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BUILDING A JUST WORLD
AND A SUSTAINABLE PLANET

Third Joint Finance and Health Task Force (JFHTF) Meeting

G20/World Health Organization/World Bank Global Report on the Framework for Health, Social, and Economic Vulnerabilities and Risks (FEVR) related to Pandemics

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GLOBAL REPORT ON FRAMEWORK FOR HEALTH, SOCIAL AND ECONOMIC VULNERABILITIES AND RISKS (FEVR) RELATED TO PANDEMICS

I. EXECUTIVE SUMMARY

The COVID-19 pandemic had a devastating impact on all our lives and caused a global economic shock of a scale greater than the 2008 Global Financial Crisis, impacting the poorest and most vulnerable, and pushed hundreds of millions back into poverty. The risks of another pandemic continue to increase, driven by an increase in novel disease outbreaks and exacerbated by biodiversity loss and climate change. The recent declaration by World Health Organization (WHO) of Mpox as a public health emergency of international concern is a timely reminder of this constant risk. Against this backdrop, the G20 Joint Finance and Health Task Force (JFHTF) has been channeling part of its efforts on the need to: i) better understand how the economic impacts interconnect with wider health, social and economic vulnerabilities and risks; ii) assess and acknowledge such risks; and iii) develop policy options for improving resilience to future pandemic risk.

This Global Report on Framework for Health, Social and Economic Vulnerabilities related to pandemics (Global Report) brings together the analysis undertaken, under the JFHTF, including updating and proposing a finalised **Framework for Health, Social and Economic Vulnerabilities and Risks (FEVR)** and policy perspectives drawn from the simulation exercises. FEVR was developed to support decision-makers to better understand and improve the health, social and macroeconomic vulnerabilities and risks related to pandemics. Launched by the G20 Indian Presidency in 2023 as a multi-year priority of the G20 JFHTF, the FEVR continued to be developed under the G20 Brazilian Presidency with guidance from members, technical experts, and partners.

By their nature and taking into account national circumstances, the Global Report and the FEVR model are country-specific and can serve as a tool for further policy development and priorities. The broad range of data, complexity of policy options and country-specific circumstances mean that the indicators and modelling are not useful and are not expected to feed into a weighted index of vulnerability or any comparative exercise, but rather are a framework for information analysis and evidence-based decision-making. In this regard, the instruments are not an index-based tool and are not intended to be used for comparison across countries.

At this stage, the FEVR cannot incorporate all the indicators suggested by members to reflect this aspect. Some were previously tested with the development of the preliminary framework, and other issues, including biodiversity and air pollution, have had data issues, including unavailability of reliable data sources, outdated existing data, insufficient evidence of linkage with social domain or economic impacts, and reverse causality with vulnerabilities and risks.

There are areas where there is evidence of the impact of specific issues such as loss of biodiversity on the increase in risks to pandemics, and the importance of adopting a One Health approach. This evidence and analysis should be used alongside FEVR to support

insights at a local regional and national levels in assessing measures to mitigate frequency and risks of pandemics. A future iteration of FEVR may consider including indicators that would show stronger linkage with One Health approach.

The **framework aims to be used as a tool at national, regional, and global levels to increase awareness of vulnerabilities, identify policies that can strengthen prevention, preparedness, and response, and demonstrate progress over time**. As a comprehensive analytical framework, the FEVR offers a **unique added value** by bringing together data on vulnerabilities and risks across the three domains (health, social, and economic) for pandemic preparedness and response, allowing for a broad understanding of the latter, and supporting a more complete picture for assessing the trade-offs of different policies and investments. The FEVR employs indicators and modelling to identify vulnerabilities and supports the development of policy options to mitigate the impacts of future pandemics and other health emergencies and seeks to help decision-makers answer two key questions: (1) what are the vulnerabilities and risks; and (2) what policy measures/actions can be taken to reduce vulnerabilities/risks and/or mitigate the impact of a future pandemic?

In 2024, the FEVR **informed simulation exercises and stress tests to develop scenario analyses** and support the further development of the policy toolkit. The aim is to assist decision-makers and stakeholders with prioritizing policies and investments in line with country-specific circumstances. Moreover, the FEVR has been also used by international actors and initiatives, such as the Pandemic Fund, to identify vulnerabilities, support policy implementation, and allocate financing.

The highly unequal outcomes from COVID-19 across societies can be attributed to several factors, significant ones include inequity in access to medical countermeasures as well as the social determinants of health, the conditions under which people are born, grow, live and age and their ability to access health care and to take measure to protect themselves from exposure. Under the Brazil Presidency, the importance of better understanding the centrality of Social Determinants of Health (SDH) was introduced as a priority for the JFHTF. A policy note on proposed SDH indicators has been submitted for use in FEVR, along with a wider analysis to better incorporate detailed SDH factors into the analysis and assessment of policy options aimed at reducing risks and vulnerabilities to pandemics.

Following the wider endorsement by G20 members, some indicators proposed in the SDH Policy Note are incorporated into the FEVR model and included in this Global Report. These indicators reflect access to social protection benefits, access to water and sanitation, education enrollment, and proportion of urban population living in slums, informal settlements or inadequate housing. Disaggregation by sex and/or age may be performed if the relevant data is available and allows such application.

It is envisioned that consistent analysis of the indicators in the FEVR and the use of the framework to increase awareness of vulnerabilities and guide policymaking and exercises, such as stress tests, could support efforts to achieve a world where countries are less vulnerable and more prepared for the next global pandemic. Ultimately, this could help to mitigate the health, social, and economic consequences of pandemics.

Building on the updated analytical framework of the FEVR as well as the result of the economic and epidemiological modelling of the simulation exercises, the **purpose of this Global Report** is to offer an overview of key risks and vulnerabilities and analytical modeling while avoiding any comparisons between specific countries. The report also presents various policies that can be implemented to reduce vulnerabilities. While these policies are recommended based on the evidence and analysis, country and regional specificities will always need to be accounted for when implementing policies and plans. This report could be published regularly to take account of the updated technical and policy perspectives as well as support tracking of finance trends where possible.

II. BACKGROUND AND INTRODUCTION

The COVID-19 pandemic was a generation-defining health emergency with devastating health, livelihoods, and economic consequences. This pandemic showed that national governments and the global multilateral system were ill-equipped to deal effectively with the scale and complexity of such health crises. It was clear that a framework that could help policymakers and experts identify critical vulnerabilities and recommend evidence-based actions that would help to address these vulnerabilities would be useful at both national and global levels. Not only were lessons learned from the COVID-19 pandemic, but a tremendous amount of evidence was also generated which was used to analyze risks, preparedness, and outcomes related to the health, social, and economic domains. Under the guidance of the G20 JFHTF, the World Health Organization (WHO), the World Bank, and other international financial institutions developed the FEVR (Table 1).

Table 1. Timeline of FEVR development

Date	Milestone
January 2023	FEVR established as a multi-annual deliverable of the JFHTF work
June/August 2023	Delivery of two reports on FEVR including proposed indicators & preliminary vulnerability and scenario analyses[1]
August 2023	The G20 New Delhi Leaders' Declaration called on the JFHTF to continue refining the FEVR to regularly assess economic vulnerabilities and risks due to evolving pandemic risks, taking into account country-specific circumstances
October 2023	Informal technical workshop with experts to review progress to date with developing FEVR and discuss how to improve the framework and its application
April 2024	Presentation of initial modelling results and revised framework to G20 JFHTF members during a simulation exercise
September 2024	Presentation of global report on FEVR including key risks, identified vulnerabilities, and a menu of policy measures

1. G20 Report on Development of a Framework for Health, Social, and Economic Vulnerabilities (FEVR) and Risks from Pandemics, August 2023; G20 Report on Economic Vulnerabilities and Risks to Pandemics and Potential Policy Measures, August 2023.

The **FEVR comprises two parts**: a set of indicators that provide overview of the health, social, and economic vulnerabilities relating to pandemics as well as a policy toolkit that can be used to guide efforts to better prevent, prepare for, and respond to pandemics. The first part builds on existing work by organizations and academic experts across the three domains[2] to identify predictive indicators of vulnerabilities, assess risks, determine the causal links between specific pandemic preparedness and response policies and impacts, and analyse these linkages with health economic modeling and related effort. The second part of the FEVR provides decision-makers with a menu of policies that aim to address the vulnerabilities and strengthen pandemic preparedness and response capabilities.

III. KEY HEALTH RISKS

The overarching trend is clear as countries are facing more frequent, more complex, and longer-lasting health emergencies including pandemics. The emergence and reemergence of epidemic-prone diseases continue to challenge health systems; hunger and shortages of essential goods are caused by and exacerbate geopolitical conflict; ecological degradation and climate change continue to intensify; and social and economic inequalities continue to widen. This has resulted in an increase in the health, social, and economic risks associated with pandemics and health emergencies driven by overlapping and interacting aggravating factors including accelerating climate change, increased conflict, and insecurity, increasing food insecurity, weakened health systems in the wake of COVID-19, and new infectious disease outbreaks.

Pandemic risk is the expected value of the impact of widespread infectious disease in humans on health, economies, and society. It is a function of **threats and vulnerabilities**, and their interactions, which must be addressed to ensure a safer world. Threats refer to new or existing pathogens that can cause a pandemic, while vulnerabilities refer to gaps between the existing capacities and the capacities needed to prevent the emergence, amplification, spread, and impact of such threats. Pandemic risks to economies and health are greatest in situations or areas with both substantial threats and vulnerabilities, making the risk of new outbreaks and international spread more likely.

The health risks that communities and countries are faced with today reflect the highly globalized and industrialized nature of modern society. The interconnectedness of the global economy and international travel, paired with the increasing pressure on the interface between humans, animals, and the environment result in an ever-present risk of the next **pandemic**. Estimates suggest that there is a 2-3% annual probability of a COVID-19-like pandemic occurring (i.e., a pandemic with similar transmission and mortality latest) equating to a pandemic like this occurring approximately every 50 years.[3] This is why many experts urge policymakers and the public to prepare for the next pandemic, which is a matter of when, not if. Based on available data, pandemics caused by high-probability, low-mortality pathogens (similar to SARS-CoV-2) result in **an annualized expected impact of**

2. This includes but is not limited to the Global Preparedness Monitoring Board (GPMB) Monitoring Framework for Preparedness, the International Health Regulations Monitoring and Evaluation Framework, and the INFORM Epidemic Risk Index.

3. Estimated Future Mortality from Pathogens of Epidemic and Pandemic Potential https://www.cgdev.org/sites/default/files/estimated-future-mortality-pathogens-epidemic-and-pandemic-potential.pdf

790,000 deaths and US$ 939 billion in economic losses,[4] the latter includes the direct and indirect economic impacts (Figure 1). The estimated secondary economic impact of US$ 740 billion is caused by containment measures and response interventions. A high-probability, low-mortality pandemic such as this is expected to infect between 20-90 million people per year worldwide and the average duration of a pandemic is estimated to be 3.5 years.

While pandemics are a significant and pressing modern risk, other types of health emergencies result in notable health and economic impacts. Ensuring that countries are prepared for and capabilities in place to detect and respond to health emergencies will not only result in better short-term outcomes, but these efforts will also help to strengthen health, economic, and social protection systems which will yield further long-term benefits related to global pandemics. For example, strengthening a country's disease surveillance system will improve the detection of existing diseases (e.g., cholera) and could also be beneficial when seeking to identify new cases or variants during a global pandemic.

High-threat epidemics including polio, cholera, meningitis, yellow fever, Ebola, and measles, jointly cause at least 223 outbreaks per year. On average, 420 million people globally are infected by neglected tropical diseases (NTDs) and these diseases each year,[5] resulting in an **annualized expected impact of 627,000 deaths and US$ 132 billion in economic losses** (Figure 1). The direct economic losses are calculated from the estimated number of disability-adjusted life years (DALYs) caused by these diseases each year, while the indirect economic losses account for the impact of the control measures implemented (e.g., isolation).[6] These global figures obscure the reality that such outbreaks do result in significant losses within countries; country-specific analyses would enable further investigation.

The benefits of pandemic preparedness and response measures can support improved resilience for other events that can have severe health impacts. **Humanitarian crises and climate-related disasters** are increasing in number, scale, and complexity. Humanitarian emergencies are often characterized by conflict, violence, displacement, food insecurity, and poor health outcomes. Humanitarian crises occur approximately 38 times a year resulting in 1 in 73 people being forcibly displaced and 300 million people in need of humanitarian assistance and protection in 2024, including 165.7 million in need of health assistance. Reported climate-related disasters (e.g., earthquakes and floods) occur more than 300 times per year with wide-ranging impacts on health, economies, and society. Globally, humanitarian crises and climate-related disasters affect up to 365mn people every year resulting in an **annualized expected impact of 87,000 deaths and US$ 45 billion in economic losses** (Figure 1). Note that mortality estimates do not include the deaths directly caused by humanitarian crises and climate-related disasters (e.g., from armed conflict or drowning), but rather the secondary health impacts which result in a lack of access to quality health services. The economic losses account for the impact based on the estimated number of DALYs and the economic cost based on the expected costs of providing health services.

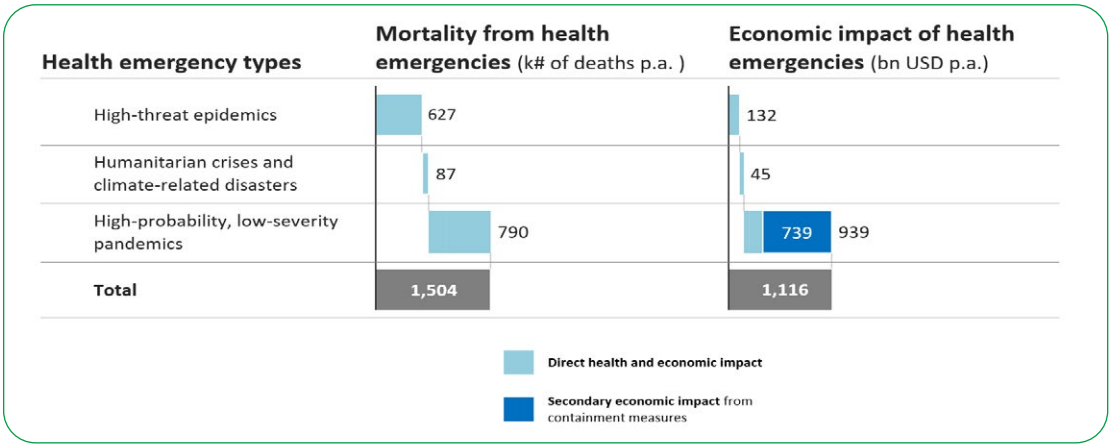
4. These figures do not include low-probability, high-mortality pandemic events.

5. Each year, approximately 390 million people are infected by dengue, 234,000 by chikungunya, and ~200 by polio.

6. Note that the indirect economic impact associated with meningitis and yellow fever outbreaks is assumed to be close to 0 as control measures are typically very limited. In addition, the large difference between the estimated health impact and economic impact of high-threat epidemics is mostly driven by the fact that most of these disease outbreaks occur in low-income countries.

Biosafety and biosecurity risks, including deliberate events, continue to be a pressing issue with limited quantitative data regarding the probability and expected health and economic impacts. However, these risks pose a serious danger to human health and society across the world. Efforts to address vulnerabilities and strengthen pandemic preparedness must include specific activities that target the health-security interface including enhancing coordination, information sharing, safety, and procedures.

Figure 1. Probability adjusted expected annual health and economic impact of health emergencies[7]



Work is ongoing to analyze further and identify the most significant pandemic risks and the likelihood of occurrence in different settings. This includes but is not limited to work by health experts at WHO, its collaborating centers, and groups around the world on a list of priority pathogens for research and development, geographic risk mapping, environmental suitability geographic analysis, and in-depth analyses of the social determinants of health and lifestyle factors that affect the emergence of pathogens and the spread of disease. In addition, experts continue to try to identify key factors that are similar or different across pathogen profiles, including existing and unknown pathogens. For example, how do different disease transmissions have a variable impact on different sectors, how do these impacts differ across regions, and how could different country settings and characteristics play a role on potential outcomes? Finally, analytical modeling and scenario analysis continue to provide insights into the potential impact of potential pandemics due to differing levels of vulnerability across the health, social, and economic domains at global and national levels.

7. Source: WHO assessments/analysis.

IV. METHODS

The methodological approach to develop and refine the FEVR evolved based on guidance from G20 JFHTF co-chairs and members as well as input from technical experts. The first iteration of the FEVR (phase 1)[8] comprised 16 existing indicators from across the health, social, and economic domains which were identified through a scoping review, suitability assessment, and correlation analyses (Table 2).[1] This approach yielded a provisional framework of 16 vulnerability indicators with strong correlations to GDP per capita or change in GDP per capita during the COVID-19 pandemic (Annex I).

Table 2. First iteration of the FEVR included 16 vulnerability indicators across the three domains which were identified through a scoping review, suitability assessment, and correlation analyses

Domain	Indicators
Health system resilience & response	1. Health expenditure per capita 2. Logistics performance index 3. Physicians per 1,000 population 4. UHC Service coverage 5. International Health Regulations
Macroeconomic stability	6. Population with bank savings 7. Exports 8. Credits to private sector 9. Global value chain 10. Agriculture and tourism 11. Central government debt
Social & economic protection	12. Informal economy relative to GDP 13. Food insecurity index 14. Social protection benefit coverage 15. SDG Index 16. Internet access

While this was a significant achievement under the 2023 India Presidency, the G20 JFHTF members agreed that a framework of vulnerability indicators covering the three domains was needed, there were limitations in the method used to develop the first iteration of the framework. First, the correlation analysis was focused only on economic outcomes and did not take into account the corresponding health and social outcomes. The indicators were only analyzed to detect potential relationships with four GDP-based outcome measures. Second, many of the indicators identified in the scoping exercise and analysis are vulnerable to any economic shock and are not specific to pandemics. Third, while data from the COVID-19 pandemic was a valuable resource for exploring these correlations, it is necessary to explore other types of pandemics and the potential vulnerabilities and impacts on health, social, and economic outcomes. For this reason, additional analytical modeling was proposed as a complementary method to further refine the list of indicators and to understand the relationships and possible causal pathways between vulnerabilities and outcomes.

8. G20 JFHTF Report on Economic Vulnerabilities and Risks to Pandemics and Potential Policy Measures (August, 2023).

Based on this guidance, an **analytical and model-based approach** (phase 2) was undertaken to better understand how health, social, and economic vulnerabilities interact and to develop a policy toolkit. An integrated economic-epidemiological model and a policy model were combined to analyze different scenarios and to understand the impact of implementing different policies before a pandemic ("**preparedness**") and during a pandemic ("**response**") (see Annex II). This modelling approach offered insights into the benefits of different policies as well as the potential short- and long-term economic costs. While social outcomes (e.g., education disruptions) were not directly captured by this approach, the financial costs of social protection measures (e.g., furlough schemes) based on COVID-19 pandemic were accounted for and represented as part of the direct economic costs in the economic model.

This modelling approach built on existing academic and expert work and was presented during a simulation exercise in April 2024 as part of a broader effort to further develop and utilize the FEVR. The pandemic simulation exercise was facilitated by WHO, the World Bank, and partners, and attended by representatives from ministries of finance and health. The membership asked for further engagement with academics and experts to provide external expert input into the approach taken and highlight existing academic literature and the relationships. Based on the results of the modelling and causal pathway framework, the FEVR vulnerability indicators were refined to better represent the links between vulnerabilities and health and economic outcomes in the context of a pandemic (Table 3). These 23 indicators were selected based on the previous correlation analysis, a feasibility assessment to ensure an up-to-date global dataset with good geographical coverage, and the indicators' predictiveness. The selection was informed by the existing evidence base in terms of the predictive value of specific indicators and by guidance from experts and academic groups. Utilizing these vulnerability indicators will enable countries and global networks to better assess existing vulnerabilities, implement appropriate policy measures, and anticipate outcomes and tradeoffs.

Table 3. Final FEVR with indicators identified using correlation analysis of historical data as well as analytical modelling[9]

Domain	Indicators	Data Source with coverage and frequency of update
Health emergency preparedness & response	1. Timeliness of event detection, notification, and response	WHO GPW13 indicator, Triple Billion progress. Global data source that is updated biannually.
	2. Laboratory testing capacity modalities	States Parties Self-Assessment Annual Reporting: SPAR capacity C4.4. It covers all WHO member states and is updated annually in April.
	3. Community engagement	States Parties Self-Assessment Annual Reporting: SPAR capacity C10.3 It covers all WHO member states and is updated annually in April.
	4. Hospital bed capacity per 100k	World Bank Data Global database, updated annually
	5. Management of health emergency response	States Parties Self-Assessment Annual Reporting: SPAR capacity 7.2 It covers all WHO member states and is updated annually in April.
	6. Effective national diagnostic network	States Parties Self-Assessment Annual Reporting: SPAR capacity C4.5 It covers all WHO member states and is updated annually in April.
	7. Vaccination coverage rate for high-priority pathogens	WHO GPW13, Triple Billion progress. Global data source that is updated biannually.
	8. Multisectoral coordination mechanisms	States Parties Self-Assessment Annual Reporting: SPAR capacity C2.2 It covers all WHO member states and is updated annually in April.
	9. UHC service coverage index (SDG 3.8.1)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	10. Health expenditure (% of GDP)	Global Health Expenditure Database (who.int) Global database covers 190 WHO member states and is updated annually.
	11. Health expenditure per capita (current US$)	Global Health Expenditure Database (who.int) Global database covers 190 WHO member states and is updated annually.
Economic & fiscal	12. Exports of goods and services (% of GDP)	World Bank Data Global database, updated annually
	13. International tourism receipts (% of GDP)[10]	World Bank Data Global database, updated annually
	14. Trade as a percentage of GDP	Several data sources including: OECD-WTO Trade in Value-Added (TiVA) database or GVC Trade Table | WITS |

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9. Note that the final list of indicators is provisional and subject to approval. Additional indicators may be added subject to approval.

10. International tourism receipts (US$) over GDP (current US$).

		Visualization (worldbank.org) but updates are not frequent to all countries. And World Bank Data Global database, updated annually
	15. General government gross debt (% of GDP)	International Monetary Fund World Economic Outlook database. Data available for 190 countries and updated twice a year for April and September publication of the World Economic Outlook.
	16. Debt servicing ratio (% of exports of goods, services and primary income)	World Bank Data Global database updated annually.
Social determinants	17. Access to water and sanitation (SDG 6) - Population using safely managed sanitation services (%) (SDG 6.2.1a)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	18. Access to education (SDG 4) - Net school enrollment rate (preprimary, primary, secondary, tertiary) (%)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	19. Urban slum population - Proportion of urban population living in slums, informal settlements or inadequate housing (%) (SDG 11.1.1)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	20. Access to social protection benefits - Proportion of population covered by at least one social protection benefit (%) (SDG 1.3.1)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	21. Internet Access (SDG 9 C: Proportion of population covered by a mobile network, by technology)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	22. Food insecurity (SDG 2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)	SDG Indicators Global Database Global database covers more than 200 country or area profiles. Regularly updated most recently in July 2024 and next update expected in Oct 2024.
	23. Informal employment	World Bank Data Global database, updated annually

The 11 health indicators were enhanced based on the analytical modelling with proxy indicators for each of the modelling input parameters established (Table 4). For example, the use of hospital bed capacity was selected in place of the number of physicians per capita based on published literature and the use of this indicator as an input parameter

for analytical modelling.[11] While many of the vulnerability indicators for the social domain remained the same (e.g., food insecurity in Table 2 and Table 3), some additional indicators were added (e.g., access to water and sanitation) in line with expert advice and the strong evidence base regarding the social determinants of health and, in particular, the influence of these determinants on disease transmission patterns. On this basis to avoid duplication the SDG index was removed. These 23 indicators shall assess national capacities to enable decision makers to determine existing vulernabilites based on expected outcomes using the scenario analysis. Furthermore, these predictive indicators will then enable the prioritization of the accompanying policy measures.

Table 4. Health indicators for FEVR and corresponding input parameters used for the analytical modelling to determine the causal pathways between vulnerabilities and outcomes in the context of pandemics

Health indicators	Corresponding input parameters for analytical modeling (Table 8 in Annex II)
1. Timeliness of event detection, notification, and response (WHO GPW13 indicator)	1. Time to detect first case or new variants (days)
2. Laboratory testing capacity modalities (SPAR capacity C4.4)	2. Time to isolation (days)
3. Community engagement (SPAR capacity C10.3)	3. Adherence to isolation (days)
4. Hospital bed capacity (per 100k) (World Bank)	4. Hospital bed capacity (per 100k)
5. Management of health emergency response (SPAR capacity 7.2)	5. Delay in implementing response measures (days)
6. Effective national diagnostic network (SPAR capacity C4.5)	6. Effectiveness of isolation (%)
7. Vaccination coverage rate for high-priority pathogens (WHO GPW13 indicator)	7. Vaccination rate (per 100k per day)
8. Multisectoral coordination mechanisms (SPAR capacity C2.2)	8. Reduction in contact rates by setting (%)

Application of framework: Current levels of vulnerability and preparedness for pandemics based on identified indicators in FEVR and other complementary analysis frameworks

There are many factors that contribute to vulnerabilities to pandemics and there is a significant amount of work being done by numerous organizations, academic groups, and national experts, that aims to better understand and identify risks and vulnerabilities to pandemics. Please refer to Annex III that shows the previous application of the 16 indicators of FEVR to assess health, social and economic vulnerability globally.

A country's **economic vulnerability** to a pandemic can be measured in several dimensions including growth, debt, trade, and other factors. Further economic analysis of the relationship between COVID-19 containment measures, economic characteristics, and GDP losses using

11. https://www-nature-com.ez.lshtm.ac.uk/articles/s43588-022-00233-0; The Economic Benefits of Preparing for the Next Pandemic (*preprint).*

the modelling approach indicated that stricter health policies, higher income levels, and dependencies on tourism, trade, and natural resources significantly influenced economic outcomes during the pandemic.

The key findings from the **economic analysis** of the impact of various country characteristics on GDP losses during the COVID-19 pandemic are as follows:

- Stringency of containment measures: There is a significant and positive association between the stringency of government containment measures (e.g., school closures and lockdowns) and short-term GDP losses. A one standard deviation increase in a Containment and Health Index is associated with a roughly 7 percentage point rise in GDP losses, suggesting that stricter policies, while aiming to protect public health, have led to greater economic losses.

- Vaccination speed: The rate at which a country vaccinated 20% of its population was associated with lower GDP losses, but this association did not exist after controlling for GDP per capita. This suggests that the economic impact of vaccination speed may be mediated by a country's overall income level, with wealthier countries generally being better equipped to obtain and distribute vaccines.

- GDP per capita: Higher-income countries experienced lower GDP losses from COVID-19. Specifically, a country with a GDP per capita one standard deviation above the mean saw about 7 percentage points less in cumulative GDP losses from 2020 to 2024, highlighting the protective effect of economic wealth against pandemic-induced economic downturns.

- Dependency on tourism, trade, and natural resources: Countries more dependent on tourism, trade, and natural resources suffered more significant economic impacts from the pandemic. The data show that a one percentage point increase in the share of trade and natural resource rents per GDP led to 0.23 and 0.45 percentage point increases in GDP losses, respectively, underscoring the vulnerability of these sectors to pandemic-related disruptions.

Overall, these results indicate that the economic impacts of the COVID-19 pandemic have been uneven, and heavily influenced by a country's policy responses, economic structure, and level of dependency on certain sectors. Further understanding how specific characteristics of an economy and dependencies on tourism, trade, and natural resources significantly influenced economic outcomes during the pandemic will support the assessment of vulnerabilities and prioritization of policies.

In addition to country-specific indicators, further work to identify the vulnerabilities and risks related to global and regional mechanisms and systems is needed. This includes, but is not limited to, ongoing efforts to enhance information sharing before and during a pandemic or emergency, access and benefits sharing regarding medical countermeasures, and rapid and predictable contingency sharing. In addition to these elements, overall coordination between countries and partners is essential to not only reduce vulnerability before a pandemic, but also to ensure responses are appropriate, cohesive, and equitable.

Menu of policy measures and recommendations to address vulnerabilities and mitigate the impacts of pandemics

The levels of vulnerability as assessed by the FEVR indicators and the results from the analytical modeling suggest that policies and investments that target the identified vulnerabilities within countries and international systems are needed. A package of measures can successfully address gaps in preparedness and prevention, taking consideration of both pandemic response and long-term economic and social development, while also ensuring that countries are better able to respond during a future pandemic and ongoing health emergencies. Such policies and investments can lower the health and economic costs associated with a pandemic, including both the costs associated with scaling health services (e.g., hospital bed capacity) and the costs of wider social and economic measures. The former reached up to 5% of GDP for many countries during the COVID-19 pandemic, while the latter was up to 40% of GDP. **Potential policies and investments** are described below for each of the three domains in the FEVR.

Health policies and investments

Insights from the FEVR and analytical modelling of a pandemic with similar characteristics to COVID-19 suggest that up to nearly half of the deaths directly caused by such a pandemic could be avoided if countries make significant efforts to prepare for pandemics, strengthen health systems, and enhance essential public health functions beforehand (Table 11). Further simulations are needed to test potential pandemics with different characteristics. Similarly, country-specific circumstances shall be taken in consideration while performing test-run of the model and country-specific simulations. Enhancing **preparedness and readiness** before a pandemic could include:

- strengthening surveillance which will enable earlier detection;
- engaging with communities and building trust which will increase adherence to isolation and vaccination rates (minimize vaccine hesitancy);
- building more resilient clinical services, facilities, and health workforce which will lead to lower mortality rates in hospitals, fewer healthcare-associated infections, and fewer disruptions to other health services;
- ensuring that R&D, manufacturing, and supply chain systems can be rapidly scaled which will result in rapid and more equitable access to medical countermeasures that can improve case isolation as well as infection and survival rates;
- enhancing emergency response management and coordination which will enable countries and communities to rapidly initiate an effective response; and
- support economic and medical research by countries themselves, to develop vaccine manufacturing and distribution at the national level, preventing the use of restrictive measures against any suppliers of vaccines at the international level.

The modelling approach did not account for the *indirect health impacts* (e.g., increased morbidity or morality associated with health conditions such as NCDs for which health services will be disrupted or delayed). WHO's Pulse surveys[12] revealed that 84% (105 of 125) countries reported some disruptions in essential health services, with up to 56% of essential health services disrupted in 2020. Therefore, efforts to ensure health systems and services and prepared and ready for pandemics and other emergencies will not only reduce the direct health impacts but also reduce the indirect health impacts. Furthermore, enhancing preparedness is also expected to reduce *indirect economic costs* due to less stringent and shorter-lasting Public Health and Social Measures (PHSMs) being implemented and fewer DALYs because health services would not be as overwhelmed.

Implementing effective and timely **response measures** during a pandemic can contribute to a significant (estimated to be more than 70%) reduction in the estimated number of deaths (Table 11). During a pandemic, a rapid and well-coordinated response includes the capacity to:

- initiate vaccination up to 150 days sooner; and
- increase access to testing to improve isolation of cases and contacts.

These response measures will reduce transmission, increase survival rates, and mitigate the strain on health systems thereby enabling governments to reduce or remove PHSMs more quickly. This will lead to lower indirect health impacts and indirect economic costs. However, most measures are far easier and less costly to scale during "peacetime" (i.e., preparedness).

While the investments in preparedness and response would result in some direct financial costs, the increased response capacity and therefore reduced need for social and economic protection costs would ultimately lead to much lower indirect and direct economic costs. The drastic reduction in cases and deaths associated with enhancing preparedness and response is expected to significantly reduce economic costs linked to PHSMs and DALYs. It is clear that the ideal scenario is that all countries invest in and enhance preparedness *and* response to mitigate the health, social *and* economic costs of pandemics.

Economic policies to support improved resilience

The economic characteristics of an economy have a significant impact on the risk and vulnerabilities to a pandemic. The measures to improve resilience could include assessing overall vulnerabilities and scenario analysis on the potential economic impact of policies, helping vulnerable sectors and businesses prepare and plan for the economic impact and engage with key international partners.

Where response measures are implemented to protect livelihoods, jobs, and businesses including the exceptional support to business to mitigate the impact of non-pharmaceutical interventions, an assessment of range of interventions and potential budgetary impact and ensuring the appropriate robustness of Public Finance Management (PFM) systems could support prioritization of such measures. Further analysis is needed to assess the

12. https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS_continuity-survey-2023.1

appropriate economic policies under different scenarios as fiscal and economic impacts will vary depending on a country's circumstances.

- Exports of goods and services (% of GDP)
- International tourism receipts (% of GDP)
- Trade (% GDP)
- General government gross debt (% of GDP)
- Debt servicing ratio (% of GDP)

Social policies and impact of public health measures

The highly unequal outcomes from COVID-19 across societies can be attributed to several factors, significant ones include inequity in access to medical countermeasures as well as the social determinants of health, the conditions under which people are born, grow, live and age and their ability to access health care and to take measure to protect themselves from exposure. Measures to directly address' the social determinants of health will be critical to improve overall resilience. Scaling of social protection schemes and policies interventions that take into account vulnerabilities identified in a pandemic response can support a more equitable outcome and effective public health policy impacts.

- Access to water and sanitation (SDG 6)
- Access to education (SDG 4)
- Urban slum population (SDG 11.1.1)
- Access to social protection benefits (SDG 1.3.1)
- Internet Access (SDG 9 C)
- Food insecurity (SDG 2.1.2)
- Informal employment (World Bank)

Financing impacts response capabilities and outcomes

These policies and measures depend on the political choices and management by governments, and on the available of domestic and international financing to address vulnerabilities and mitigate the impact of pandemics. The economic indicators in FEVR can be complemented by country specific analysis using relevant macroeconomic assessments from international and regional financial institutions.

Analyses were conducted to evaluate the estimated incremental **costs to increase preparedness capacity** (i.e., from moving from level X to X+1). These analyses resulted in global estimates (Table 5) as well as estimates by income group. Global figures for the total costs and costs per capita for increasing preparedness capacities are presented below. These estimated costs were also used to evaluate the potential tradeoffs between different polices and response measures when conducting the scenario analyses using the analytical model.

Table 5. Global estimates of the total costs and costs per capita for increasing preparedness capacities[13]

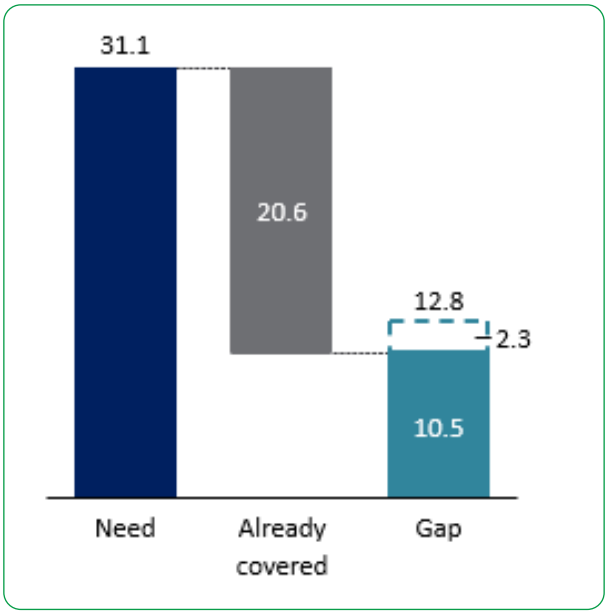
		Level 1 to 2	Level 2 to 3	Level 3 to 4	Level 4 to 5
Surveillance	Total cost ($US)	$ 1,930,518,450	$ 1,930,518,450	$ 5,791,555,351	$ 7,722,073,801
	Cost per capita ($US)	$ 0.24	$ 0.73	$ 0.97	$ 0.24
Community engagment & public health measures	Total cost ($US)	$ 680,876,395	$ 680,876,395	$ 2,042,629,185	$ 2,723,505,580
	Cost per capita ($US)	$ 0.09	$ 0.26	$ 0.34	$ 0.09
Health services & clinical care	Total cost ($US)	$ 768,771,753	$ 768,771,753	$ 2,306,315,258	$ 3,075,087,010
	Cost per capita ($US)	$ 0.10	$ 0.29	$ 0.39	$ 0.10
Access to medical countermeasures	Total cost ($US)	$ 362,314,355	$ 362,314,355	$ 1,086,943,064	$ 1,449,257,419
	Cost per capita ($US)	$ 0.05	$ 0.14	$ 0.18	$ 0.05
Emergency response management & coordination	Total cost ($US)	$ 378,616,335	$ 378,616,335	$ 1,135,849,005	$ 1,514,465,340
	Cost per capita ($US)	$ 0.05	$ 0.14	$ 0.19	$ 0.05

With an estimated US$ 10.5 billion **preparedness financing** gap per annum (Figure 2),[14] efforts to secure sustainability, and the coordinated allocation of financing are greatly needed.

13. Source: WHO assessments/analysis.

14. https://thedocs.worldbank.org/en/doc/5760109c4db174ff90a8dfa7d025644a-0290032022/original/G20-Gaps-in-PPR-Financing-Mechanisms-WHO-and-WB-pdf.pdf

Figure 2. Total financial need (in dark blue) and gap (in light blue) for pandemic preparedness (US$ billion)[15]



In addition to financing needs to increase preparedness capacity, early access to **contingency financing**[16] is crucial to enable countries to scale response measures, procure emergency supplies, and protect lives and livelihoods. The timely availability of finance is a critical component of an effective response in terms of accessing medical countermeasures and financing social protection and other measures that require curtailing economic activity to reduce transmission and control the disease. Effective and timely mobilization and coordination of the multiple existing response financing streams are essential.

Similar analyses were conducted to estimate the **costs of scaling response measures** for health (i.e., procuring and delivering tests and vaccines) and social and economic protection (e.g., furlough schemes). These figures included total costs and costs per capita (by income group). While these analyses can be useful for evaluating potential tradeoffs, the estimates are specific to the COVID-19 pandemic. The fiscal measures put in place to respond to the COVID-19 pandemic were also assessed by income group including total spending and average per capacity for above-the-line measures and liquidity support (Table 6).

15. https://thedocs.worldbank.org/en/doc/5760109c4db174ff90a8dfa7d025644a-0290032022/original/G20-Gaps-in-PPR-Financing-Mechanisms-WHO-and-WB-pdf.pdf

16. Contingent sources of financing are designed to cover immediate and limited needs, and not finance later stages of a response. These could be domestic through reserves in the budget, or external financing by IFIs. Please refer to "Mapping Pandemic Response Financing Options and Gaps" by G20 JFHTF, August 2023.

Table 6. National level fiscal measures in response to the COVID-19 pandemic since January 2020

	Above-the-line measures[17]				Liquidity support			
	Spending on health		Spending on non-health		**Below the line measures[18]:** equity injections, asset purchases, loans, debt assumptions, including through extra-budgetary funds)		**Contingent liabilities:** guarantees[19], quasi-fiscal operations[20]	
Income group[21]	Total **(US$ billion)**	Average per capita spending **(US$)**	Total **(US$ billion)**	Average per capita spending **(US$)**	Total **(US$ billion)**	Average per capita spending **(US$)**	Total **(US$ billion)**	Average per capita spending **(US$)**
High income	1289.4	538.4	7996.6	3094.8	318.7	375.1	5109	1875.1
Upper middle income	105.6	59.6	1073.3	270.7	44.3	33.1	457.7	150.4
Lower middle income	53.6	25.5	177.6	72.5	12.7	2.9	174.8	26.6
Low income	2.34	6.12	7.37	13.45	0.94	1.28	0.17	0.3
Global	1451.0	203.0	9255.0	1124.4	376.0	134.8	5741.0	671.9

Source: IMF country fiscal measure database (as of October 2021), IMF Fiscal Monitor (April 2020), OECD policy responses to COVID-19

Current financing landscape

Global development assistance for health which supports pandemic preparedness increased to historic levels during the COVID-19 pandemic (Figure 3)

17. Involves revenue raising and government expenditure, which affects the overall fiscal balance and government debt including forgone revenue.

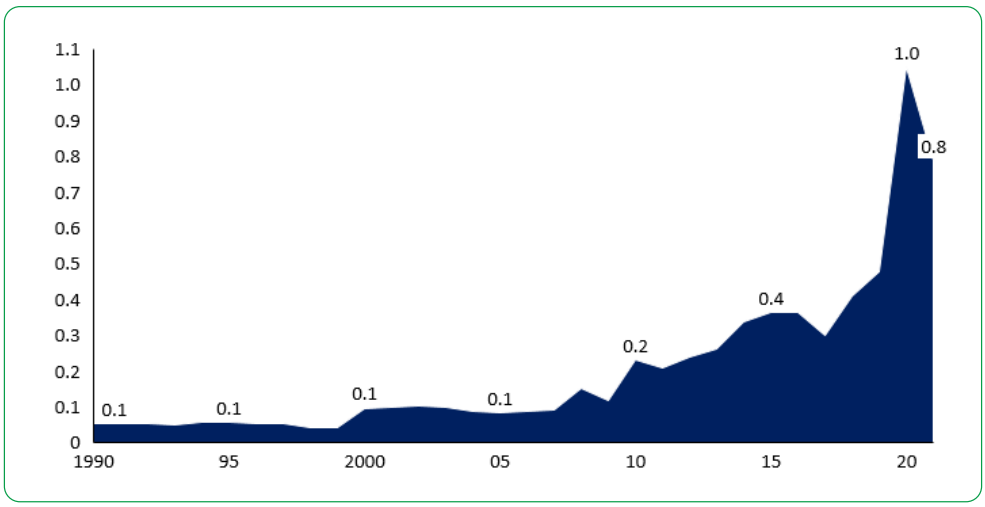
18. Generally involves the creation of assets or liabilities without affecting fiscal revenues and spending today.

19. Guarantees on loans, deposits, etc.

20. Noncommercial activity of public corporations on behalf of government.

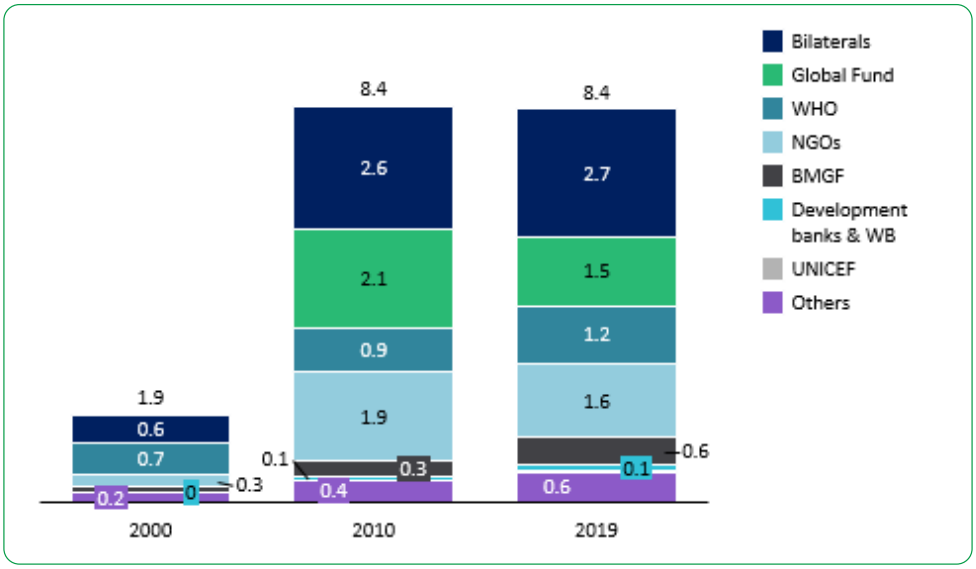
21. For operational and analytical purposes, economies are divided among income groups according to 2022 gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income, $1,135 or less; lower middle income, $1,136 to $4,465; upper middle income, $4,466 to $13,845; and high income, $13,846 or more. Population data used to estimate per capita spending was sourced from United Nations Population Division, World Population Prospects: 2022 Revision. Countries without any fiscal measure information during the pandemic were excluded.

Figure 3. Global development assistance for health which supports pandemic preparedness between 1990-2021 (US$ billions)[22]



Global development assistance for health which supports **pandemic preparedness** flows through different channels (Figure 4), but efforts are ongoing to enhance coordination among funding mechanisms and establish more efficient allocation mechanisms. Two-thirds of the financing in 2019 flowed through the three largest channels: ~33% through bilaterals, 18% through the Global Fund, and ~15% through WHO.

Figure 4. Global development assistance for health which supports pandemic preparedness by channel from 2000-2019 (US$ billions)[23]

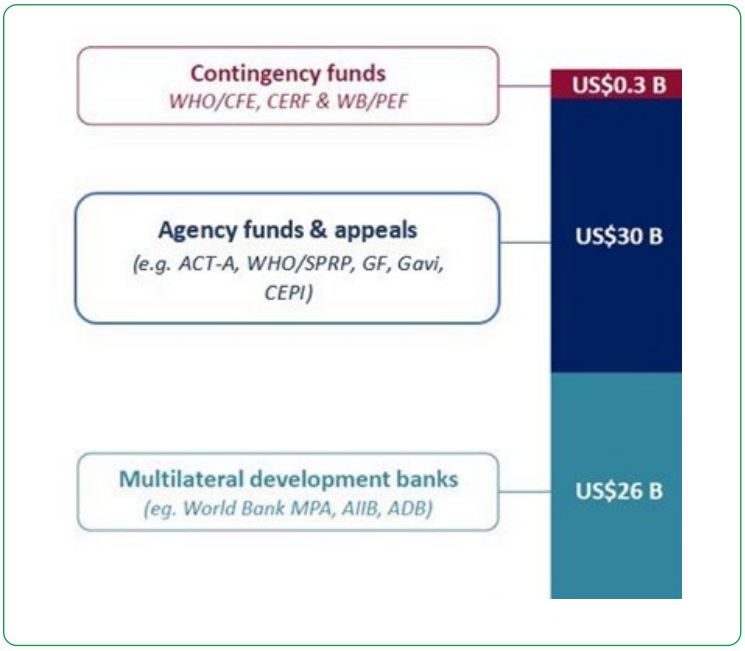


22. Source: WHO assessments/analysis.

23. Source: WHO assessments/analysis.

Contingency financing which enables countries to respond to emergencies and pandemics also saw significant growth during the COVID-19 pandemic (Figure 5). This experience demonstrated that more than US$ 30 billion in surge finance is needed to facilitate emergency response at national and global levels. A large proportion of this financing is needed to ensure the procurement and equitable allocation of medical countermeasures (e.g., vaccines), to support research and development, and to surge the health workforce.

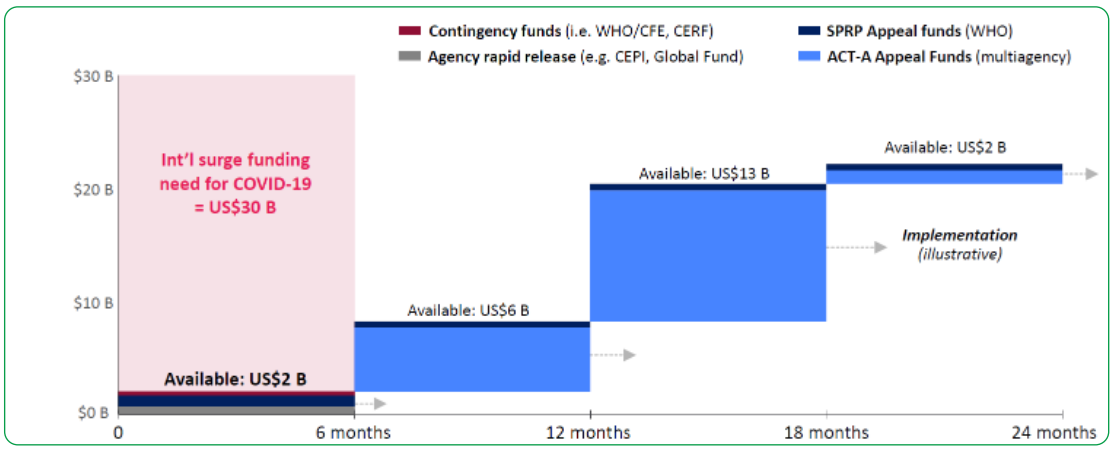
Figure 5. Indicative spending via multilateral agencies and banks for the COVID-19 response (US$ billion)[24]



However, the timeliness and efficiency of contingency financing are key to ensuring that emergency responses are robust. A timeline of the contingency financing made available during the COVID-19 pandemic suggests that most financing was made available more than 12 months into the pandemic which likely led to a suboptimal impact (Figure 6).

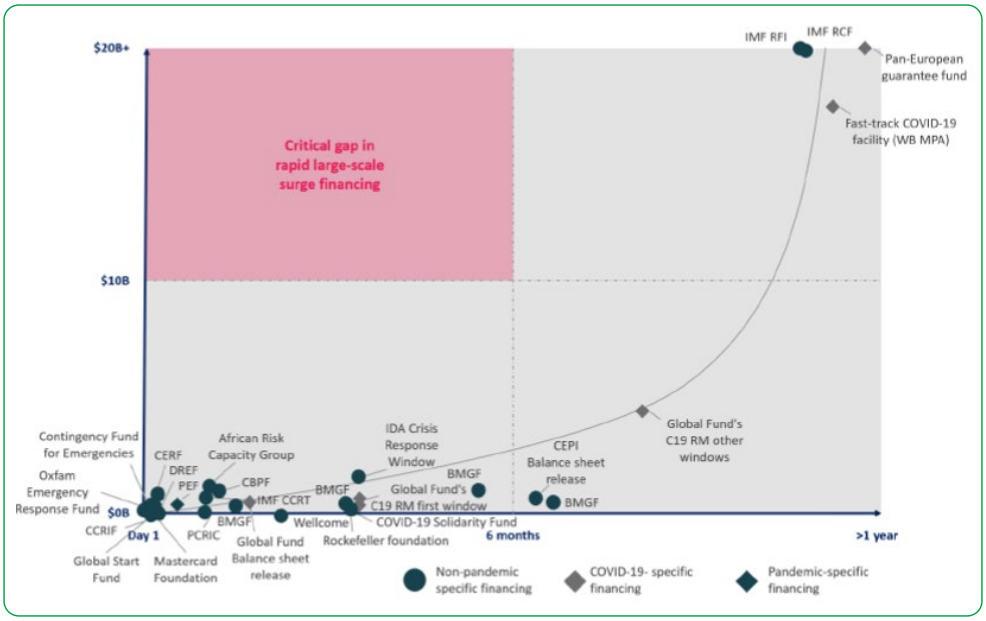
24. Source: WHO assessments/analysis.

Figure 6. Timeline of the contingency financing made available during the COVID-19 pandemic from the onset of the initial outbreak (US$ billion)[25]



A landscape analysis of potential financing mechanisms that were used during the COVID-19 pandemic and which could be used for future pandemics reveals that there is a critical gap with regards to rapid, large-scale surge financing (Figure 7).

Figure 7. Landscape analysis of potential financing mechanisms that were used during the first year of the COVID-19 pandemic and which could be used for future pandemics.[26] Note that not all mechanisms are plotted on this landscape analysis due to lack of data availability for some; release times are indicative based on case study examples.[27] Publicly available data was used to complete this landscape analysis.



25. Source: WHO assessments/analysis.

26. Noting the signing of first COVAX agreement in August 2020, and the advance purchase agreement by December 2020 for 2 billion doses.

27. Figure 7 is based on publicly available data. For certain actors such as the Global Fund and CEPI, it is the time of the balance sheet release.

To address this gap and ensure that sufficient and rapid contingency financing is available for the next pandemic, a number of issues have been identified:

1. A scale of response needed depending on the scenario is potentially estimated at US$ 30 billion released to support a response to a global pandemic.

2. To complement and establish other/additional financing sources to complement existing streams

3. SOPs for managing and reporting on surge funds by multilateral agencies

4. A pre-agreed approach to accelerate and coordinate existing funding streams including the establishment of a coordinating mechanism as part of the implementation of the amendments to the International Health Regulations (2005).

Previous modelling and scenario analysis did consider the impact of different mitigation strategies during a pandemic on schooling (see Table 7). The analytical modelling and scenario analyses indicated that the direct costs of scaling a response are significantly higher than enhancing preparedness. Not only is it costly to scale response measures during a pandemic, but it may also be slow or even impossible (e.g., scaling bed capacity will require substantial investments in infrastructure, supplies, training, and healthcare workers, all of which are likely to be in short supply and challenging to scale rapidly). However, social and economic protection costs (e.g., furlough schemes or efforts to ensure food security), may be lower when countries are able to scale response measures compared to when they only focus on enhancing preparedness. The early reduction or removal of PHSMs will also lead to lower social impacts such as disruptions to schooling and education and associated future economic impacts (outside the scope of this analysis). Enhancing response is expected to significantly reduce economic costs due to the lack of PHSMs which will minimize business closures and losses in productivity as well as fewer DALYs.

Table 7. Impact on health, social, and economic outcomes of different mitigation strategies for a virus with the same properties as the SARS-CoV-2 delta[28]

	Strategy	Total cost	YLLs Health impact	Education Social impact	GDP Economic impact
Low and lower middle income	No Closures	202	196	0	6
	School Closures	186	132	44	10
	Economic Closures	142	79	39	24
	Elimination	145	76	44	25
Upper middle income	No Closures	244	239	0	5
	School Closures	183	151	23	9
	Economic Closures	130	89	19	22
	Elimination	130	83	23	24
High income	No Closures	383	378	0	5
	School Closures	767	752	7	8
	Economic Closures	156	132	4	20
	Elimination	148	118	6	24

International systems and coordination

Strong international cooperation, including sharing critical information in a timely manner, and the allocation of critical medical supplies based on needs and demand can reduce the spread of a pandemic and its severe health, social and economic consequences. The speed of access to medical countermeasures requires both the successful development and production of supplies at the scale required and the access to finance to be able to contract and secure supply. The role of different stakeholders in these complex chains will be critical in understanding how to support more rapid deployment of medical countermeasures and fully assess the benefits of earlier access to effective medical countermeasures.

28. Source: WHO assessments/analysis.

V. CONCLUSION AND NEXT STEPS

Building on the updated analytical framework of the FEVR as well as the result of the economic and epidemiological modelling, the Global Report presents a final version of FEVR with 23 identified indicators. These indicators building on 16 in the first iteration of FEVR were refined based on the availability of reliable data sources, running a simulation exercise with the original model, and proposing a set of indicators in the Social Determinants of Health Policy Note. The Global Report takes the analysis further to propose various policies that can be implemented to reduce vulnerabilities and increase pandemic response capacity. While these recommended policies are evidence-based, it is crucial to consider country and regional specificities.

The FEVR model is not intended to make cross-country comparisons or to be binding to countries. Country-specific analysis will run upon country's request and in support of an international organisations if needed. Recognizing the countries' sovereignty over policy and investment decisions, the aim of applying FEVR with country-specific data as a diagnostic tool to identify vulnerabilities in order to plan for investment, facilitate evidence-based decision-making, and inform policy trade-offs to achieve value-for-money. Further work could include the following steps.

1. The FEVR can be operationalized by regularly analyzing vulnerabilities using the agreed indicators with the support of global and regional partners. The FEVR indicators can be utilized taking in consideration countries specificities with a potential support from global or regional partner to ensure awareness of existing and emerging vulnerabilities and how this can serve as a key diagnostic tool.

2. The FEVR can also be used to conduct stress tests at national, regional, and global levels to identify persistent gaps, inform planning, and guide evidence-based decision-making.

3. Further analysis and exploration of the trade-offs of specific policies will be important when considering prioritizing measures and investments to improve prevention and preparedness.

4. Further develop the indicators and potential policy measures which are focused on international collaboration and systems as well as social outcomes such as the scenario analysis of different mitigation strategies which considered the impact on education (Table 7).

Annex I. Methodology used to develop first iteration of the FEVR composed of 16 indicators

First, a broad scoping of the literature of existing health, social, and economic analysis frameworks related to pandemic preparedness, response, and resilience was undertaken to identify a long list of 72 indicators. This scoping included The European Investment Bank (EIB) COVID-19 Economic Vulnerability Index,[29] the Supporting Economic Transformation (SET) Economic Risks & Vulnerabilities to Health Pandemics,[30] Diop *et al*. COVID-19 Economic Vulnerability & Resilience Indexes,[31] the Global Preparedness Monitoring Board Monitoring Framework for Preparedness (GPMB),[32] the WHO health emergency prevention, preparedness, response, and resilience (HEPR) framework,[33] the WHO decision framework for sustaining lives and livelihoods during the COVID-19 pandemic,[34] A UN framework for the immediate socio-economic response to COVID-19,[35] and the Report for the G20 High Level Independent Panel on Financing the Global Commons for Pandemic Preparedness and Response.

In order to establish a relationship between the proposed indicators and pandemic outcomes, each indicator needed to be linked to a dataset covering at least 100 countries that is regularly updated and sufficiently detailed. Among the 72 indicators identified, only 35 indicators had an existing global database with a high coverage of countries, and recent data reflective of the pandemic period. While many members made suggestions for additional indicators, the availability of high-quality datasets was a key limitation for many of the proposed indicators. The indicators needed to also be relevant for all countries regardless of the level of development and income group. In addition, while other activity, such as seeking access to IMF financial assistance or World Bank programmes could also be considered to indicate economic vulnerability at the time of the pandemic, given the comprehensive nature, with over 90 countries accessing IMF financial assistance, this may provide little insight when considering economic vulnerability to future pandemic scenarios.

Next, a preliminary univariate analysis of the 35 candidate indicators across the domains of health system resilience and response capacity, macroeconomic stability, and social and economic protection was conducted. Of these, 16 indicators were strongly correlated with GDP per capita (PPP $), and GDP change between 2019-2020 driven by the COVID-19 pandemic the only past pandemic for which we have adequate data to explore this relationship.

Initial analysis of the indicators aimed to identify those correlated with GDP per capita and GDP per capita change (measured as percentage change) during the first year of the

29. The European Investment Bank COVID-19 Economic Vulnerability Index, August 2020; Link available here.

30. Economic vulnerabilities to health pandemics: Which countries are most vulnerable to the impact of coronavirus, February 2020; Link available here.

31. Diop, S., Asongu, S.A. and Nnanna, J. (2021), COVID-19 economic vulnerability and resilience indexes: Global evidence. International Social Science Journal, 71: 37-50. https://doi.org/10.1111/issj.12276

32. GPMB MONITORING FR AMEWORK FOR PREPAREDNESS Technical Framework and Methodology, Link available here.

33. https://www.who.int/publications/m/item/strengthening-the-global-architecture-for-health-emergency-prevention--preparedness--response-and-resilience/

34. https://www.who.int/publications/i/item/9789240017948

35. https://unsdg.un.org/resources/un-framework-immediate-socio-economic-response-covid-19

COVID-19 pandemic. GDP was measured in two ways, both in current US$ using purchasing power parity (PPP) exchange rate, and secondly in constant local currency units. Preliminary analysis of Pearson's correlation coefficient (r) was conducted for the 194 countries between their GDP per capita (current US$ in PPP, 2019) and change in GDP per capita (current US$ PPP, measured in %) between 2020 and 2019, with the 35 indicators. This initial analysis showed the relationship between the indicators, GDP per capita, and short-term GDP loss during the first year of the COVID-19 pandemic. The use of Pearson's correlation was based on the assumption that relationships are linear.

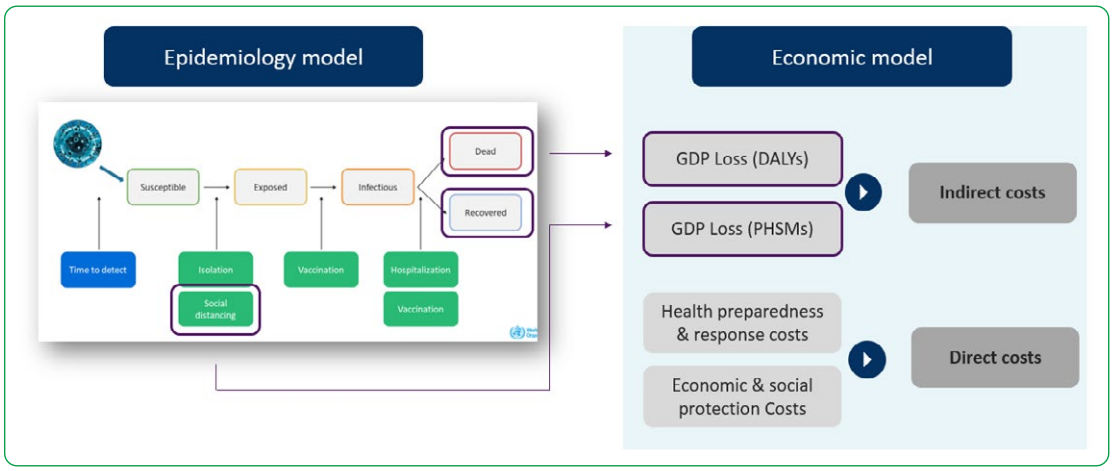
The analysis showed strong correlations between some indicators and GDP per capita as measured in PPP US$ and much lower correlations between *change* in GDP per capita. The use of local currency units was intended to remove distortion effects from currency exchange rates. However, the variation in the valuation of local currency units results in much weaker correlations.

Given these results, 16 indicators were selected for the first iteration of the FEVR which had strong correlations with GDP per capita or change in GDP per capita measured in PPP.

Annex II. Details on the analytical and model-based approach used to better understand the relationships between economic, health, and social vulnerabilities, determine relationships between vulnerabilities and outcomes, identify potential policy measures, and develop the final iteration of the FEVR

An **integrated economic-epidemiological model** was developed to simulate four scenarios based on different pandemic preparedness and response levels, in a COVID-19-like pandemic situation (Figure 8).

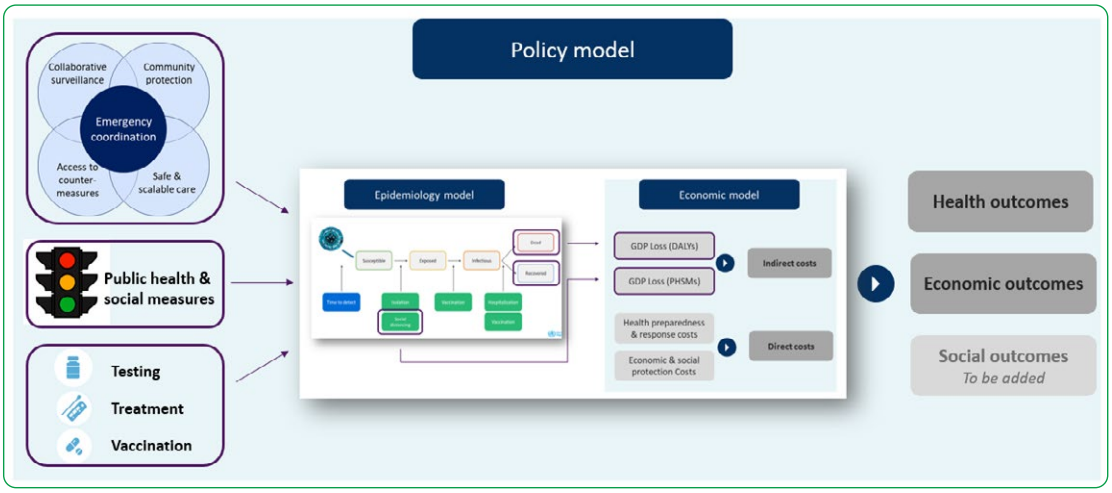
Figure 8. Integrated economic-epidemiological model[36]



In order to account for pandemic preparedness capacities and response capabilities for the scenarios, a **policy model** was developed (Figure 9). The preparedness capacities and response capabilities determined the adjustable input parameters for the economic-epidemiological model based on a causal pathway framework that was developed through a literature review and expert consultation. The levels of preparedness and response corresponded to quantified input parameters (levels 1 -5) based on existing literature and information (Table 8). The existing baseline and different levels of preparedness were represented by input parameters under categories of collaborative surveillance, community protection, safe & scalable care, access to countermeasures, and emergency coordination (Table 8). Response interventions were categorized by parameters relating to diagnostic capability and effectiveness and vaccination rate (Table 8). The associated costs were captured in the health preparedness and response costs as part of the short-term economic impact.

36. Source: Updated note on Framework for Economic Vulnerabilities and Risks (FEVR), June 2024.

Figure 9. A policy model was linked to the integrated economic-epidemiological model to understand how vulnerabilities and response measures influence health and economic outcomes in different pandemic scenarios[37]



This type of analytical model was chosen because it enables the integration of health, social, and economic outcomes, and the assessment of potential tradeoffs of different policies.

The epidemiological model was based on a standard SEIR (Susceptible, Exposed, Infected, and Recovered) model. The input parameters which were modeled and adjusted according to the levels of preparedness and response interventions in the different scenarios include timeliness of event detection, time and effectiveness of case isolation, contact rates among the population, time and rate of vaccination, and hospitalization rate and capacity (Table 8).

The **economic model** was responsive to the relevant input parameters and the outputs of the epidemiological model.

For the **direct economic costs**, the *health preparedness & response costs* included: (i) the estimated costs (per capita) associated with increasing preparedness capacity from the baseline level to the new level[38] (e.g., increasing surveillance from level 2 to 3 for a middle-income country was estimated to be $0.71 per capita); and (ii) the estimated costs (per capita) associated with scaling response capabilities[39] (e.g., increasing testing capacity to level 3 for a middle-income country was estimated to be $7.52 per capita). The **short-term economic impact** also encompassed the *economic & social protection costs* associated with the public health and social measures (PHSM)[40] that were applied in each scenario, including to facilitate social distancing, one of the adjustable input parameters for the epidemiological model (in green in Figures 8 and 9 above).

37. Source: Updated note on Framework for Economic Vulnerabilities and Risks (FEVR), June 2024.

38. Estimated cost per capita to increase preparedness capacity by country income group.

39. Health response costing including the estimated procurement and delivery costs per unit for diagnostics (PCR tests) and vaccines by country income group.

40. The estimated economic & social protection costs calculation was: (stringency & duration of PHSMs) X (the average social protection & fiscal response costs incurred by country by income group (as % of GDP) during the COVID-19 pandemic).

The **indirect economic costs** included the *GDP loss associated with the PHSMs*[41] that were applied in each scenario. The stringency and duration of the PHSMs determined these estimated costs. The **indirect economic costs** also included the *GDP loss calculated from years of life lost due to mortality and disability,* i.e., DALYs,[42] which was based on the epidemiological model outputs (the number of people who were infected and either recovered or died).

Table 8. The input parameters and values from the policy model used for the different pandemic scenarios that were simulated[43]

Area	Sub-area	Input parameter	Value of input parameter for levels 1-5				
			1	2	3	4	5
Health emergency preparedness capacity[43]	Surveillance	Time to detect first case or new variants (days)	150	120	90	60	30
		Time to isolation (hours)	96	72	48	24	0
	Community engagement and trust	Adherence to isolation (%)	29	47	65	83	100
	Health services and care	Hospital bed capacity (per 100k population)	0	123	237	322	504
	Access to medical countermeasures	Delay in start of vaccination given Vx availability (days)	118	88	64	36	12
	Emergency response management and coordination	Delay in implementing response measures (days)	52	39	26	13	0
Response interventions	Diagnostics (DX)	Effectiveness of isolation (%)	0	27	41	49	59
	Vaccination (VX)	Vaccination rate (per 100k population per day)	50	137	223	320	438
Public health & social measures (PHSM)	Social distancing	Reduction in contact rates by setting (%): home, school and work	6 10 8	13 21 17	31 52 42	56 94 75	63 100 83

Multiple **pandemic scenarios** were simulated using the economic-epidemiological model and inputs from the policy model. The pandemic scenarios also utilized specific parameters for the **country archetype profiles** and **pathogen characteristics** (Table 10). A pathogen similar to SARS-CoV-2 was used for the simulated pandemic scenarios due to the high availability of data and literature from the COVID-19 pandemic that could be used for the pathogen

41. The estimated GDP loss associated with the PHSMs calculation was: (Containment index) X (Tourism as % of GDP) X (Trade as % of GDP) X (Natural resources as % of GDP).

42. The estimated GDP loss associated with years of life lost due to mortality and disability (DALYs) calculation was: (Years of life lost due mortality (YLLs)) X (Years of life lost due to disability (YLDs)) X (Life Expectancy) X (Ratio of Value of Statistical Life (VSL) to GDP Per Capita).

43. Source: Updated note on Framework for Economic Vulnerabilities and Risks (FEVR), June 2024.

44. Based on the system capabilities defined in the paper on Strengthening the global architecture for health emergency prevention, preparedness, response and resilience (May 2023): https://www.who.int/publications/m/item/strengthening-the-global-architecture-for-health-emergency-prevention--preparedness--response-and-resilience/

characteristics, other input parameters, and estimated costs. Four pandemic scenarios were explored in detail during the April 2024 simulation exercise and paper (Table 9).

- **Scenario 1: Baseline**. Based on existing global data, a standard level 2 in preparedness capacity was used.
- **Scenario 2: Enhanced preparedness** (increasing preparedness from level 2 to level 4). This scenario is characterized by improved health emergency preparedness capacity (e.g., improving the detection time of the first case in a country from 120 to 60 days).
- **Scenario 3: Enhanced response** (increasing response from level 2 to level 4). This is characterized by scaling response capabilities (e.g., increasing the effectiveness of isolation from 27% to 41% due to an increased availability and use of diagnostic testing enabling people to isolate more efficiently and effectively).
- **Scenario 4: Enhanced preparedness & response** (increasing both preparedness and response from level 2 to level 4, i.e., the combination of improvement as captured by the input parameters used in scenarios 2 and 3).

Table 9. Input parameters used to simulate four pandemic scenarios[45]

Input parameters	Scenario 1: Baseline	Scenario 2: Enhanced preparedness	Scenario 3: Enhanced response	Scenario 4: Enhanced preparedness and response
Preparedness level (level 1 to 5)	Level 2	Level 4	Level 2	Level 4
Time to vaccination (days)	300 days	300 days	150 days	150 days
Contingency financing (days)	> 30 days	> 30 days	< 30 days	< 30 days
Application of public health & social measures (level 1 to 5)	Level 2 for 190 days	Level 1 for 190 days	None	None
Time to detect first case (days)	> 30 days	> 30 days	< 30 days	< 30 days
Isolation effectiveness	0.27%	0.41%	0.27%	0.41%
Hospital bed capacity (per 10K population)	121	320	121	320

45. Source: WHO assessments/analysis.

Table 10. Input parameters for the pathogen characteristics used to simulate four pandemic scenarios[46]

Key pathogen characteristics based on SARS-CoV-2	Value
Reproduction rate (R0)	3
Mean generation time (days)	10
Mean incubation period (days)	6
Relative infectiousness of pre-symptomatic cases to symptomatic cases	0.25
Proportion of cases that eventually develop symptoms	0.8

The health outcomes and economic outcomes, including both direct and indirect costs, for the four pandemic scenarios were derived from the integrated economic-epidemiological model.

Health outcomes (Table 11):

- **Scenario 2: Enhanced preparedness capacities** (as identified in the parameters in Table 9 from level 2 to level 4) contributes to a 50% reduction in the estimated number of deaths.
- **Scenario 3: Enhanced response capabilities** (as identified in Table 9 from level 2 to level 4) contributes to a 74% reduction in the estimated number of deaths.
- **Scenario 4: Enhanced preparedness capacities and response capabilities** (the full range of improvement from level 2 to level 4 in all the categories identified in Table 9) contributes to a 97% reduction in the estimated number of deaths.

Economic outcomes (Table 11):

- **Scenario 2: Enhanced preparedness capacities** requires investments before the pandemic which results in higher preparedness costs but lower economic and social protection costs because the PHSMs that are applied are less stringent (as indicated in Table 1 so from level 1 instead of level 2 for 190 days i.e. impact from social distancing policies in reducing contact rates by the following percentages: at home (from 6% to 13%), school (10% up to 21% and work (from 8% to 17%)). This results in *a 41% reduction in the estimated short term fiscal impact*. Increasing preparedness results in a reduction in the broader economic and social costs from the application of PHSMs (due to less stringent measures being applied) and the economic costs associated with DALYs (due to fewer cases and deaths). This results in a *52% reduction in the estimated indirect economic costs.*
- **Scenario 3: Enhanced response capabilities** requires investments to scale the response to the pandemic; however, the economic and social protection costs are eliminated because PHSMs are not necessary as hospital capacity is not

46. Source: WHO assessments/analysis.

being reached/exceeded. This is a result of the response significantly improving detection and an earlier and more rapid vaccination rate. This results in an *86% reduction in the estimated short-term economic costs*. Enhanced response results in the elimination of economic costs from the application of PHSMs (due to them not being applied) and a reduction in the GDP losses associated with DALYs (due to fewer cases and deaths). This results in a *92% reduction in the estimated indirect economic costs.*

- **Scenario 4: Enhanced preparedness capacities and response capabilities** requires investments in preparedness and response; however, the economic and social protection costs are once again eliminated because PHSMs are not required as hospital capacity is not breached. This results in an *84% reduction in the estimated short-term economic costs*. Enhanced preparedness and response results in the elimination of broader economic and social costs from the application of PHSMs (due to them not being applied) and a significant reduction in the economic costs associated with DALYs (due to fewer cases and deaths). This results in a *99% reduction in the estimated indirect economic costs.*

Table 11. Summary of the health and economic outcomes for the four pandemic scenarios which were modelled[47]

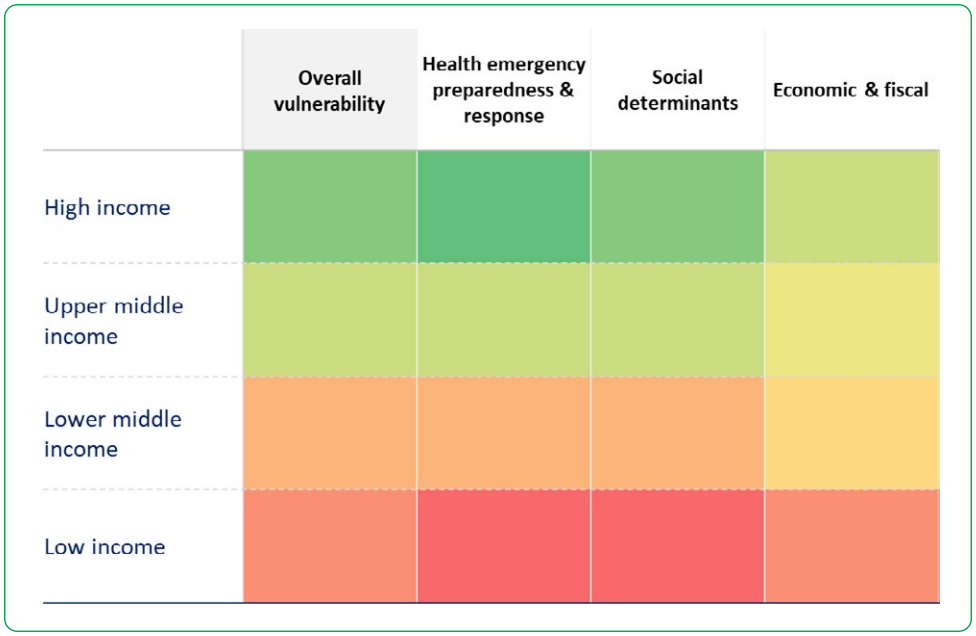
	Scenario 1: Baseline	Scenario 2: Enhanced preparedness	Scenario 3: Enhanced response	Scenario 4: Enhanced preparedness and response
% Change in number of deaths compared to baseline (scenario 1)		-51%	-74%	-97%
% Change in total direct economic costs compared to baseline (scenario 1)		-41%	-86%	-84%
% Change in total indirect economic costs compared to baseline (scenario 1)		-52%	-95%	-99%

47. Source: WHO assessments/analysis.

ANNEX III. Previous application of the 16 indicators of FEVR

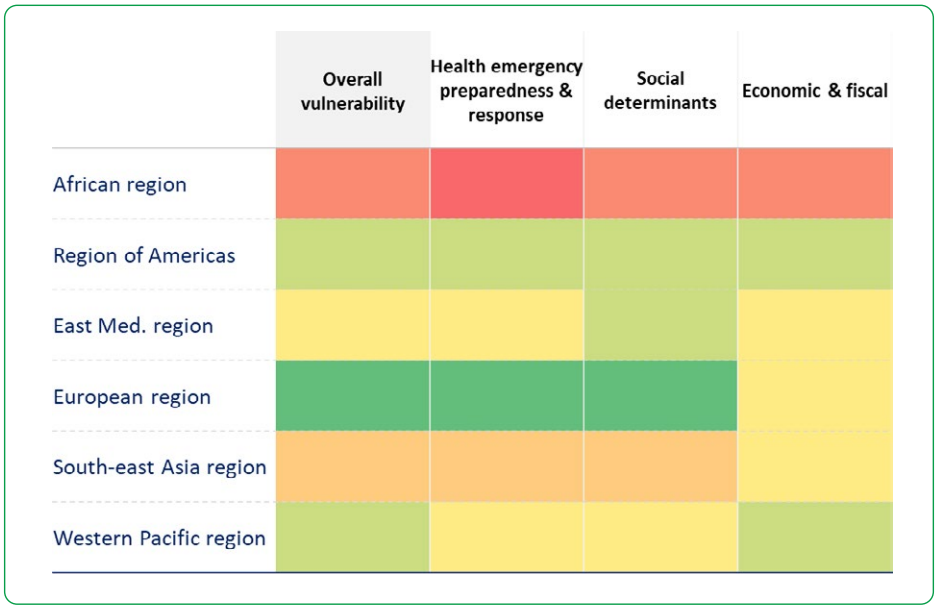
The 16 indicators of the first version of the FEVR were applied to assess health, social, and economic vulnerabilities globally1. Within each domain, indicators were ranked by decile, and a simple average was used to score the domain, with all indicators equally weighted within each domain. The analysis indicates that health, social, and economic vulnerabilities vary by income level (Figure 10) and region (Figure 11). Low-income countries and countries in the African region are assessed to be most vulnerable. Perhaps unsurprisingly, vulnerabilities increase as income level decreases, and the WHO African Region, which consists of the highest number of low-income countries, also faces the greatest vulnerabilities. It is important to note that these data are presented based on a relative scale, meaning that the countries with the lowest vulnerability to a pandemic (e.g., high-income countries) may still suffer a significant shock across all domains during a pandemic, particularly if response measures are not appropriately scaled or if international coordination and information sharing is ineffective.

Figure 10. Summary of the health, economic, and social vulnerabilities by income level. Vulnerabilities are presented as a heatmap, with the darkest green showing the lowest level of vulnerability, and red indicating the highest level of vulnerability. Colors in between are on a sliding scale. Based on the initial 16 indicators from August 2023[48]



48. Source: Initial analysis on economic vulnerabilities and risks to pandemics and potential policy measures (June 2023), a briefing to support discussion at the 3rd JFHTF meeting. Developed by WHO in consultation with WB, IMF and EIB.

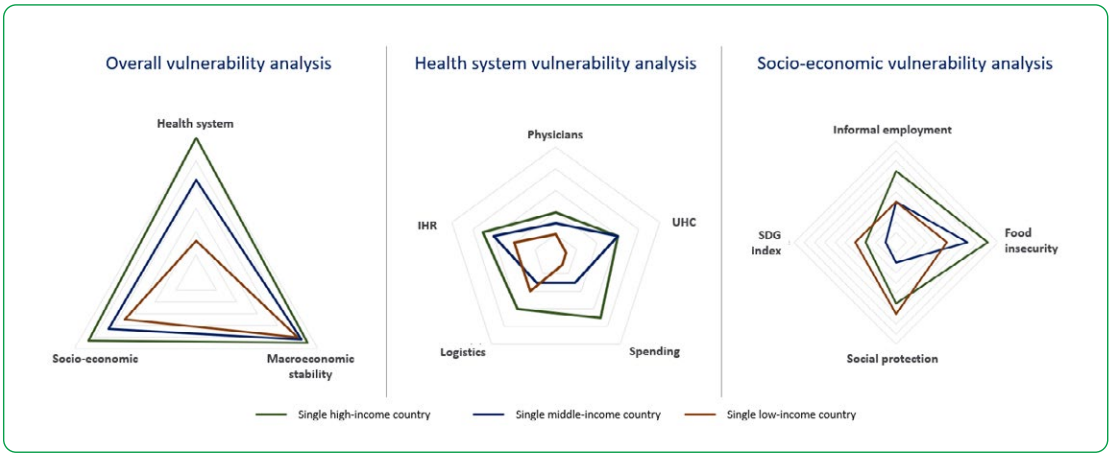
Figure 11. Summary of the health, economic, and social vulnerabilities by region. Vulnerabilities are presented as a heatmap, with the darkest green showing the lowest level of vulnerability, and red indicating the highest level of vulnerability. Colors in between are on a sliding scale. Based on the initial 16 indicators from August 2023[49]



To inform investments, it can be useful to look at the variation in individual indicators *within* a domain (e.g., health), to understand vulnerabilities within a country, and to focus on the change in vulnerability over time as a measure of increasing resilience to pandemics. For three archetype countries (one each of high, middle- and low-income groups) vulnerability profiles are presented (Figure 12). For comparisons of individual indicators within a domain, these are scored based on the decile ranking, with a high score denoting low vulnerability, and a low score denoting high vulnerability.

49. Source: Initial analysis on economic vulnerabilities and risks to pandemics and potential policy measures (June 2023), a briefing to support discussion at the 3rd JFHTF meeting. Developed by WHO in consultation with WB, IMF and EIB.

Figure 12. Vulnerability profiles for three archetype countries. Higher scores represent lower vulnerability. Illustrative country examples[50]



In line with the income-group level vulnerability levels (Figure 10), the high-income country (dark green lines in Figure 12) and middle-income country (dark blue lines in Figure 12) face the lowest relative vulnerabilities, while the low-income country (dark red lines in Figure 12) faces much higher vulnerabilities across all domains. Delving into the vulnerability profiles for specific domains with a focus on select indicators can inform policymaking and investments. For example, when looking at the **health system vulnerability** profiles (center panel in Figure 12), although the high-income country faces overall lower vulnerabilities, this country should increase the number of physicians in order to further reduce vulnerabilities and ensure patients receive timely and quality healthcare during a pandemic (Table 4). Conversely, for the middle-income country, universal health coverage (UHC) is relatively strong, but the country should focus on enhancing logistics capacity to ensure essential supplies and support can be delivered during a pandemic. The low-income country shown has comparably the highest vulnerabilities in health and needs to strengthen all indicators except for logistics capacity. The **socio-economic vulnerability profiles** (right panel in Figure 12) suggest that both the high- and middle-income countries need to focus attention on strengthening social protection capacity and services in order to address existing vulnerabilities.

50. Source: WHO assessments/analysis.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