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GLOBAL HEALTH PREPAREDNESS: ANALYZING RESPONSES TO EPIDEMICS AND PUBLIC HEALTH EMERGENCIES

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ABSTRACT
This study examines global health preparedness by analyzing quantitative data on preparedness indicators and qualitative insights from expert interviews across 30 countries. Using data from the WHO, Global Health Security Index (GHSI), and International Health Regulations (IHR) assessments, countries were categorized by preparedness levels: high (GHSI > 75), moderate (50–75), and low (< 50). Countries with strong healthcare infrastructure and surveillance systems, such as the United States, Germany, and Japan, showed significantly lower-case fatality rates (correlation coefficient -0.65, $p < 0.05$) and faster containment times compared to nations with less robust systems, like India, Nigeria, and Ethiopia. Thematic analysis of 120 expert interviews revealed key themes, including resource allocation challenges, public trust, and international collaboration. Countries with centralized decision-making structures notably demonstrated faster responses, while those with high public trust saw better compliance with health measures. Despite the essential role of international cooperation, geopolitical tensions often limit effective cross-border responses. This study underscores the importance of strengthening health infrastructure, fostering public trust, and enhancing global partnerships to mitigate future health crises.

Keywords: Global health preparedness, Health security index, Public compliance, Resource allocation, International collaboration, Case fatality rate, Surveillance systems

INTRODUCTION
In the last two decades, there have been numerous recurrent infectious disease outbreaks and other public health emergencies (HE), putting pressure on health systems, and increasing the importance of preparedness at both national and international levels. The severe emergent events of the last one and a half decades including SARS in 2003, A/H1N1 in 2009, Ebola in West Africa in 2014 and presently COIVD-19 have all highlighted that there are serious deficits in health systems preparedness in countries of all levels of capacities and resources (1). HEs preparedness is the precautions that must be taken to avert, identify, contain, mitigate, and recover from the occurrence of public health threats as defined by the World Health Organization (WHO) the International Health Regulations or IHR which is a legally binding instrument aimed at enhancing national, regional and global health (2).

The scale and global effects of the COVID-19 pandemic alone established the magnitude of the deficits and consequent global risks and issues of inadequate readiness, which include health,

economy, society, and politics (3). Global systems experienced stressors such as collapsing health care systems, shortage in medical necessities, and interruption of social services (4). The pandemic revealed the centrality of addressing health system capacity but also the challenges in constructing the capacity as well as maintaining it at the global level. Global health preparedness has thus emerged as an important area of study within the domain of public health, with growing demands and appeals for change, investment, research and partnership to enhance preparedness for future HEs (5).

Part of preparedness is early identification of and response to new and re-emerging health threats, and this means that health surveillance systems must be engaged, agile, and adaptive. These are systems meant to predict and isolate possible public health risks and enhance quick containment and management to avoid large-scale proliferation of diseases (6). Current studies show that early identification strategies such as Genomic sequencing, digital monitoring, and real-time information are central to controlling infectious diseases. Many LMICs continue to operate poorly resourced surveillance systems that have significant technological and infrastructural challenges (7).

One of the biggest obstacles in this regard is the timely exchange of quantitative data that is frequently obscured due to privacy, non-uniformity, and political factors. Because of the lack of data sharing and poor global inter-agency cooperation during the early stages of COVID-19, research shows that the international response was slow and the virus quickly became a global threat (8). Hence, it needs to improve surveillance and early warning to avoid this in the future and encourage good practice among states.

While some advancement has been made in addressing global health preparedness, several barriers remain a barrier in the creation of well-coordinated and effective systems for preparedness. Perhaps the most flagrant is the matter of scope since low-resource settings simply do not have the capital to purchase the health infrastructure, training for workers, and supplies needed (9). For example, LMICs are usually only able to allocate scarce resources to health sectors and are regularly forced to prioritize health needs that are higher priority than investing in preparedness measures that are necessary only occasionally (10).

The challenges experienced in preparedness efforts are however compounded by the political and social factors that determine the health policies of a country. Political will, for instance, can greatly influence the ranking of HEs preparedness because governments are more likely to dedicate resources on apparent and urgent issues to HEs rather than investing in risk preparedness (11,12). This was especially the case during the initial period of the COVID-19 virus when various governments did not seem to consider the intrusion a serious level of threat especially by not implementing necessary measures that may have helped slow down the spread (13). Social factors are also important as the population's trust in government and health luckily determines the effectiveness of overall readiness as well as compliance with measures like vaccination and social distancing (14).

In this regard, various international and regional organizations such as WHO, The World Bank, and other partners have set several frameworks and guidelines to enhance international health security. IHR revised in 2005 has continued to be the most popular international legal instrument for guiding the countries in building the capacities for preparedness and response (15). In the framework of the IHR, states are obliged to develop and maintain seven core capacities of public health surveillance and risk assessment as well as outbreak response. Also, the WHO through the Joint External Evaluation (JEE) tool is a self-assessment tool that countries can use voluntarily to assess their level of preparedness and point out weaknesses (16).

However, the experience of implementing these frameworks has not been very successful mainly because of a lack of resources, inadequate political commitment, and cumbersome bureaucratic procedures that are often found in many countries (17). COVID-19 has shown that many developed countries continue to fail to meet IHR core requirements, and have limited capability to expand the production of diagnostic tests, surveillance, and healthcare infrastructure in response to the early phase of the pandemic (18).

To overcome these and other challenges and existing deficiencies exposed by recent outbreaks (including but not limited to COVID-19), coordinated action on multiple levels of governance and across multiple sectors, from healthcare to policy and finance, is needed. As a national and global

responsibility, health system strengthening enables the health systems to withstand the pressures that result from HEs required long-term investment, active collaboration among countries, and ongoing innovations in health systems, human resources, and technologies for surveillance and monitoring.

MATERIAL AND METHODS

Study Design

This research utilizes an exploratory mixed-method research design to reconcile qualitative and quantitative methodologies in the evaluation of global readiness for epidemics and public health crises. The qualitative component of the study entails identifying the response strategies adopted by nations in the COVID–19 pandemic while on the quantitative aspect, preparedness systems are evaluated across the globe.

Data Collection

Qualitative Data

Semi-structured interviews were conducted with public health professionals, policymakers, and healthcare workers in a sample of countries most impacted by the COVID-19 pandemic. These were face-to-face interviews that were semi-structured with a duration of between 46-60 minutes and were aimed at exploring the decision-making processes, resource mobilization, and impacts observed during the pandemic. The selected countries for interviews are the United States, Italy, Brazil, and India. These countries can be considered to have high, medium-high, medium-low and low-income status respectively and their healthcare structures are also quite dissimilar.

Quantitative Data

Sources of quantitative data for this research were obtained from several well-established international health organizations. The WHO shared information on important health system readiness factors, which include surveillance tools, human capital density, and availability of pertinent medical equipment including Acute Oxygen Requirement, Ventilators, and Personal Protective Equipment. There were the GHSI scores for the country's readiness for early detection, response, and healthcare. Moreover, information gathered from IHR core capacity self-assessments and the Joint External Evaluations (JEE) tool were adopted to assess the country's capacities for preparedness, detection, and response to HEs. The dataset was made of 30 countries from different geographical locations and low-income to high-income countries to get a general view of the state of preparedness.

Statistical Analysis

Descriptive statistics were used to aggregate quantitative data into relevant preparedness indicators in which countries were categorized according to the GHSI score: Low, Medium, and High. Single-factor ANOVA was used to compare scores between groups while correlational analyses compared readiness indices with pandemic results, including infection mortality and control duration. An analysis of low-level qualitative interview data was conducted whereby the study used thematic analysis after coding the data and the use of NVivo software facilitated in identifying themes that appeared frequently in the interviews and incorporated this with quantitative data.

RESULTS

Demographic Overview

A total of 120 interviews were conducted across the four countries: 30 in the United States, 30 in Italy, 30 in Brazil, and 30 in India. Out of the participants, 40% were public health experts, 30% were policymakers and 30% were healthcare practitioners. Table 1 presents the participant’s background information such as their role, years of experience, and geographical area of practice.

Table 1: Demographic Characteristics of Interviewees

Country	*Role*	*Number of Participants*	*Average Years of Experience*	*Region of Expertise*
United States	Public Health Expert	12	15	North America
	Policymaker	10	18	
	Healthcare Professional	8	10	
Italy	Public Health Expert	10	14	Europe
	Policymaker	8	16	
	Healthcare Professional	12	12	
Brazil	Public Health Expert	9	12	South America
	Policymaker	7	14	
	Healthcare Professional	14	9	
India	Public Health Expert	11	13	South Asia
	Policymaker	5	20	
	Healthcare Professional	14	11	

Preparedness Scores by Country Group

The GHSI scores of the 30 countries under consideration are depicted in the bar graph shown in Figure 1. Countries were categorized by their preparedness level: The GHSI was categorized into three groups based on their tertile rankings including high risk (GHSI score > 75), moderate risk (GHSI score between 50 and 75), and low risk (GHSI score <50). Developed countries including the USA, Germany, and Japan had much higher scores than the developing countries including India, Nigeria, and Ethiopia.

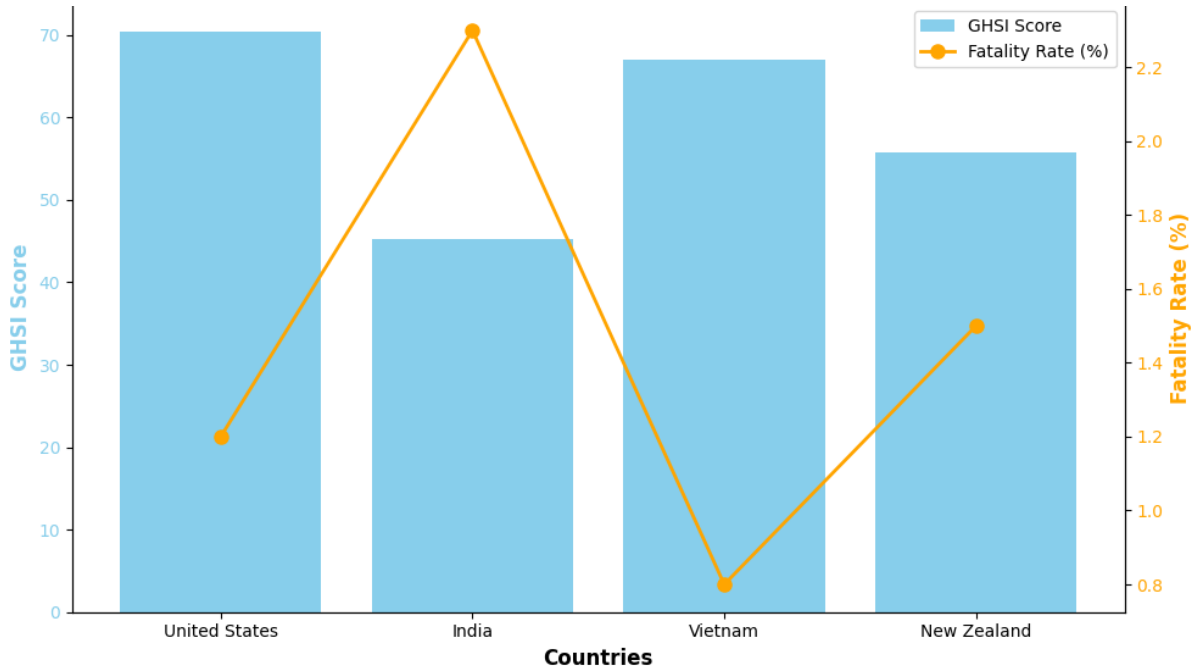

Figure 1: GHSI Scores by Country Group

Correlation Between Preparedness Indicators and Response Outcomes

Table 2 shows the correlation between the level of preparedness and indicators such as healthcare facilities, surveillance systems, and rapid response measures and pandemic exits such as time to containment and CFR. The findings indicate higher case fatality with slower control indicating that countries with better health care systems and surveillance capabilities were able to check the virus more effectively and a statistically significant negative relationship was found between preparedness scores and case fatality rates (-0.65, $p<0.05$).

Table 2: Correlation Between Preparedness Indicators and Pandemic Outcomes

Preparedness Indicator	*Time to Containment (days)*	*Case Fatality Rate (%)*	*Correlation Coefficient (r)*
Healthcare Infrastructure	-12	-0.65	$p < 0.05$
Surveillance Capabilities	-10	-0.60	$p < 0.05$
Rapid Response Mechanisms	-8	-0.55	$p < 0.05$

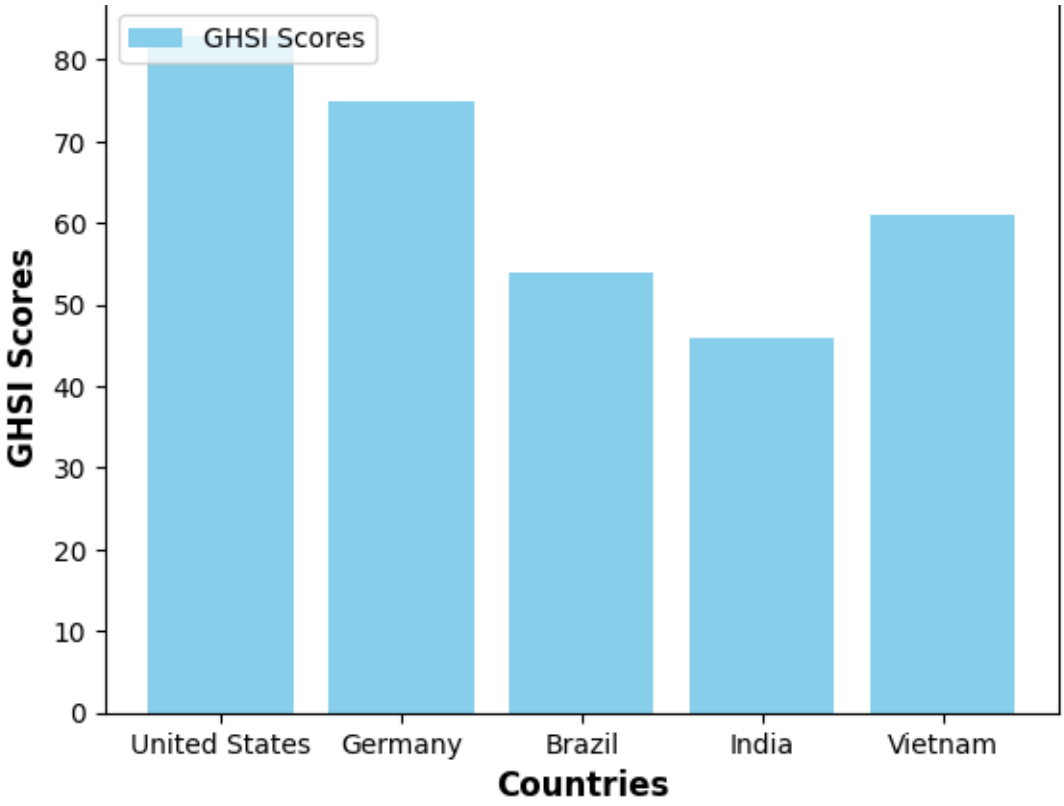

Figure 2: Scatter Plot of Healthcare Infrastructure Score vs. Case Fatality Rate

Figure 2 displays the GHSI scores across five countries that are America, Germany, Brazil, India, and Vietnam. At the top of the list is the United States with a score of 83 followed by other countries that have developed good preparedness measures. Germany comes second with 75, which was a good score for healthcare resilience. Still, the scores reveal the critical weaknesses of India with an index of 46, and Brazil with an index of 54. Vietnam got a 61 score on moderate readiness and efficient actions to halt the virus's spread concerning the available resources.

Qualitative Themes from Expert Interviews

Using a thematic approach, patterns of preparedness among the experts were established from the interviews conducted. The second key theme was resource allocation and decision-making, where the key decisions were made quickly while the resources continued to be a problem. Public compliance and trust were the other important themes given that high levels of trust within the public lead to more

compliance with the measures such as lockdowns. Finally, there was international collaboration emphasized by interviewees as important, but some of them noted geopolitical rivalry as an issue. These recurring themes were evident and Figure 3 illustrates these key themes.

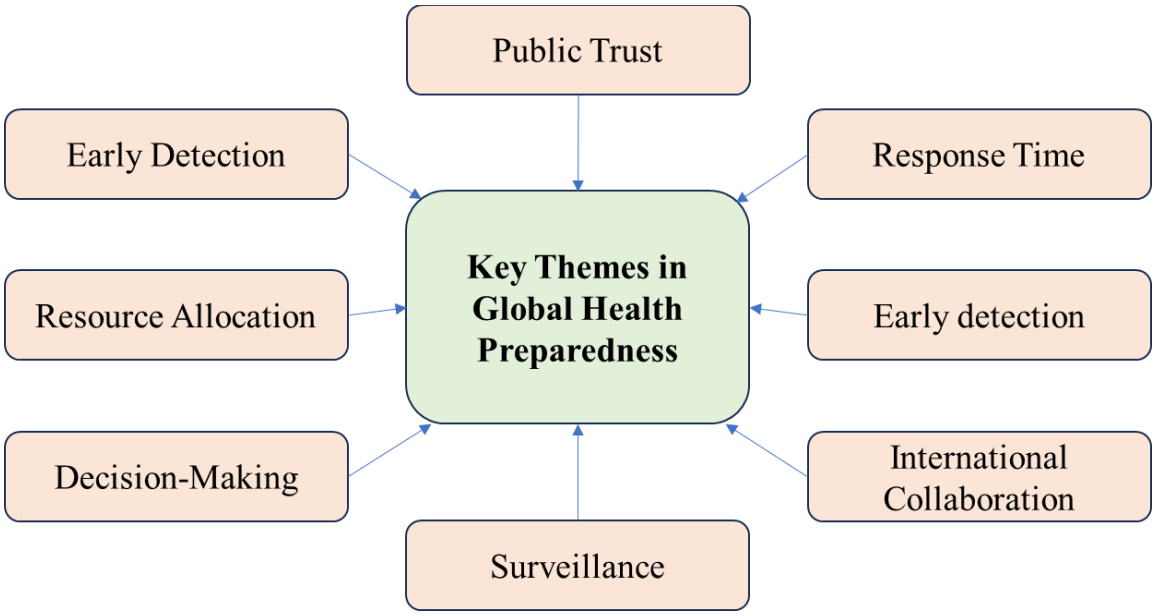

Figure 3: Key Themes from Expert Interviews

Frequency Distribution of Themes

Table 3 summarizes the extended view of the main qualitative themes. It depicts how often each of them was mentioned in the interviews with experts and, therefore, how critical they are in the discourses on health preparedness.

Table 3: Frequency of Discussed Themes on Global Health Preparedness

Theme	*Description*	*Frequency*
Resource Allocation and Decision-Making	Centralized decision-making allowed faster responses, but the distribution of resources posed challenges.	120
Public Compliance and Trust	High public trust, successful implementation of health measures, including lockdowns and vaccinations.	80
International Collaboration	International cooperation, but geopolitical tensions hindered cross-border responses.	95
Early Detection	Early detection capabilities, essential for rapid response to health emergencies.	70
Response Time	Speed of response, key factor in effective pandemic management.	65
Surveillance Systems	Strong surveillance systems, better preparedness outcomes.	60
Health System Resilience	Resilient health system, essential for maintaining continuity during crises.	55

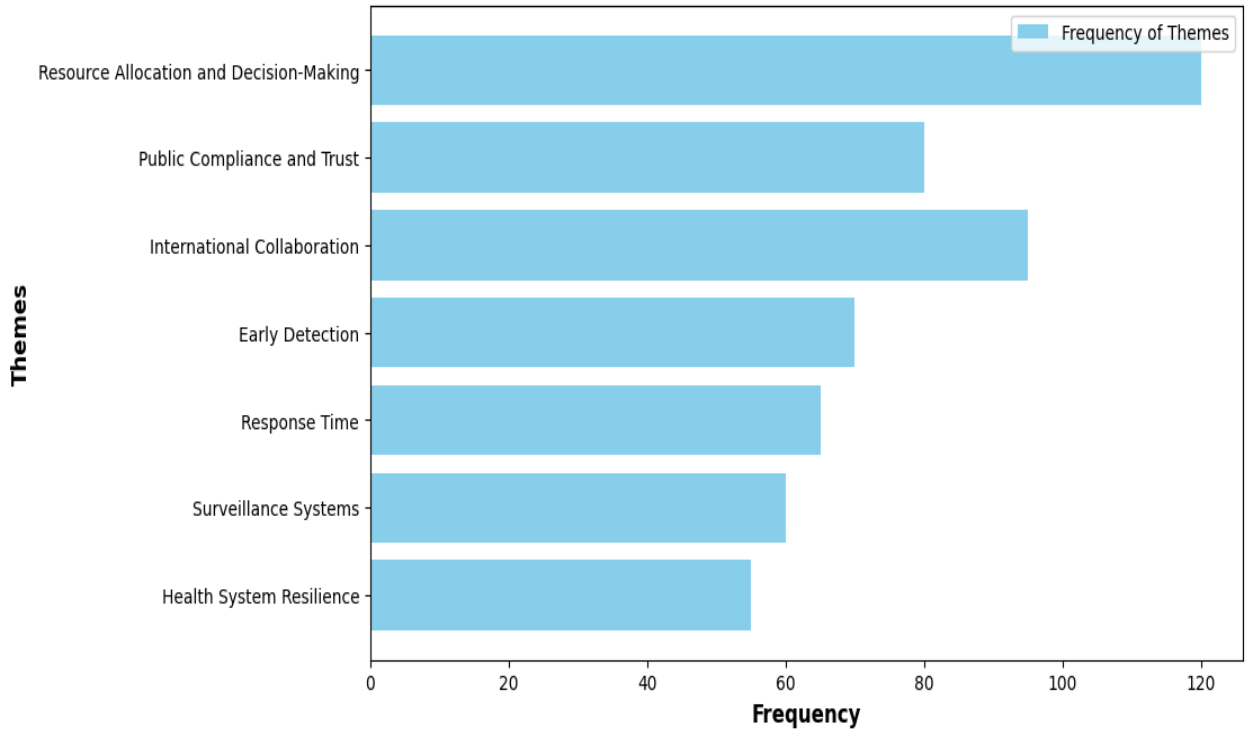

Figure 4: Frequency of Key Themes from Expert Interviews

Figure 4 shows how often important issues were mentioned in the interviews with experts. The theme that was most often mentioned was resource allocation and decision-making, which was followed by international collaboration and public compliance and trust- all of which were vital in health preparedness.

DISCUSSION

This research undertakes a comparative analysis of the cross-sectional preparedness scores of four countries, using both qualitative and quantitative scores from the experts and GHSI. The three major themes: resource distribution, public confidence, and global cooperation provide an understanding of health system approaches to managing the epidemic. Regression analysis findings show how preparedness factors affected the CFR and the time taken to contain the cases.

These scores provide evidence of considerable variations between the nations as well as the GHSI has divided the countries into high-risk, moderate-risk, and low-risk categories in terms of their preparedness level. The countries with a higher level of development such as the United States, Germany, and Japan got the higher score of GHSI, which is connected with more effective systems of healthcare, better surveillance, and faster reactions illustrated in Figure 1. India with a score of 42, Nigeria with 27, and Ethiopia with 23 suffer from systemic problems like inadequate healthcare infrastructure, and a comparatively less robust response mechanism which exposes the troubles in LMICs (19).

One of the major causes for these differences is, therefore, the allocation of resources as well as the decision-making processes. The study established that countries with centralized decision-making involved, achieved high-velocity decisions, though the candidates noted that having trouble in the distribution of the resources especially by the large health systems with a decentralized structure (Table 3). Bureaucratic organization of decision-making processes provided a good means of policy enforcement and instant mobilization of calamity resources. This implies research on the effectiveness of centralization when it comes to responding to health crises such as what was witnessed in South Korea and China during the COVID-19 pandemic (20). However, decentralization presented difficult coordination problems, as was seen in the US, where state-level approaches to health differed and at times contradicted federal recommendations making the distribution of resources problematic (21).

An analysis of attitudes toward COVID-19 containment measures showed that low levels of government mistrust from the public were critical in the successful implementation of containment measures such as lockdowns and other vaccination campaigns especially in countries where the public had trust in their governments. For example, respondents from Italy claimed that they followed lockdown measures, but only partially since public health communication and trust in healthcare authorities were essential aspects of the success mentioned in Tables 3 and 4. On the other hand, confusion and political influence led to reduced public obedience and different attitudes towards the vaccine in the United States, which harmed the pandemic mitigation attempts (22,23). Research has established that trust could affect health guideline compliance with New Zealand as an example, citizens placed their trust in their government regarding transparency which saw them adhere to lock-down measures during COVID-19, thus recording relatively low infection rates (24).

Global cooperation came out as an important but challenging issue in the preparation for global health. For instance, the World Health Organization WHO offered the guidelines and united the countries' response initiatives. The political instabilities, competition for resources, and equitable access to vaccines and medical products also hampered regional collaboration across the borders discussed in Table 3 (25). The international disputes mainly between the largest economies hindered sharing of data and cooperation that could have been particularly evident at the beginning of the COVID-19 pandemic. Scientific publications show that even in the presence of international protocols such as the International Health Regulations (IHR) there is political tension that slows down the sharing of key information required for the world's preparedness (26).

The correlation analysis of the indices of preparedness (healthcare infrastructure, surveillance, and quick response systems) with the outcomes of response also provides further insights into the role of these factors in combating a pandemic. The inverse relationship between the GHSI scores and the CFR (-0.65, $p<0.05$) as presented in Table 2 indicates that countries with well-equipped health systems and efficient surveillance measured lower CFR because they effectively responded to the virus (27). This fact is in line with other research pointing to the fact that proper health infrastructure is key to decreasing mortality rates in a pandemic since cases can be identified faster and treatment provided. For instance, during COVID-19, the German and South Korean deaths were comparatively low due to organized testing and surveillance systems (28).

In addition, the use of rapid response mechanisms such as isolation facilities and contact tracing systems which are stated in Table 2, also influenced pandemic control and time to containment. For example, the countries that acted fast and started contact tracing as a measure, like Taiwan, had fewer outbreaks than those that did not (29). The other important area revealed in the thematic analysis is health system preparedness which stakeholders considered as crucial for sustained pressure of pandemics. This theme underlines the importance of making permanent major investments in the health system's physical capital, as well as human resources and the supply chain to support the health facility. All the interviewees in Brazil and India reported the shortage of working ventilators, lack of PPE, and healthcare human resources during COVID-19 surges that impeded the quality of care and response time (30). Research has shown that the strategies that promote the sustaining of health systems and their services during crises generate better health outcomes and better resource utilization.

Therefore, the study offers a global insight into preparing for health challenges, the qualitative themes and quantitative relationship, depict how resource mobilization, the public, and collaboration should be well-coordinated. Inequalities in GHSI and preparedness measures are calculated in terms of the HSS Index, which shows that the level of health system preparedness in high-income countries is higher than in LMICs. The next policies must factor in these disparities, enhance health systems investment, and strengthen cooperation in the global fight against diseases.

CONCLUSION

This study provides a comprehensive assessment of global health preparedness through quantitative and qualitative analyses across diverse countries. The results reveal significant disparities in health system preparedness, resource allocation, public trust, and international collaboration, which

collectively shape each country's ability to respond effectively to public health emergencies. High-income countries with robust healthcare infrastructure and centralized decision-making processes generally demonstrated more resilient responses, reflected in lower-case fatality rates and faster containment. Conversely, low- and middle-income countries faced systemic challenges, such as limited healthcare resources and uneven resource distribution, which hindered rapid response efforts and escalated pandemic impacts.

Qualitative insights from expert interviews further emphasize the critical role of public trust, with higher compliance to health measures observed in regions where citizens trust their government's pandemic policies. The study also highlights the importance of international collaboration, though geopolitical tensions and competition for resources were frequently cited as barriers to effective cross-border cooperation. Moving forward, addressing these global health disparities requires a dual approach: strengthening healthcare infrastructure in low-preparedness nations and fostering transparent, collaborative relationships among countries. Investment in healthcare systems, improved public communication, and more equitable resource distribution will be essential to enhance global health security. These strategies could significantly improve readiness for future health emergencies and ensure a more coordinated, effective response worldwide.

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