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Overview of global governance, capacity, and health systems implication of pandemic prevention, preparedness, and response: A narrative review and descriptive analysis of open-source data

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Abstract: The COVID-19 pandemic has highlighted the importance of pandemic prevention, preparedness, and response (PPPR) in global health. This review first examined global health governance (GHG) for PPPR, identifying its core-satellite structure. Key GHG functions include rule-setting, resource mobilization, medical countermeasures (MCMs) supply, surveillance and data/pathogen sharing with rapid response, and One Health. Major gaps exist in global collaboration, enforcement of the International Health Regulations (IHR), and the World Health Organization's (WHO) capacity. The most urgent issue is pathogen access and benefit-sharing (PABS). Second, the PPPR capacity across world regions were assessed using two public datasets: eSPAR and GHS Index. Sub-Saharan Africa requires urgent support to strengthen most PPPR aspects, while epidemiological and laboratory surveillance, infection prevention and control (IPC), and regulatory functions need improvement in low- and middle-income countries (LMICs) in various regions outside Europe. Japan, with its strong PPPR capacity, is well-positioned to assist. Lastly, the review explored the link between PPPR and health systems strengthening (HSS). PPPR must be firmly integrated into HSS to ensure resilience, equity, inclusiveness, continuity of care, and sustainability. Core health system components — service delivery, workforce, health information systems, MCMs access, and governance — along with communication and trust-building, effectively contribute to PPPR. However, pandemic exceptionalism and the over-securitization of PPPR and health security may hinder coordination. The enhanced GHG for PPPR, led by the empowered WHO, should effectively facilitate and coordinate technical assistance to LMICs to strengthen their PPPR capacities and promote PPPR-HSS integration by bringing together the often-divided health security and HSS communities.

***Keywords*:** pandemic prevention, preparedness and response (PPPR), health security, global health governance, IHR core capacities, health systems, Universal Health Coverage (UHC)

Introduction

Pandemics are global events that require global actions in prevention, preparedness, and response (*1*) based on multilateralism, shared responsibility, and mutual accountability among countries (*2*). Since the Coronavirus Disease 2019 (COVID-19) pandemic, reflections on its devastating public health and socioeconomic impacts, as well as the deficiencies in the global preparedness and response system, have brought pandemic prevention, preparedness, and response (PPPR) to the forefront of global health discussions, leading to the emergence of various international initiatives.

Against this backdrop, this review contributes to the *Global Health and Medicine*'s topic issue of "Health Security and Infectious Diseases" from a global health perspective through three key approaches. First, it examines global health governance (GHG) for PPPR, focusing on its structure, functions, and existing gaps through a narrative review of relevant literature. We focused on global health governance because the existing governance architecture largely determines the feasibility of the global actions required for PPPR. Second, it assesses the status of PPPR capacities across regions of the world through a descriptive analysis of open-source data from the electronic State Parties Self-Assessment Annual Reporting (eSPAR) on core capacities under the International Health Regulations (IHR) and the Global Health Security (GHS) Index. Through this analysis, we sought to elucidate the existing gaps in global PPPR capacities. Lastly, it explores the interconnections between PPPR and health systems strengthening (HSS) in the global context through a narrative review. We explored this aspect because HSS is considered a

tangible action point for addressing the PPPR capacity gaps identified in the second section.

Global health governance (GHG) for pandemic prevention, preparedness, and response (PPPR): structure, functions, and existing gaps

The United Nations Development Programme (UNDP) defines governance as the mechanisms, processes, and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations, and mediate their differences (*3*). There is no universally accepted formal definition of GHG. However, it is generally defined as the use of formal and informal institutions, rules, and processes by states, intergovernmental organizations, and non-state actors to address health challenges that require cross-border collective action for effective resolution (*4*). In the following subsections, we will examine the structure, functions, and existing gaps of GHG in relation to PPPR.

Structure of GHG for PPPR

Global health is not governed by a single regime but rather by a "regime complex", a collective of partially overlapping and non-hierarchical regimes (*5*). Here, a regime refers to a set of principles, norms, rules, and decision-making procedures around which actors' expectations converge within a given issue area of international relations (*6*).

Indeed, in GHG for PPPR, multiple regimes operate in a partially overlapping and non-hierarchical manner. These include the United Nations (UN) system, which encompasses the World Health Organization (WHO), World Bank, United Nations Children's Fund (UNICEF), Food and Agriculture Organization (FAO), World Organisation for Animal Health (WOAH), and United Nations Environment Programme (UNEP); groups of nations such as the G7 and G20; and public-private partnerships (PPPs) such as the Pandemic Fund, Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), Global Alliance for Vaccine and Immunization (Gavi), Coalition for Epidemic Preparedness Innovations (CEPI), Global Health Security Agenda (GHSA), and Unitaid.

The WHO, as the sole entity authorized to establish legally binding instruments such as the so-called pandemic treaty — formally known as the WHO Convention, Agreement, or Other International Instrument on Pandemic Prevention, Preparedness, and Response (WHO CA+) — and the International Health Regulations (IHR), holds a uniquely central position in GHG for PPPR due to its comprehensive representation of 194 member states. Its central role in GHG is rooted in the widely held belief in its instrumental legitimacy (*7*). A Delphi survey of global health experts confirmed that the WHO is both the current and future leading actor in stewardship, guideline and policy development, and the promotion of solidarity and collaboration in global PPPR (*8*). The WHO's centrality in GHG for PPPR will be further reinforced by the anticipated adoption of WHO CA+ at the 78th World Health Assembly (WHA78) in May 2025. Additionally, the 2024 amendments to the IHR have strengthened the WHO's regulatory authority.

We can recognize a core-satellite structure within the existing GHG for PPPR, where the WHO serves as the central core, while other UN agencies, the G7/G20, and PPPs function as surrounding satellites with partially overlapping mandates and functions in a nonhierarchical order. These satellites are not under the direct command or control of the WHO as the central core but instead operate autonomously, sometimes without proper coordination.

Functions of GHG for PPPR

Based on a review of existing literature through Google Scholar searches using the keywords "global health governance"' AND ("pandemic"' OR "'pandemic prevention" OR "'pandemic preparedness"' OR "'pandemic response"), as well as websites and documents published by major actors in GHG for PPPR, we have identified five key functions and the major actors associated with each, as presented in Table 1. Below, we will examine each of these functions in detail.

Rule-setting

Since 2024, a trilogy of global health law reforms — including the formulation of the WHO CA+, the revision of the IHR, and the implementation of the GHSA's Legal Preparedness Action Package (LPAP) — has taken place, aiming to support global solidarity and establish a comprehensive legal framework for global PPPR (*9*). The WHO CA+ seeks to prevent pandemics, save lives, reduce disease burdens, and protect livelihoods by strengthening global capacities for PPPR (*10*). The agreement encompasses achieving equity, strengthening and sustaining PPPR and health system recovery capacities, enhancing coordination, collaboration, and cooperation for PPPR, securing financing for PPPR, and establishing governance mechanisms. The most debated issue within the WHO CA+ has been the pathogen access and benefit-sharing (PABS) mechanism. This issue is further analyzed in the subsection "Global supply of medical countermeasures (MCMs)" below.

A far-reaching and decisive package of amendments to improve the IHR was agreed upon at WHA77, underscoring the commitment to solidarity and equity, particularly in relation to access to medical products and financing, the establishment of the States Parties Committee to facilitate the effective implementation of the amended IHR, and the creation of National IHR Authorities (*11*). The amendments primarily expand assurances of equity, enhance global oversight of the

Table 1. Key functions of global health governance (GHG) for pandemic prevention, preparedness, and response (PPPR) and major actors

Key functions	Major actors
1. Rule-setting	WHO, GHSA
2. Resource mobilization, particularly surge finance	Pandemic Fund, World Bank, WHO, Gavi, Global Fund, GHSA, G20
3. Global supply of medical countermeasures (MCMs)	i-MCM-Net, WHO (CFE), G7, Unitaid, GO2AL, Gavi, CEPI, UNICEF
4. Surveillance and data/pathogen sharing with rapid response and containment	WHO (IHR, GOARN, IPSN & GISRS), US-CDC, FAO, WOAH
5. One Health	WHO, FAO, WOAH, UNEP, GHSA

WHO: World Health Organization; GHSA: Global Health Security Agenda; Gavi: Global Alliance for Vaccine and Immunization; i-MCM-Net: Interim Medical Countermeasures Network; CFE: Contingency Fund for Emergencies; GO2AL: Global Oxygen Alliance; CEPI: Coalition for Epidemic Preparedness Innovations; IHR: International Health Regulations; GOARN: Global Outbreak Alert and Response Network; IPSN: International Pathogen Surveillance Network; GISRS: Global Influenza Surveillance and Response System; US-CDC: United States Centers for Disease Control and Prevention; FAO: Food and Agriculture Organization, WOAH: World Organisation for Animal Health; UNEP: United Nations Environment Programme.

regulations' implementation, and increase authorization for national-level implementation, reflecting the stagnation in IHR core capacity building in low- and middle-income countries (LMICs) over the past 20 years.

The GHSA is an international collaboration launched in 2014 to strengthen global capacities to prevent, detect, and respond to infectious disease threats. The LPAP was introduced in March 2022 to address gaps in national legal capacities for public health security by providing technical tools and resources to help countries strengthen their public health laws. It aims to bring together state and non-state actors to advocate for legal preparedness and support countries in enhancing their legal frameworks for future health emergencies (*9*). However, unlike the WHO CA+ and IHR, it provides guidance and best practices rather than imposing binding legal requirements.

The UN itself, rather than its specialized agencies, has also sought leadership and rule-setting in PPPR. In September 2023, the UN General Assembly convened a High-Level Meeting on PPPR and issued a Political Declaration. However, this meeting ultimately failed to generate strong commitment and momentum for global health emergency governance due to diplomatic tensions, disagreements among member states, and the weakness of the Political Declaration (*12*). In 2022, the G7, under Germany's presidency, introduced the Pact for Pandemic Readiness to enhance the global landscape for pandemic preparedness. However, it failed to gain significant global momentum.

In the rule-setting process for GHG concerning PPPR, equity is emerging as a key concern, as reflected in the content of the WHO CA+ and the amended IHR. Assurance of equal access to vaccines has been strongly advocated by countries in the Global South (*13*). The issue of global equity is closely interlinked with other aspects of GHG, such as governance structures, political and economic power, laws and regulations, private investment and PPPs, and partnership and solidarity (*14*). Civil society engagement has been proposed to ensure that the equity concerns are properly addressed (*15*).

Resource mobilization, particularly surge finance

The Pandemic Fund, WHO, and Gavi currently have tangible global financing mechanisms for PPPR. The Pandemic Fund was established in 2022 by renaming the World Bank's Financial Intermediary Fund for PPPR. It can allocate up to US$25 million for single-country projects and up to US$40 million for multi-country projects in principle. The fund places a relatively greater emphasis on financing prevention and preparedness rather than response, as these are recognized as being more cost-effective (*16*). In 2015, the WHO launched the Contingency Fund for Emergencies (CFE) in response to the Ebola crisis in West Africa. The fund allows the WHO to respond rapidly to disease outbreaks and health emergencies often within 24 hours (*17*). Gavi launched the Day Zero Financing Facility in 2024 to provide rapid funding for vaccine procurement in response to global pandemics. It has already been applied to recent Mpox outbreaks in Africa (*18*).

The Global Fund launched the COVID-19 Response Mechanism (C19RM) in 2020 to combat COVID-19, adapt essential human immunodeficiency virus (HIV), tuberculosis, and malaria programs, and strengthen health systems (*19*). However, the Global Fund is no longer accepting new C19RM applications.

The GHSA and G20 are also active in pandemic financing, though they do not have any tangible financing mechanisms. In 2019, GHSA launched the Sustainable Financing for Preparedness Action Package Working Group to strategically mobilize global, regional, and country-level resources to achieve sustainable financing for PPPR. In 2021, the G20 notably launched the High-Level Independent Panel (HLIP) on Financing the Global Commons for Pandemic Preparedness and Response, aiming to identify global financing gaps and propose actionable solutions to address them (*20*). Coordinating the various financing mechanisms mentioned in the previous paragraphs will be a key challenge for GHG in PPPR over the coming decades.

Global supply of medical countermeasures (MCMs)

The US Food and Drug Administration (US-FDA) defines medical countermeasures (MCMs) as biologics, drugs, and devices that may be used in response to a potential public health emergency caused by terrorism or a naturally occurring emerging disease (*21*). In response to the COVID-19 pandemic, the WHO established the Interim Medical Countermeasures Network (i-MCM-Net), which became operational by early 2024. It is a network of UN agencies, PPPs, civil society organizations (CSOs)/non-governmental organizations (NGOs), regional bodies, industry, and the private sector, aimed at enhancing collaboration for timely and equitable access to MCMs during public health emergencies (*22*).

Japan launched the "MCM Delivery Partnership for Equitable Access (MCDP)" based on the "G7 Hiroshima Vision for Equitable Access to Medical Countermeasures (MCMs)" announced at the G7 Hiroshima Summit in 2023. The initiative aims to ensure the equitable distribution of MCMs, address all stages from research and development to manufacturing and last-mile delivery, and facilitate the mobilization of financial resources (*23*). During the COVID-19 pandemic, Unitaid co-led the Therapeutics Pillar of the Access to COVID-19 Tools (ACT) Accelerator to ensure equitable access to vaccines, tests, and treatments (*24*). It also launched the Oxygen Emergency Taskforce to address critical shortages of medical oxygen, which later evolved into the Global Oxygen Alliance (GO2AL) (*25*).

The COVID-19 pandemic has sparked much debate over the equitable global supply of COVID-19 vaccines. As previously mentioned, the most heated debate during intergovernmental negotiations on the WHO CA+ has centered around the PABS mechanism. LMICs have expressed concerns that, despite obligations to share pathogen samples and genetic data, they may not receive timely and affordable access to the resulting medical products (*26,27*). Conversely, high-income countries (HICs) and pharmaceutical companies argue that the proposed PABS may contradict existing intellectual property laws. The draft treaty suggests that manufacturers provide a minimum of 20% of their pandemic-related products — split between donations and affordable pricing — to the WHO for distribution based on public health needs (*28*).

The COVID-19 Vaccines Global Access (COVAX) Facility, coordinated by Gavi and involving the WHO, CEPI, and UNICEF, was the first global effort to ensure access to COVID-19 vaccines for all countries worldwide (*27*). Although it significantly contributed to delivering vaccines to LMICs, various operational shortcomings were identified. According to a scoping review, the primary implementation challenge was vaccine nationalism and hoarding by HICs. Governments of HICs with purchasing power signed bilateral agreements with vaccine manufacturers to secure supplies for their populations before they were made available to LMICs through COVAX, resulting in a "too little, too late" delivery to LMICs (*29*). Others point out governance issues inherent to PPPs, such as conflicts of interest among suppliers sitting on the governing board (*30*). However, the COVAX model is likely to be relevant for future pandemics, particularly as an effort to ensure the PABS mentioned above.

Surveillance and data/pathogen sharing with rapid response and containment

The WHO hosts several reporting mechanisms for public health emergencies, including pandemics. First, the IHR requires member states to notify the WHO of any events that may constitute a public health emergency of international concern (PHEIC) through the National IHR Focal Point within 24 hours (*31*). Second, the Global Outbreak Alert and Response Network (GOARN), a network of expert institutions primarily focused on responding to and controlling outbreaks by rapidly deploying experts to outbreak sites, also works on alerting and risk assessments through weekly operational calls since 2017. These calls facilitate the sharing of alerts and operational information to ensure that all stakeholders are informed about emerging epidemic threats (*32*). Third, the International Pathogen Surveillance Network (IPSN), a global network of pathogen genomic communities including governments, academia, the private sector, civil society, and international organizations, was launched in 2023 to facilitate the early detection of new epidemic threats through global genomic surveillance (*33*). Fourth, although its scope is limited to influenza, the Global Influenza Surveillance and Response System (GISRS), established in 1952, monitors and analyzes influenza viruses to detect emerging strains with pandemic potential (*34*).

The United States Centers for Disease Control and Prevention (US-CDC) operates the Global Disease Detection (GDD) Program since 2004, aiming to detect and stop infectious diseases at the source before crossing international borders through the network of CDC technical experts stationed worldwide (*35*). In the field of One Health, the Global Early Warning System (GLEWS), a collaboration between WHO, FAO, and WOAH launched in 2006, is operating to track zoonotic diseases (*36*). Notably, GOARN, GDD, and GLEWS provide frameworks for rapid response and containment of pandemics.

A study identified governance and coordination, health systems infrastructure and resources, and community engagement as the three key areas needing improvement in global health information systems to optimize PPPR (*37*). A commentary by authors, including the former Director of the US-CDC, based on lessons learned from COVID-19, advocates for global information-sharing and collaboration, and more specifically, the prototype pathogen approach. This strategy involves selecting and studying virus families with high pandemic potential in order to preemptively

gather information on basic virology, diagnostic assays, animal models, antigenic targets, optimal vaccine platforms, and potential immune correlates for the rapid development of MCMs when pandemics occur (*38*).

One Health

One Health is defined as a holistic, systems-based approach that recognizes the interconnection between the health of humans, animals, plants, and the environment. This concept has gained renewed attention and evolved over the past decade due to the increased frequency and severity of threats that link the health of humans, animals, plants, and the environment (*39*). One Health, along with measures to prevent antimicrobial resistance (AMR), is one of the few approaches that directly address the "prevention" aspect of PPPR.

Among the existing global One Health initiatives, the most notable is the One Health Joint Plan of Action (OHJPA) led by the UN quadripartite organizations: WHO, FAO, WOAH, and UNEP (*39*). The One Health High-Level Expert Panel (OHHLEP) was launched in 2021 by the same four UN agencies to provide scientific guidance on One Health risks and policy recommendations. The multisectoral and transdisciplinary expertise of OHHLEP members spans a wide range of fields, including animal, human, and environmental health, biodiversity conservation, and social sciences (*40*). The Zoonotic Disease Action Package (ZDAP) of the GHSA involves countries and organizations around the world, aiming to support its members in developing and strengthening their capacity to prepare for, prevent, detect, and respond to zoonotic disease threats using a One Health approach (*41*).

Several pieces of literature highlight the weaknesses of the global governance of One Health. One source identifies four key issues: *i*) sectoral, professional, and institutional silos, along with tensions between human, animal, and environmental health; *ii*) challenges posed by the international legal system and state sovereignty; *iii*) asymmetry in power between countries represented in multilateral institutions; and *iv*) chronic underinvestment (*42*). Another source points out the lack of global governance over wildlife trade for human consumption to prevent zoonotic spillovers (*43*). The third specifically identified the relative lack of integration of environmental and social sciences compared to human and animal health (*44*).

Existing gaps of GHG for PPPR

Literature has identified various existing gaps in GHG for PPPR, particularly those that arose in response to the COVID-19 pandemic. Three broad categories of gaps are mentioned across multiple articles. The first is the lack of global collaboration, coordination, and partnership. This category encompasses two distinct dimensions: *i*) dyscoordination among governance actors (*45*), and *ii*) dyscoordination among governance subjects, most notably national governments (*46*). The former is specifically illustrated by the differing and fragmented responses of the WHO, the European Union (EU), and the International Monetary Fund (IMF)/ World Bank to COVID-19. The latter is manifested in the lack of coordination between HICs and LMICs (*46*), the domination of HICs (*47*), rivalry between powerful countries (*48*), and inequitable representation (*49*).

The second gap is the lack of enforcement of global rules, particularly the IHR, and the compliance of countries. Although the IHR is legally binding regulations, the WHO has limited enforcement power over its member states. As a result, the level of voluntary implementation and compliance among countries remains low (*50-52*). This situation is rooted in the world order dominated by sovereign nations, where the obligations stipulated in the IHR can only be achieved by balancing national and global interests (*46*). The UN Charter explicitly prohibits the UN from intervening in matters that are essentially within the domestic jurisdiction of any state (*53*). Several proposals have been made to address this issue, including incentives for participation, penalties for non-compliance (*52*), independent rapporteurs with investigatory missions, a formal structure for civil society reporting and accountability, and trust-building activities between the WHO and countries (*54*).

The third gap is the insufficient capacity of the WHO, which forms the central core of the GHG architecture for PPPR. Insufficiencies identified include conflicts of interest and political bias, a more political than technical orientation (*50*), ineffective communication of crucial scientific information, a small budget that largely depends on voluntary contributions (*48*), and delayed declarations of PHEIC, as seen in the case of the West Africa Ebola crisis in 2014 (*55*).

From the review above, it is apparent that the future GHG for PPPR must confront the daunting task of effectively coordinating among governance actors, as illustrated in Table 1, as well as among governance subjects, including national governments, private corporations, and civil society, and between governance actors and subjects. With the anticipated adoption of the WHO CA+ in May 2025, it is crucial to revisit the issues of enforcement and compliance, alongside those related to the amended IHR, and ideally develop innovative solutions to this longstanding problem. The WHO must be empowered in terms of authority, operations, and financial resources to function effectively as the central hub of the GHG for PPPR. Finally, the most pressing issue within the GHG for PPPR — the PABS — must be effectively resolved within the framework of the WHO CA+.

Overview of the status of PPPR capacities across world regions: A descriptive analysis of open-source data

This section examines the status of PPPR capacities across world regions and identifies major gaps through a descriptive analysis of the electronic State Party Self-Assessment Annual Reporting (eSPAR) for the IHR and the Global Health Security (GHS) Index. Table 2 compares the 15 IHR core capacities assessed in eSPAR with the six categories of the GHS Index. Generally, the former provides a more detailed breakdown of specific aspects, while the latter takes a more aggregated approach.

A major difference between the two datasets is that while eSPAR covers non-biological threats, such as chemical events and radiation emergencies, the GHS Index focuses specifically on infectious diseases. A large proportion of the components overlap. For example, "5. Surveillance" in eSPAR corresponds to "2. Early detection and reporting" in the GHS Index, while "1. Policy, legal, and normative instruments to implement IHR" in eSPAR aligns with "5. Commitments to improve national capacity, financing plans to address gaps, and adherence to global norms" in the GHS Index. Risk communication, explicitly covered as Capacity 10 in eSPAR, is also included under Category 3 (Rapid response) in the GHS Index.

PPPR capacities across world regions assessed by the electronic State Parties Self-Assessment Annual Reporting (eSPAR)

The IHR mandates member states to report to the World Health Assembly on the implementation of the Regulations. Between 2010 and 2017, an IHR monitoring questionnaire was sent to IHR National Focal Points. In 2015, the comprehensive IHR Monitoring and Evaluation Framework (IHRMEF) was introduced, which included the State Parties Self-Assessment Annual Reporting (SPAR), Joint External Evaluation (JEE), after-action reviews, and simulation exercises. SPAR is a mandatory, country-led, multisectoral review of progress toward IHR core capacity implementation. In contrast, the JEE is an external review of a country's progress conducted every 4-5 years. To facilitate SPAR, the electronic State Party Self-Assessment Annual Reporting (eSPAR) tool was implemented in 2018 (*56*).

The eSPAR generates scores for each of the 15 IHR core capacities for all countries worldwide, making it suitable for assessing status of IHR core capacity implementation across world regions. However, due to its self-reporting nature, SPAR scores are susceptible to overreporting by countries. In contrast, the JEE is more objective and less prone to bias. Indeed, a study comparing SPAR and JEE scores revealed an average difference of 18%, with the average JEE score at 56% and the average SPAR score at 75% in 2017 (*57*). Nevertheless, since the JEE is conducted only once every 4-5 years for any given country, its annual coverage is limited, making it unsuitable for assessing the cross-sectional status of world regions. Existing literature has found a high correlation between JEE and SPAR scores (*56,58*). For these reasons, we used eSPAR rather than JEE scores to assess the PPPR status of different world regions.

The Sustainable Development Goals (SDGs) have set Target 3.d, "Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction, and management of national and global health risks", as one of the means of implementation targets. This target has two indicators: 3.d.1 measures IHR capacity and health emergency preparedness, monitored through eSPAR, while 3.d.2 tracks the percentage of bloodstream infections caused by selected antimicrobial-resistant organisms, monitored by the

Table 2. Comparison of IHR core capacities in eSPAR and categories in GHS Index

IHR core capacities in eSPAR[a]	Categories in GHS Index[a]
1. Policy, Legal and normative Instruments to implement IHR	1. Prevention of the emergence or release of pathogens
2. IHR Coordination, National IHR Focal Point functions and advocacy	2. Early detection and reporting epidemics of potential international concern
3. Financing	3. Rapid response to and mitigation of the spread of an epidemic
4. Laboratory	4. Sufficient and robust health system to treat the sick and protect health workers
5. Surveillance	5. Commitments to improve national capacity, financing plans to address gaps, and adhering to global norms
6. Human resources	6. Overall risk environment and country vulnerability to biological threats
7. Health emergency management	
8. Health services provision	
9. Infection prevention and control (IPC)	
10. Risk communication and community engagement (RCCE)	
11. Points of entry (PoEs) and border health	
12. Zoonotic diseases	
13. Food safety	
14. Chemical events	
15. Radiation emergencies	

IHR: International Health Regulations; eSPAR: electronic State Parties Self-Assessment Annual Reporting; GHS: Global Health Security. [a]The numbers of the 15 IHR core capacities in eSPAR (left column) and the six categories in GHS Index (right column) do not correspond to each other.

Global Antimicrobial Resistance and Use Surveillance System (GLASS).

The eSPAR currently consists of 15 IHR core capacities and 35 indicators. Each indicator is scored from 1 to 5 based on predetermined rating scale definitions and then converted into a percentage (0-100%). Capacity scores are calculated as the arithmetic mean of all indicator scores (%) within each capacity (*59*). The total eSPAR score (%) for a country is obtained by calculating the arithmetic mean of the 15 capacity scores, rounded up to the nearest integer. The aggregated scores for the six WHO Regions are calculated as the arithmetic mean of the total scores of all countries within each Region. Figure 1 presents the map of the six WHO Regions.

Figure 2 illustrates the trend in the total average score (%) of the 15 IHR core capacities reported by eSPAR across the six WHO Regions and Japan from 2021 to 2023. Revisions to categories and indicators occurred between 2017 and 2018, and again between 2020 and 2021. In particular, the number of core capacities increased from 13 to 15 between 2020 and 2021. Given this inconsistency in the timeline, we focused only on data from 2021 to 2023. There are four major findings. First, Japan consistently scored much higher than the averages of all six WHO Regions. Second, among the six Regions, the European Region (EUR) had the highest scores throughout the three years. Third, the African Region (AFR) consistently had the lowest scores during the period. Lastly, the scores of the remaining four Regions — the Americas Region (AMR), Eastern Mediterranean Region (EMR), South-East Asia Region (SEAR), and Western Pacific Region (WPR) — were closely grouped, positioned just below those of EUR.

Japan's high scores can be partly explained by the fact that each WHO Region includes LMICs among its members. Even EUR encompasses LMICs in Central Asia. SEAR has no HICs, AFR has only Seychelles as an HIC, and AMR, EMR, and WPR consist of a mix of HICs and LMICs. These findings clearly indicate that AFR should be a priority for support to strengthen its IHR core capacities for improved PPPR, particularly through assistance from Japan.

PPPR capacities across world regions assessed by Global Health Security (GHS) Index

The GHS Index is an initiative led by the Nuclear Threat Initiative (NTI) and the Johns Hopkins Center for Health Security (JHU), in collaboration with The Economist Intelligence Unit (EIU). It represents the first comprehensive evaluation and comparison of health security and related capacities across 195 countries. The Index is based solely on publicly available information, including data that countries have either disclosed themselves or that has been provided to or documented by international organizations (*60*). Given the complexity of global health security, a multidimensional analytical framework was employed for an objective, country-level assessment. An international panel of experts provided insights and recommendations on the Index's structure, questions, and data sources. The EIU conducted research to generate the Index scores. Countries were given the opportunity to review and comment on preliminary results, but score changes were considered only if publicly available evidence was provided that had not been previously identified by the research team (*61*).

The GHS Index is also susceptible to overreporting by countries due to its reliance on open-source data. However, it is considered more objective than eSPAR because data are researched and scored consistently by a third party, and a multidimensional analysis is conducted on collected data to generate scores. While eSPAR primarily reflects government authorities, the GHS Index mainly reflects evaluations by foreign experts. A study found a low correlation between SPAR and GHS Index scores, suggesting that they measure different aspects of PPPR capacities (*58*).

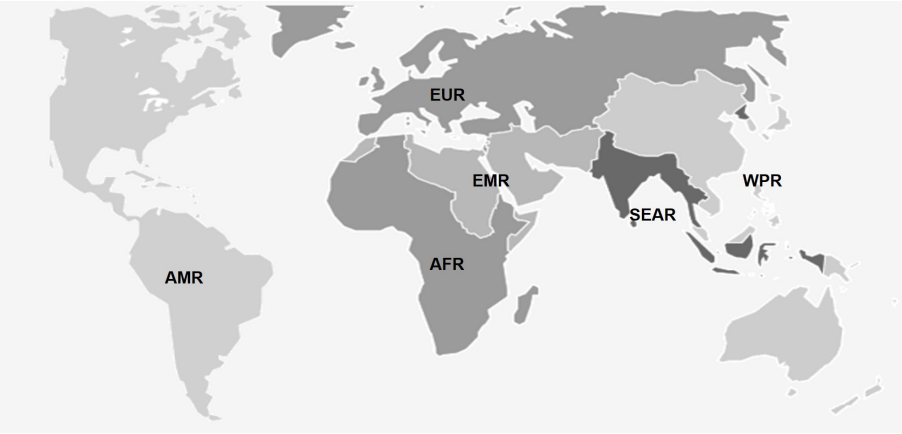

Figure 1. Map of WHO Regions. Data Source: WHO MiNDbank (*https://extranet.who.int/mindbank*). AMR: Americas Region; AFR: African Region; EUR: European Region; EMR: Eastern Mediterranean Region; SEAR: South-East Asia Region; WHO: World Health Organization; WPR: Western Pacific Region.

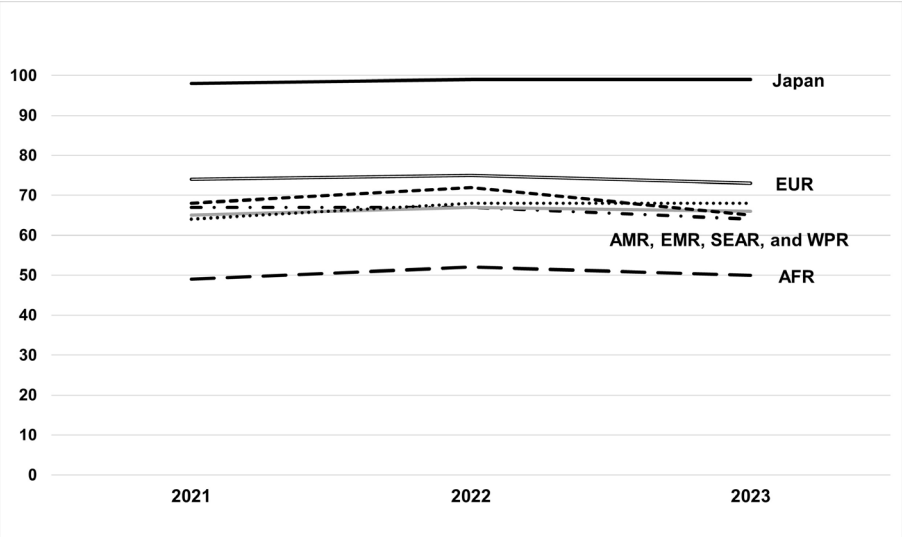

Figure 2. Trend of total average score (%) of 15 IHR core capacities reported by eSPAR by WHO Regions and Japan (2021-2023). IHR: International Health Regulations; eSPAR: Electronic State Parties Self-Assessment Annual Reporting; AMR: Americas Region; AFR: African Region; EUR: European Region; EMR: Eastern Mediterranean Region; SEAR: South-East Asia Region; WHO: World Health Organization; WPR: Western Pacific Region.

The Index consists of six categories and 37 indicators, which are further subdivided into 96 sub-indicators and 171 questions. Different indicators use different rating scales, but all scores are normalized to a range of 0 to 100. When aggregating indicator scores to calculate category scores, different weighting principles were applied to reflect varying assumptions about relative importance of indicators. These principles included equal weighting, expert-informed panel weighting, and weighting based on Principal Components Analysis. Consequently, category scores were calculated as weighted means of indicator scores, as determined by the weighting profile. Total GHS Index score for a country was also calculated as the weighted mean of the six category scores (*61*).

Figure 3 illustrates the trend in the total average scores (%) of the six GHS Index categories by WHO Region and Japan from 2019 to 2021. The aggregated scores for the six WHO Regions were calculated as the arithmetic means of the total scores of all countries within each Region, ensuring consistency with eSPAR. Findings reflect three key patterns observed in the eSPAR data analysis: Japan's higher scores, EUR's position as the highest-scoring Region, and AFR's position as the lowest-scoring Region in both years. However, while the scores for AMR, EMR, SEAR, and WPR were closely grouped in the eSPAR analysis, they were more dispersed in the GHS Index. EMR ranked as the second-lowest, followed by WPR. Overall, these four Regions scored significantly lower and were positioned closer to AFR than to EUR. This last finding may reflect a reduced impact of overreporting by countries in AMR, EMR, SEAR, and WPR in the GHS Index compared to eSPAR.

Based on the assumption that the GHS Index is more objective than eSPAR, discrepancies in the GHS Index scores, averaging the 2019 and 2021 figures for all six categories, between Japan and the six Regions were examined to identify the categories most in need of assistance (Table 3). EUR scored highest in all six categories, while AFR scored lowest in four out of six categories. When examining discrepancies of more than 25 percentage points (pp) between Japan and the Regions, AFR showed discrepancies greater than 25pp in five out of six categories, except for Category 5: Commitments to Improve National Capacity. This indicates an urgent need for support in sub-Saharan African countries to enhance most aspects of PPPR. For Category 2: Early Detection and Reporting (Surveillance), all Regions except EUR showed discrepancies greater than 25pp. For Category 4: Sufficient and Robust Health Systems, AFR, EMR, and WPR exhibited discrepancies greater than 25pp. Several Regions require support to strengthen these two categories.

For Categories 2 and 4, we examined discrepancies at the indicator level to gain a better understanding. For Category 2, the arithmetic means of the six indicator scores for Japan and all countries in AFR, AMR, EMR, SEAR, and WPR were compared. For Category 4, the arithmetic means of the seven indicator scores for Japan and all countries in AFR, EMR, and WPR were compared. Among indicators for Category 2 (Surveillance), discrepancies greater than 50pp were observed in laboratory supply chains (62.1pp), real-time surveillance and reporting (66.0pp), and surveillance data accessibility and transparency (57.3pp). Countries in AFR, AMR, EMR, SEAR, and WPR require support for both epidemiological and laboratory surveillance for early detection and reporting. Among the indicators for Category 4 (Health Systems), discrepancies greater

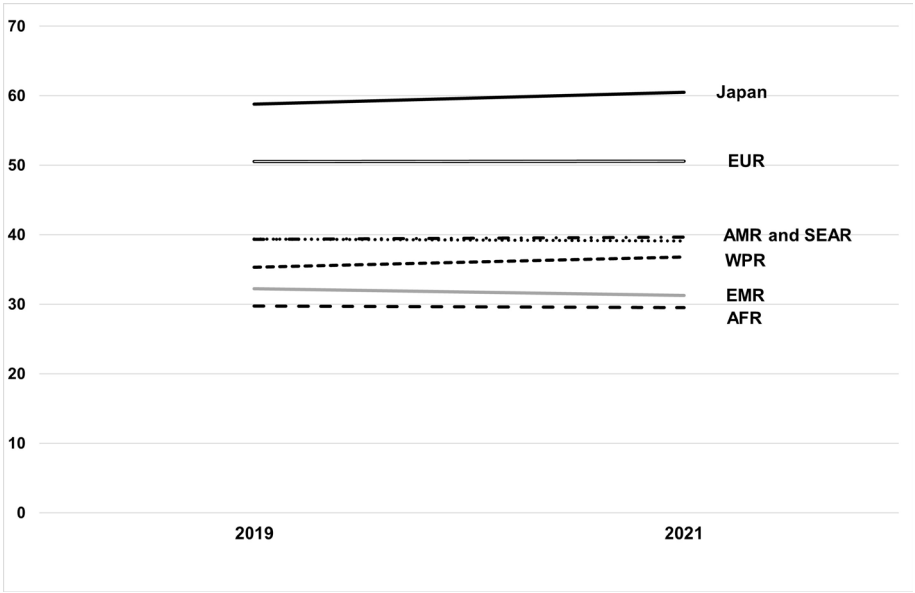

Figure 3. Trend of total average score (%) of six GHS Index categories by WHO Regions and Japan (2019 and 2021). GHS: Global Health Security; AMR: Americas Region; AFR: African Region; EUR: European Region; EMR: Eastern Mediterranean Region; SEAR: South-East Asia Region; WHO: World Health Organization; WPR: Western Pacific Region.

than 50pp were observed in infection control practices (83.9pp) and capacity to test and approve new medical countermeasures (64.3pp). Countries in AFR, EMR, and WPR need support for infection prevention and control (IPC) in medical facilities and for strengthening regulatory functions.

In summary, the above analysis indicates that countries in sub-Saharan Africa urgently need support to enhance most aspects of PPPR, so they do not become the weakest link in the chain of global PPPR. AFR, AMR, EMR, SEAR, and WPR require support on epidemiological and laboratory surveillance, while AFR, EMR, and WPR need support on IPC and regulatory functions. Japan is well-positioned to provide such support, given its strong performance in nearly all aspects of PPPR.

Interconnections between PPPR and Health Systems Strengthening (HSS) in the global context

In 2000, the WHO defined a health system as encompassing all activities whose primary purpose is to promote, restore, or maintain health in the World Health Report 2000. The report outlined three fundamental objectives of health systems: *i*) improving the health of the population, *ii*) responding to people's expectations, and *iii*) providing financial protection against the costs of ill health (*62*). In 2010, the WHO introduced Health Systems Framework, which identifies six building blocks of health systems: *i*) service delivery, *ii*) health workforce, *iii*) health information systems, *iv*) access to essential medicines, *v*) financing, and *vi*) leadership/ governance (*63*).

The Ebola virus disease outbreak in West Africa (2014-2016) and the COVID-19 pandemic have highlighted the crucial role of health system capacity and resilience in PPPR, underscoring need for stronger integration between PPPR and health system strengthening (HSS) (*64-66*). Indeed, the 15 core capacities of the IHR include health service provision, human resources, financing, and policy, as well as legal, normative, and legislative instruments — all of which are components of health systems (Table 2).

Based on a review of existing literature through Google Scholar searches using the keywords ("pandemic prevention, preparedness, and response" OR "health security") AND ("health systems strengthening" OR "universal health coverage" OR "'primary health care"), in the following subsections, we will examine the concept of interconnections between PPPR and HSS, the tangible contributions of health systems to PPPR, and potential barriers to effective PPPR-HSS coordination.

Conceptual relationship between HSS, Universal Health Coverage (UHC), Primary Health Care (PHC), and health security

In 2016, Kutzin and Sparkes argued that HSS comprises the means or policy instruments, while Universal Health Coverage (UHC) serves as a framework for defining policy objectives. UHC means that all people have access to the health services they need without financial hardship (*67*). They further explained that HSS represents actions taken, whereas UHC, health security, and resilience represent desired outcomes (*68*).

At the WHA 75 in 2022, Dr. Tedros Ghebreyesus, Director-General of the WHO, reported on strengthening global architecture for health emergency preparedness,

Table 3. Discrepancies of GHS Index scores for six categories between Japan and six WHO Regions (average of 2019 and 2021)

Regions	Category 1		Category 2		Category 3		Category 4		Category 5		Category 6	
	Scores	Discrepancy (pp)	Scores	Discrepancy (pp)	Scores	Discrepancy (pp)	Scores	Discrepancy (pp)	Scores	Discrepancy (pp)	Scores	Discrepancy (pp)
Japan	45.2	NA	63.6	NA	61.3	NA	50.5	NA	66.7	NA	70.6	NA
EUR	45.2	0.0	40.7	-22.9	46.4	-14.9	47.1	-3.3	55.9	-10.8	68.0	-2.6
AFR	15.0	-30.2	23.7	-39.9	32.1	-29.2	17.5	-33.0	45.5	-21.2	44.0	-26.6
AMR	29.9	-15.2	29.5	-34.1	41.0	-20.3	31.4	-19.0	48.9	-17.8	56.3	-14.3
EMR	22.8	-22.3	23.6	-40.0	35.2	-26.1	23.6	-26.9	36.9	-29.8	48.4	-22.2
SEAR	29.3	-15.8	37.4	-26.2	39.6	-21.7	30.4	-20.1	46.2	-20.5	52.8	-17.8
WPR	22.7	-22.4	28.4	-35.2	40.6	-20.7	23.9	-26.5	42.4	-24.3	58.3	-12.3

Discrepancy of more than 25 percentage points (pp) are highlighted by bold letters. GHS: Global Health Security; WHO: World Health Organization; PP; percentage points; European Region; AFR: African Region; AMR: Americas Region; EMR: Eastern Mediterranean Region; SEAR: South-East Asia Region; WPR: Western Pacific Region. Category 1: Prevention of the emergence or release of pathogens. Category 2: Early detection and reporting epidemics of potential international concern. Category 3: Rapid response to and mitigation of the spread of an epidemic. Category 4: Sufficient and robust health system to treat the sick and protect health workers. Category 5: Commitments to improve national capacity, financing plans to address gaps, and adhering to global norms. Category 6: Overall risk environment and country vulnerability to biological threats.

response, and resilience. He emphasized that health security, Primary Health Care (PHC), and health promotion should be built upon a solid foundation of strong health systems (*69*). PHC refers to healthcare provided as close as possible to people's everyday environment, encompassing health promotion, disease prevention, treatment, rehabilitation, and palliative care (*70*). Several articles have also highlighted critical interconnections between health security, UHC, and HSS (*71,72*). Based on the above, HSS is regarded as a concrete action point in achieving aspirational objectives of UHC, PHC, and health security, including PPPR.

A proposal has been made to integrate core capacities of global health security into comprehensive UHC systems as a robust defense against future pandemics. Such integration simultaneously strengthens both global health security and UHC, ensuring long-term resilience and equity (*73,74*). Similarly, PHC has been proposed as a crucial component of health system resilience due to its inclusiveness and ability to ensure continuity of care during pandemics (*75,76*).

Tangible health systems contributions to PPPR

Numerous articles elaborate on contributions of health systems to PPPR, primarily based on past pandemic experiences, including the West African Ebola outbreak and the COVID-19 pandemic. Figure 4 summarizes the contributions of health systems components and functions to PPPR. Among the six building blocks of health systems, five have been identified in several studies as direct contributors to PPPR. The first is service delivery, often discussed in the context of ensuring continuity and scalability of routine services during pandemics (*77-79*). The second is the health workforce, with particular emphasis on its surge capacity (*77,80,81*). The third is the health information system, particularly — but not limited to — disease surveillance (*78-81*). The fourth is supply chain management, especially regarding MCMs, with a focus on equitable distribution (*77,78,80,81*). The last is leadership and governance, encompassing issues such as command and control, jurisdictional authority across administrative levels, and coordination (*78,80,81*). The remaining building block, financing, has not been extensively addressed in the existing literature but is also critical for PPPR.

In addition to the components of health systems, two key functions have been identified as notable contributors during pandemics. The first is communication, which includes risk communication strategies, community engagement, and partnerships with the media (*80,81*). Community engagement is particularly important for ensuring equity in service delivery and promoting social justice. The second is trust-building, which involves fostering trust in health systems among the public and trust in management among healthcare workers (*80,81*).

Recognizing that health system resilience is key

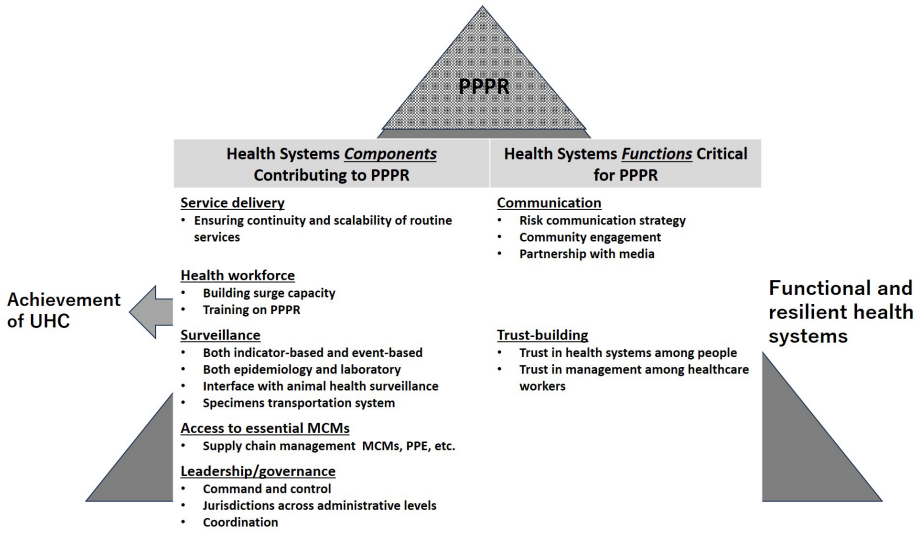

Figure 4. Contributions of health systems components and functions to pandemic prevention, preparedness, and response (PPPR). MCMs: medical countermeasures; PPE: personal protective equipment; UHC: Universal Health Coverage.

to effective PPPR, several articles have elaborated on factors contributing to resilience during pandemics. These factors include multi-sectoral responses, adaptation of health system capacity to evolving situations, strengthening of PHC, and increasing and sustaining public financing through domestic resource mobilization for health and social protection (*75,82,83*).

To safeguard surge capacity of the health workforce and contingency financing for pandemics, redundancy in human resources and budgets is necessary. However, ensuring redundancy presents a challenge due to the continuous demand for efficiency, which often involves reducing redundancy in health systems and health facility management.

Potential barriers to PPPR-HSS coordination

Several potential barriers to PPPR-HSS coordination are noted in existing literature. The first is the exceptionalism of PPPR and health security (*84*). The mentality that pandemics are exceptional events requiring exceptional measures may lead to deprioritization of sustainable and stable resource allocation to health systems, as it overlooks the functions of existing health systems.

The second is the over-securitization of PPPR and health security by framing them as part of the national security agenda. This can cause countries to prioritize national interests over global public goods and view LMICs as security threats rather than partners (*84*). Furthermore, norms, values, and approaches of the health sector may be eroded by the increased presence of security actors, primarily from the defense and intelligence communities, within the health-security nexus (*85,86*).

In contrast to a narrow, state-centric approach to health security, the concept of universal health security has been proposed as a more inclusive and people-centered framework that aligns closely with the principles of human security (*85,87,88*). Rather than prioritizing national interests over global public goods, universal health security emphasizes equitable access to essential health services, strengthened global cooperation, and resilient health systems that protect all populations, particularly those in vulnerable settings. By integrating health security into the broader framework of human security, this approach highlights the need to address structural determinants of health, promote international solidarity, and ensure that PPPR efforts are guided by principles of equity and sustainability, rather than narrowly defined national security agendas. The Government of Japan has been actively promoting the concept of human security (*89*), along with UHC.

Conclusion

Aiming to provide an overview of PPPR from a global health perspective, this review first examined the GHG for PPPR, focusing on its structure, functions, and existing gaps. Actors within the GHG for PPPR form a core-satellite structure, with the WHO as the core, while other UN agencies, the G7/G20, and PPPs function as satellites with partially overlapping mandates in a non-hierarchical order. They mainly fulfill five key functions: *i*) rule-setting, *ii*) resource mobilization, particularly surge finance, *iii*) global supply of MCMs, *iv*) surveillance and data/pathogen sharing with rapid response and containment, and *v*) One Health. Major gaps include: *i*) global collaboration, coordination, and partnership, *ii*) enforcement of global rules, particularly the IHR, and countries' compliance, and *iii*) capacity of the WHO. The most pressing issue within the GHG for PPPR is the PABS mechanism.

Second, it assessed the status of PPPR capacities across the six WHO Regions through a descriptive

analysis of eSPAR and GHS Index data. Results indicated that countries in sub-Saharan Africa urgently need support to strengthen most aspects of PPPR. Epidemiological and laboratory surveillance, IPC, and regulatory functions require support across various Regions, except for EUR. Japan is well-positioned to provide such support, given its strong performance in nearly all aspects of PPPR as measured by both eSPAR and the GHS Index.

Lastly, it explored the interconnections between PPPR and HSS in the global context. HSS was regarded as a concrete action point in achieving the aspirational objectives of UHC, PHC, and health security, including PPPR. Almost all health systems building blocks — namely service delivery, health workforce, health information systems, access to essential MCMs, and leadership/governance — as well as two key functions, communication and trust-building, were identified as health systems contributors to PPPR. Multi-sectoral responses, adaptation to evolving situations, strengthening PHC, and domestic resource mobilization for health and social protection were identified as factors contributing to health systems' resilience during pandemics. Pandemic exceptionalism and the over-securitization of PPPR and health security were acknowledged as potential barriers to PPPR-HSS coordination.

These findings provide the following critical directions for future global PPPR: *i*) GHG for PPPR must enhance coordination among governance actors, governance subjects, and between the two. It should also revisit the enforcement of global rules, including the amended IHR and the forthcoming WHO CA+, while strengthening the WHO's authority, operational capacity, and financial resources; *ii*) Technical assistance for PPPR capacity-building is particularly needed in the African Region, as well as in other LMICs, with a specific focus on surveillance, IPC, and regulatory functions; *iii*) PPPR must be firmly integrated into HSS, UHC, and PHC to ensure resilience, equity, inclusiveness, continuity of care, and sustainability. Ideally, the enhanced GHG for PPPR, led by the empowered WHO, should effectively facilitate and coordinate technical assistance to LMICs to strengthen their PPPR capacities and promote PPPR-HSS integration by bringing together the often-divided health security and HSS communities.

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