARS outbreak in China[158] and Taiwan.[159] Capacity to communicate nonpharmaceutical interventions was an important aspect of emergency response in pandemic influenza.[160] During the COVID-19 pandemic, effective public communication has been outlined as an essential component for behavioral modification necessary to limit the spread of disease,[161,162] and fast intragovernmental communication between authorities has been credited with improving COVID-19 containment in Hong Kong, Singapore, and Japan.[163] Effective risk communication relies on effective community engagement, often through personnel without prior communications training.[164] In this regard, NCD prevention approaches offer many lessons. A systematic review of 16 studies from LMICs documents the practice of deploying CHWs for risk communication in the areas of tobacco cessation, hypertension, and diabetes control through the promotion of treatment adherence and behavior modification.[94] One action item for integrating NCDs in the area of risk communication, presently addressed by many governments, is including NCD-related information in emergency risk communication plans. For example, identifying select comorbidities as risk factors for severe COVID-19 illness during the pandemic has helped with messaging around the need for added precautions and risk reduction.[165] Additionally, messaging directed at people with NCDs about the need to maintain adequate supplies of medications for emergency scenarios can mitigate the risk of reduced access to care during an outbreak.

Sustainable Financing

The objective of the GHSA action package on sustainable financing is closing gaps in funding for health security. Within the Haddon matrix, sustainable financing fits within the preevent, event, and postevent periods of the social environment element, where it impacts resource availability for health security. However, resources for health security are not fully separable from broader public health objectives because both exist within a shared health

system infrastructure. For instance, key health system attributes, such as healthcare access or medical supply chains, are shared ingredients for both communicable and noncommunicable aspects of population health.[92,166] Allocating resources to strengthen these shared ingredients has comprehensive benefits such as health security.[167] Recognizing the shared foundation for successful outcomes across the disease spectrum, local stakeholders are transitioning away from prioritizing single diseases and instead considering a more horizontal approach to health system financing.[168,169] In this context, the sustainability of health security financing may be reinforced by including financing for horizontal health system elements, such as supply chains for essential medicines. A model of a horizontal initiative with broad health sector applicability is the Pan American Health Organization Strategic Fund—a mechanism for aggregate procurement of medicines for the region.[170] By ensuring access to essential NCD medicines during epidemic outbreaks, joint procurement mechanisms can increase sustainability through economies of scale and a multipronged approach to financing support.

Additionally, NCD prevention approaches can be an independent source of funding for the health system, ultimately contributing to health security objectives. For example, Thailand and the Philippines have experienced success with using taxation of NCD risk products, such as tobacco and alcohol, as an earmarked source of domestic health financing.[171-173] NCD fiscal policy conducted through the taxation of unhealthy products offers a path toward sustainable financing for national health priorities, including those related to health security.[174]

Discussion

We used the Haddon matrix as a framework to outline the relevance of NCDs to health security goals. NCDs play a role in all elements of outbreak preparedness and response: host population, disease agent, physical environment, and social environment. NCDs also affect all phases of the disaster life cycle: preevent, event, and postevent. They can determine population susceptibility to epidemics before an outbreak occurs, can impact the capacity of health systems during outbreaks, and can complicate the recovery period through epidemic-related sequelae. Given the broad importance of NCDs for health security outcomes, we identified 6 action areas that are particularly suitable for integration of NCD components: surveillance, workforce development, laboratory capacity, immunization, risk communication, and sustainable financing. In the area of surveillance, integration can occur through tracking of NCD-related indicators alongside other priority data. Workforce development integration can occur through training of public health and healthcare staff in NCD prevention and control. Diagnostic tests for select NCD indicators can be included in national plans for developing laboratory capacity, and vaccination for HPV and hepatitis B can be included in community immunization plans. In risk communication plans, including information on NCD risk factors as part of preparedness can strengthen health messaging. In the area of sustainable financing, supporting horizontal health system elements such as shared procurement mechanisms for essential medicines and supplies can strengthen sustainability.

The importance of approaching GHSA strengthening activities from the perspective of health systems integration is well recognized.[98,163,175-178] As the COVID-19 pandemic has demonstrated, a key test for health systems worldwide is their resilience in simultaneously addressing emergencies and ongoing health needs.[179-183] An imbalance between emergency care and essential care can have negative repercussions and can raise equity concerns, especially in low-resource settings. For example, a review of lessons learned from the 2014 Ebola outbreak in communities that receive GHSA investment noted that individuals view health needs for infectious diseases and chronic diseases through a unified lens, not compartmentalized into separate pillars.[175] A lack of access to primary and chronic care prior to emergencies therefore erodes individuals' faith in health systems to manage infectious disease outbreaks when emergencies strike, even when emergency resources are plentiful, resulting in cross-border movement and distrust. Conversely, access to integrated healthcare strengthens the trust that is central to a health system's ability to use measures necessary to contain epidemics.[184-186]

The integration of NCD components in global health security action areas is subject to implementation barriers in resource-limited environments. Surveillance approaches may be challenged by limited access to vulnerable populations. Workforce development initiatives may face overburdened healthcare staff and limited capacity of CHWs to address long-term NCD needs. When strengthening laboratory capacity, determining which core NCD assays are suitable for laboratory rather than clinical settings may be difficult. Limited access to primary care can limit the objectives of immunization plans related to NCD prevention. Persistent vertical separation between financing for NCDs and health security objectives is a key challenge in developing a unified approach to health development. Finally, the integration of NCDs in health security plans may be limited unless all global frameworks recognize its importance, including GHSA, IHR, and their respective evaluation tools.

The success of US investment in global health through programs such as the US President's Emergency Plan For AIDS Relief (PEPFAR) has demonstrated the potential for public health improvement in LMICs.[187] As health needs in LMICs continue to evolve, existing platforms for specialized disease-specific care can serve as catalysts for the integration of health services.[188,189] For instance, in recent integration initiatives, the baseline PEPFAR infrastructure for HIV care has facilitated the delivery of hypertension

control and cervical cancer prevention services.[190,191] On a broader scale, the approach of "building once" when establishing health infrastructure in LMICs can be an optimal approach for health systems investment.[176] The integration of services for communicable and noncommunicable diseases helps maintain investment in health systems between and during outbreaks, which ensures a more consistent source of health funding between outbreaks, mitigating the impacts of future outbreaks. While this approach requires advanced planning in its broader consideration of public health needs, it represents both a strategic and a sustainable investment in the long-term capacity of countries to address local and global health threats.

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