



Health systems resilience in managing the COVID-19 pandemic: lessons from 28 countries

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Health systems resilience is key to learning lessons from country responses to crises such as coronavirus disease 2019 (COVID-19). In this perspective, we review COVID-19 responses in 28 countries using a new health systems resilience framework. Through a combination of literature review, national government submissions and interviews with experts, we conducted a comparative analysis of national responses. We report on domains addressing governance and financing, health workforce, medical products and technologies, public health functions, health service delivery and community engagement to prevent and mitigate the spread of COVID-19. We then synthesize four salient elements that underlie highly effective national responses and offer recommendations toward strengthening health systems resilience globally.

COVID-19 has caused an unprecedented global crisis, including millions of lives lost, public health systems in shock and economic and social disruption, disproportionately affecting the most vulnerable. As of April 2021, there are over 140 million confirmed cases and over three million COVID-19 deaths globally¹. While vaccination has commenced in numerous countries, new outbreaks and variants continue to emerge. At the same time, the global distribution of vaccines is marred by challenges of equity on top of logistical complications. Millions more are therefore still at risk of dying, facing significant morbidity or losing their livelihoods given the uncertain economic outlook.

The pandemic has challenged local, national, regional and global capacities to prepare and respond. The various national strategies taken to control viral transmission are widely debated^{2,3}. However, the relative success of these strategies depends largely on how an existing health system is organized, governed and financed across all levels in a coordinated manner⁴. The pandemic has exposed the limitations of many health systems, including some that have been previously classified as high performing and resilient⁵. A comprehensive analysis of the resilience of health systems during the pandemic can therefore pinpoint important lessons and help strengthen countries' preparedness, response and approach to future health challenges.

While resilience is a core concept in disaster risk reduction, its application to health systems is relatively new. It has been defined broadly as institutions' and health actors' capacities to prepare for, recover from and absorb shocks, while maintaining core functions and serving the ongoing and acute care needs of their communities^{6,7}. During a crisis, a resilient health system is able to effectively adapt in response to dynamic situations and reduce vulnerability across and beyond the system. Experience from previous epidemics, such as Ebola, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome, emphasized the links between resilience and thwarting new outbreak transmission⁸.

Health systems resilience literature stresses that efforts should focus not only on absorbing unforeseen shocks precipitated by emerging health needs, but also on ensuring continuity in health improvement, sustaining gains in systems functioning and fostering people centeredness, while delivering high-quality care^{9,10}. As COVID-19 has overwhelmed health systems worldwide, debates around resilience have become more urgent, and there is a need to better understand the elements of national responses through a resilience lens^{11,12}. Thus, in this perspective, we use an expanded health systems resilience framework centered on community engagement to examine 28 national responses to COVID-19. This analysis provides insights into the policies countries implemented and how these were implemented to tackle the pandemic.

Conceptual framework. Our conceptual framework (Fig. 1) is grounded in the World Health Organization's (WHO) health systems framework¹³. We develop the framework elements by adding public health functions, including testing, contact tracing, disease surveillance and non-pharmaceutical public health interventions, which often operate separately from health service delivery. Yet, they are critical both to pandemic responses and to ongoing population health. Similarly, health information systems are vital functions for both public health and health systems as, ideally, they should be integrated to capture data at individual, health system and population levels.

We centered our analysis on community engagement as core to all elements of health systems resilience (see Box 1 for more information on the analytical approach). To serve communities in a more equitable manner and promote healthy societies, resilience must be developed with these communities and according to their needs. There can be no health systems resilience without community engagement across domains¹⁴. We also acknowledge the critical role of coordination with non-health sectors as essential to providing necessary supports to address the social determinants

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Fig. 1 | Determinants of health systems resilience framework. The scheme illustrates the components of the resilient health systems framework we developed based on the WHO's health systems building blocks framework. The five elements of resilient health systems are centered around community engagement as core to all elements of health systems resilience.

of health. Underpinning these elements are health equity and outcomes. Resilient health systems should aim to generate positive physical and mental health outcomes for all, including vulnerable and marginalized groups. In many countries, COVID-19 mortality rates have been disproportionately higher among older populations, minority ethnic groups, socioeconomically deprived populations and low-wage and migrant workers, emphasizing the interconnectivity between equity and health outcomes¹⁵.

COVID-19 responses in 28 countries

Using our framework, we organized our results beginning with domains often viewed as external to health, which are nevertheless central determinants of health systems resilience—governance, finance, collaboration across sectors and community engagement—before exploring domains more closely associated with traditional views of health and health systems—health service delivery, health workforce, medical products and technologies and public health functions. We offer illustrative examples of selected countries for each domain in Tables 1–6. We analyzed 28 countries based on a purposive selection, including positive and negative outliers in relation to reported COVID-19 deaths per capita among highly populous countries, as well as a selection of countries in the middle ground (as of 6 November 2020). Figure 2 provides an overview of countries in our review.

Governance, finance and collaboration across sectors. COVID-19 has made policymakers and the wider public acutely aware of the relationship between health systems, domestic economies and governance. Government decisions determine healthcare infrastructures, regulations and guidelines, defining access to medication and treatment, the provision of health coverage and the financing of these. Government responses to COVID-19, in the immediate term, have meant the difference between lockdown or business as usual, and have eroded or increased public trust. In the longer term, they have shaped national choices regarding private healthcare or

Box 1 | Analytical approach

The analysis presented in this review is based on a purposive selection of countries including positive and negative outliers in relation to reported COVID-19 deaths per capita among highly populous countries, as well as a selection of countries in the middle ground from different regions and with widely varying health systems and economic status. Figure 2 provides an overview of countries in our review. Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. Given the dynamic and continuously changing situation, the ranking of positive and negative outliers in terms of death per capita may have changed during the pandemic. The analysis is thus limited to this specific time period.

Five complementary methods were adopted to analyze national responses to COVID-19:

1. **Literature review:** using standardized methods, we identified peer-reviewed papers and public reports that examined national and subnational policy responses and extracted data for each country on five dimensions comprising 62 items. The dimensions and items were identified through a review of 14 existent frameworks.
2. **Semi-structured interviews and national government submissions:** to supplement the literature review, we asked the selected countries and country experts a set of questions related to the measures implemented to contain COVID-19 in their respective countries. A total of 45 interviews and written submissions were provided. Semi-structured interviews with COVID-19 national experts at the policy, operational and academic levels were recorded and transcribed in full. All interviews were coded through an inductive approach and thematic analysis, using QSR NVivo 12 software, drawing on techniques of the constant comparison method.
3. **In-depth case studies** of 6 countries to validate the data from the 28 countries.
4. **Expert validation of country-specific data** with country experts. Experts in countries were provided with the specific data for each of their respective countries to validate the data.
5. **Expert validation through roundtable discussions** with country experts. A total of 35 national and international experts in COVID-19 policies participated in two roundtable discussions.

universal health coverage (UHC) and strengthened or impoverished social safety nets that underpin health and well-being.

Overall, COVID-19 responses saw health policy moving beyond the remit of Ministries of Health and in doing so, draw on expertise from other ministries, particularly during the early response. Countries took whole-of-government approaches to strengthen health systems in response to COVID-19, particularly those with experience of other health-related disasters, such as Ebola. These decisions were, in most countries, made by translating evidence-based research into policies that preserve health system capacity, while protecting both public health and livelihoods. As such, most countries established temporary COVID-19 advisory groups to inform government decisions. However, in the majority of countries, the views represented on these committees were largely biomedical. More information on national responses from a governance and leadership perspective is available (V.H., A.-S.J., R. Neill, S.W. and M. Jamieson, unpublished data).

The COVID-19 response requires testing, treatment and vaccines to be financed with either a portion or all of these costs

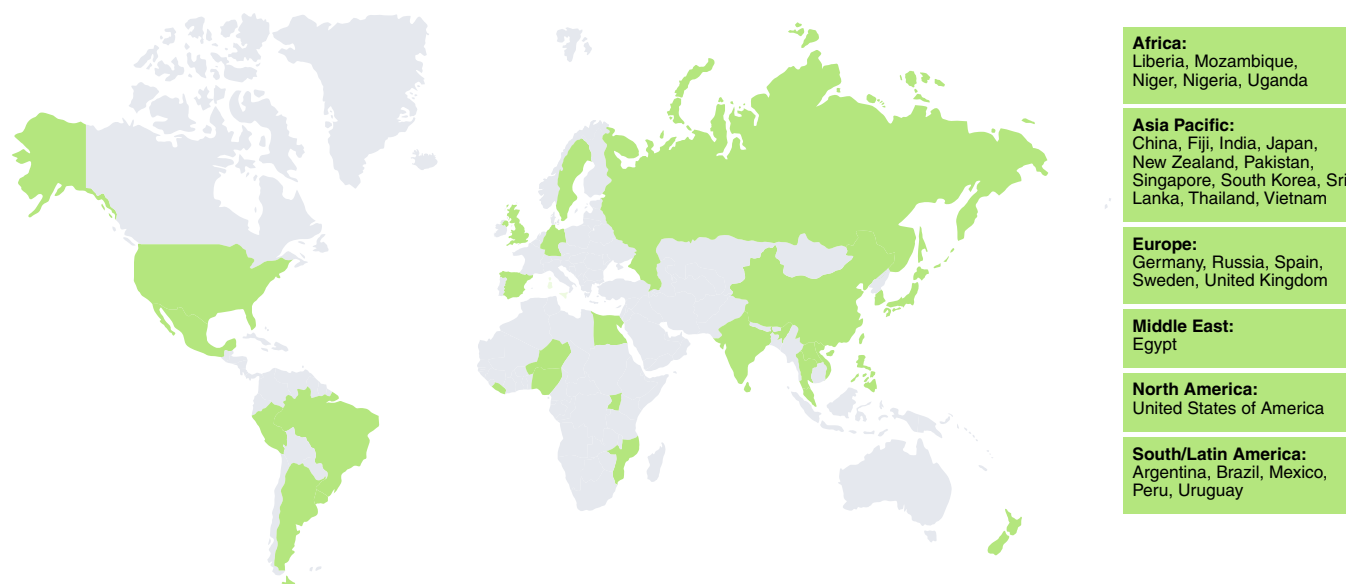


Fig. 2 | Countries included in the review. The map presents an overview of countries selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. Countries are listed according to region and in alphabetical order.

coming from public funds, and depends on healthcare infrastructures, workforce and supplies to provide much-needed surge capacity within health systems. Additionally, fiscal support measures, including relief packages aiming at helping businesses stay viable, protect jobs or provide financial aid to low-income households and the unemployed have been taken by many countries. These policies support people to adhere to public health guidance, with the aim of preventing infections, in turn mitigating the strain on the health system resulting from the need to deliver high-intensity COVID-19 care. To further enhance the reach of health services, many countries reviewed took specific actions to mitigate potential financial and physical barriers to care, such as covering part or all of the costs of COVID-19 care, and funding the establishment of testing and treatment centers in communities¹⁶. Importantly, the outcomes resulting from financial expenditures on health and well-being are only as good as the structures that support them. Thus, they require governance expertise across levels, sectors and domains and depend on a system's ability to reach (vulnerable) populations.

Community engagement. Deep engagement with local communities is central to resilient health systems as a way to inform service delivery, decision-making and governance and to meet the needs of communities before, during and after crises. Community engagement strategies, such as building partnerships with local leaders and working alongside community members to tailor messages and campaigns are crucial during public health emergencies¹⁷. The range of non-pharmaceutical public health interventions employed in response to COVID-19, such as mask wearing and social distancing, rely on shared values and a sense of social responsibility within communities to break chains of viral transmission¹⁸.

Several countries reviewed engaged networks of community health workers (CHWs) to encourage active community participation in COVID-19 responses. Their roles range from creating awareness through door-to-door visits, supporting contact tracing efforts, maintaining essential health services, providing necessary medication to patients without COVID-19, surveillance or monitoring adherence to quarantine measures and assessing mental well-being¹⁹. They are also key to identifying and referring patients who face barriers to accessing healthcare services. For example, Thailand deployed over 1 million CHWs to disseminate and amplify messages widely in communities. Singapore deployed

volunteers to educate seniors and help distribute daily necessities. Liberia further empowered community leaders by providing orientation on COVID-19 epidemiology to support containment efforts. However, many of these efforts depended on volunteers.

During early response efforts, a few countries conducted surveys to understand public sentiment regarding evolving measures. Japan conducted a survey in April 2020 to understand compliance with social distancing measures, using the results to inform response strategies. Governments also started multilingual hotlines to ensure comprehensive access to COVID-19 information. Other countries used social media platforms to engage communities. For example, the #TakeResponsibility campaign in Nigeria called on citizens to join forces and be proactive in taking greater individual and collective responsibility in controlling the spread of COVID-19²⁰.

Health service delivery. Health systems globally have employed three common approaches to rapidly scale up health system infrastructure, namely by constructing new treatment facilities, converting public venues and reconfiguring existing medical facilities to provide care for patients with COVID-19. Thus, some of the health systems reviewed invested significant resources into rapidly creating dedicated field facilities. For example, in early 2020, China established two specialty field hospitals in under 2 weeks²¹. Where field hospitals were set up to house patients with COVID-19, countries often drew on their armed forces and military field hospital models, or adapted existing large public facilities. However, most health systems relied on a less resource-intensive approach that modified traditional healthcare facilities into dedicated COVID-19 care centers²². Other health systems relied on home care for patients with mild to moderate COVID-19, with facilities available if patients were unable to safely self-isolate within their homes. Additionally, the majority of reviewed countries canceled elective surgeries in an effort to ensure system capacity for COVID-19 care.

In many health systems, primary-care providers are the front-line of the health system providing continuous, coordinated and people-centered care. Primary care is an important point of COVID-19 triage, as well as the point at which most routine and acute care services are provided within communities²³. In many of the countries reviewed, primary-care providers rapidly adopted and scaled up digital technology or telehealth services to provide ongoing and acute care while also triaging and referring persons with

Table 1 | Examples of governance and financing approaches

Subdomain	Snapshot of health systems resilience measures in reviewed countries		Countries in the middle category in terms of deaths per 100,000 population
	Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million	
Governance approach	<p>China: established top-down governance structures to reach across all levels within the government and created a whole-of-government approach. The State Council established a Joint Prevention and Control Mechanism. It is a platform for communication, collaboration and mobilization of resources between 32 different ministries and departments. It consists of workgroups responsible for COVID-19 control, medical treatment, research, education, logistics and frontline workers. At local levels, emergency response leading groups, headed by local government leaders, were established in provinces, cities and counties across the country. The local emergency response leading groups are responsible for implementing the central government's policies and control strategies, thus forming a top-down system.</p> <p>Mozambique: opted for a multi-sectoral, whole-of-government approach. The Ministry of Health established an Emergency Commission to ensure effective coordination of COVID-19 prevention and response through the efforts of nine Technical Working Groups co-led by Ministry of Health staff and development partners. The Government's disaster agency (INGC) and the Ministry of Economy and Finance are currently working with line ministries to identify the needs and priority measures to be implemented. Aligned with this, the Humanitarian Country Team, led by the resident coordinator and composed of UN agencies, NGOs, Red Cross and donor representatives, is developing a response plan to COVID-19, focusing on sector-specific impacts of COVID-19.</p>	<p>Peru: despite political instability, there was an emphasis on multi-sectoral action in the pandemic response. In the early stages (end of March 2020), the president convened a teleconference between regional health governors together with the Minister of the Interior, the Minister of Health and the Minister of Agriculture, who each presented the plans of their sectors and the measures that were adopted to guarantee security and food supply.</p> <p>Mexico: the Ministry of Health initiated a national meeting of state governors and health authorities to coordinate efforts to respond to COVID-19. During the meeting, state authorities agreed to participate in working groups to learn firsthand the national situation, updates and the decisions made to address each step of the pandemic. It was also agreed that local and municipal governments will be involved and will collaborate on communicating cases, incidents and necessary actions.</p>	<p>Germany: a whole-of-government approach was adopted. At the national level, the central government convenes weekly as the 'Small Corona Cabinet'. It consists of the Chancellor and various ministries. Additionally, the government convenes on a weekly basis in the 'Large Corona Cabinet'. Besides the members of the small cabinet, ministers from specific ministries, depending on issues discussed, are invited to join.</p> <p>Japan: set up the coronavirus task force, consisting of diverse medical experts (virology, infectious disease, molecular genetics, genomic medicine and computational science) and includes 36 high-ranking bureaucrats from several ministries. The headquarters acts as the site of the prime minister's decision-making process on the country's virus countermeasures.</p>
Coordination with scientific advice	<p>Uruguay: in June, an Honorary Scientific Advisory Group (GACH) was formed, which included a broader and more diverse group of expertise, including socioeconomic, than the previous committee formed in March. As of June 2020, this group comprised 55 members and holds weekly meetings with subgroups, makes biweekly reports to the Transition group, holds special meetings with the president and has daily contact with the government: all the announced measures have the support of scientists on the GACH.</p> <p>Uganda: CDC Uganda provides technical input to the Uganda Ministry of Health. For example, Emergency Operations Center set up a national task force to prepare for the COVID-19 pandemic before the first cases were detected. CDC support for influenza surveillance at the Uganda Virus Research Institute is proving critical in the COVID-19 response. The Ugandan government drafted researchers into a COVID-19 scientific committee to inform the country's prevention and treatment strategy for the pandemic after cases were reported in East Africa. This committee has been at the center of Uganda's COVID-19 response, drafting local measures and guidelines for the prevention and treatment.</p> <p>Argentina: the government created a special government unit to respond to the COVID-19 pandemic. The unit's main task is to advise the Presidency and the Ministry of Health on matters regarding available human resources and infrastructure. In addition, The Ministry of Health of Argentina has jointly coordinated the pandemic response together with provincial ministries of health within the Federal Health Council (COFESA) and the following groups of experts: National Immunization Commission, National Advisory Committee on Research Ethics and National Commission on Vaccine Safety, among others.</p> <p>Spain: the government has appointed highly recognized clinical experts and epidemiological scientists as members of the COVID-19 Scientific and Technical Committee to provide advice to the government and inform policymaking. The Ministry of Health, through the Centre for the Coordination of Health Alerts and Emergencies (CAEAES, in Spanish), activated the COVID-19 protocol and coordinates the response with the departments of health in Spain's 17 autonomous communities. To design the exit strategy plan and the vaccination strategy, a group of multidisciplinary experts were appointed to produce the reports.</p> <p>South Korea: the Korea Disease Control and Prevention Agency has the leading role in the country's response to COVID-19. The COVID-19 Response Strategy Consultation Committee convenes on a regular basis to discuss government response strategies and areas for improvement. The Korean government supports Korean researchers by providing data that were used for forecasting the spread of COVID-19 and the effectiveness of response measures, which aided in decision-making for infection control. The Korea Institute of Science and Technology (KIST) used a supercomputer and Individual Simulation for Transfer Phenomena, KIST's own modeling method, to analyze the effectiveness of disease control measures taken by the Korean government.</p> <p>New Zealand: epidemiologists, immunologists and public health experts advised on the risk the virus posed to the country and helped communicate the threat to the public and the government officials in charge of the response. The Ministry of Health brought some of these experts into a Technical Advisory Group, established as part of the Ministry of Health's response to COVID-19, which is chaired by the chief science advisor, Ministry of Health and comprises various health professionals (epidemiologist, pathologist, virologist, infectious disease physician, microbiologist, and public health officer). The group met twice weekly to provide updated advice to the Director-General of Health.</p>	<p>South Korea: the Korea Disease Control and Prevention Agency has the leading role in the country's response to COVID-19. The COVID-19 Response Strategy Consultation Committee convenes on a regular basis to discuss government response strategies and areas for improvement. The Korean government supports Korean researchers by providing data that were used for forecasting the spread of COVID-19 and the effectiveness of response measures, which aided in decision-making for infection control. The Korea Institute of Science and Technology (KIST) used a supercomputer and Individual Simulation for Transfer Phenomena, KIST's own modeling method, to analyze the effectiveness of disease control measures taken by the Korean government.</p>	

Continued

Table 1 | Examples of governance and financing approaches (continued)

Snapshot of health systems resilience measures in reviewed countries	
Subdomain	Countries in the middle category in terms of deaths per 100,000 population
	Countries with the least deaths per 100,000, with a population of over 20 million
Cost of COVID-19 treatment services	<p>Thailand: the government covers the cost of seeking COVID-19-related treatment services at all levels of care.</p> <p>China: the government covers all COVID-19 costs for all patients, including domestic migrants, a payment structure that is part of its 'wartime' governance.</p> <p>United Kingdom: residents of the United Kingdom need not pay for COVID-19-related treatment services. The free services are also extended to certain exemption categories of people such as those covered by the immigration health surcharge.</p> <p>Peru: cost of COVID-19 treatment was reduced to make it more accessible for the general public, after the government had struck an agreement with private healthcare providers to charge a lower fee for COVID-19-related services.</p> <p>Russia: the entire amount of medical care, including testing and treatment, is covered by the state insurance system. All assistance is provided to the population free of charge.</p>
Cost of diagnostic testing	<p>Sri Lanka: testing is provided free of charge at designated public hospitals.</p> <p>Uganda: cross-border cargo truck drivers, Ugandans returning from abroad, visitors arriving in the country and individuals and employers who want their staff tested are required to pay a fee for testing.</p> <p>United States: the federal government enacted The Families First Coronavirus Response Act, which provides funding for free coronavirus testing, 14-d paid leave for American workers affected by the pandemic and increased funding for food stamps.</p> <p>South Korea: free testing for all; initially, however, asymptomatic persons wishing to receive a COVID-19 diagnostic test on their own had to pay about 160,000 KRW/133 USD if their test results came back negative.</p> <p>New Zealand: COVID-19 tests are free of charge. This applies whether you have symptoms of COVID-19 or not, and regardless of your citizenship, immigration status, nationality or level of medical insurance coverage.</p>
Financial relief packages to individuals/households/businesses	<p>Niger: an updated crisis response plan has been presented to donors with an estimated cost of 18.4% of GDP, divided into an immediate health response and broader economic and social mitigation. Key elements include food distribution, free utilities to vulnerable households and temporary tax relief for hard-hit sectors. The Finance Ministry also announced credit support to the private sector in the form of loan guarantees. The revised cost includes large-scale support for agricultural production, revenue shortfalls and the building of liquidity buffers. An additional supplementary budget with 1.3% of GDP was also approved.</p> <p>Vietnam: the government introduced a fiscal support package valued at VND 291.7 trillion/USD 12.5 billion or 3.6% of GDP to support the economy. Measures include deferring payment of rent and taxes. The government also approved a cash transfer package for affected workers and households with monthly cash transfers provided for no more than 3 months, among others.</p> <p>United Kingdom: financial support includes: (1) additional funding for the NHS; public services and charities (GBP 48.5 billion/USD 66.6 billion); (2) measures to support businesses (GBP 29 billion GBP/USD 39.8 billion), including property tax holidays, direct grants for small firms and firms in the most-affected sectors and compensation for sick pay leave; and (3) strengthening the social safety net to support vulnerable people (by GBP 8 billion/USD 10.9 billion) by increasing payments under the Universal Credit scheme, as well as expanding other benefits. The government has launched three separate loans schemes to facilitate business access to credit. Self-employed and furloughed employees also received financial support to cover loss of wages, among others.</p> <p>Brazil: a series of fiscal measures adding up to 12% of GDP, of which the direct impact in the 2020 primary deficit is estimated at 8.4% of GDP. Congress declared a state of 'public calamity' on 20 March 2020, lifting the government's obligation to comply with the primary balance target in 2020. The fiscal measures included the expansion of health spending and temporary income support to vulnerable households, among others.</p> <p>Germany: the clause for exceptional circumstances in the debt break was triggered on 25 March 2020. This allows debt financing of a supplementary budget of EUR 156 billion/USD 185 billion or 4.5% of GDP to cover response measures. On 3 June 2020, an additional recovery package was agreed on of roughly EUR 130 billion/USD 154 billion or 3.8% of GDP for 2020 and 2021. Economic support for businesses and individuals during the second lockdown was also provided. Emergency loans were made available for self-employed workers and businesses, among others.</p> <p>Pakistan: the federal government announced a relief package worth PKR 1.2 trillion/USD 7.5 billion in March 2020. Key measures include cash transfers to 6.2 million daily-wage workers (PKR 75 billion/USD 4.9 million); cash transfers to more than 12 million low-income families (PKR 150 billion/USD 981 million); support to SMEs and the agriculture sector (PKR 100 billion/USD 654 million) in the form of power bill deferment, bank lending, as well as subsidies and tax incentives, among others.</p>

Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. CDC, Centers for Disease Control and Prevention; GDP, gross domestic product; NGO, nongovernmental organization; NHS, National Health Service. SME, small and medium-sized enterprise; UN, United Nations.

Table 2 | Examples of community engagement approaches

Subdomain		Snapshot of health systems resilience measures in reviewed countries	
Countries with the least deaths per 100,000, with a population of over 20 million		Countries with the most deaths per 100,000, with a population of over 20 million	
Involvement in providing essential services	<p>Thailand: VHV's assess mental well-being of people in the community and refer to care if needed. They also undertake health surveys, collect data and maintain family health records to support the public health authorities during the pandemic.</p>	<p>China: WeChat app was used to find volunteer drivers to assist people working in vital roles, like doctors and other healthcare workers.</p> <p>Brazil: in some communities, primary-care providers work with CHWs to conduct home visits, promote social distancing and continuity of health services for patients with chronic conditions in the community.</p>	<p>Spain: Red de Cuidados (Care Network) was set up for volunteers to link up with the most vulnerable groups to help out with everyday tasks such as buying and delivering medicines from pharmacies to their homes.</p> <p>Liberia: the government worked with Last Mile Health to augment the National Community Health Assistant Program by providing training to CHWs to ensure continuity of primary-care services and reduce transmission from known cases.</p>
Risk communication strategies for the community	<p>Uganda: the government engaged community members in COVID-19 hot spots to warn the public about the consequences of negative behaviors, given that fewer deaths and a lack of knowledge about asymptomatic cases led to reports of public complacency in adhering to public health measures.</p>	<p>Thailand: the government deployed over 1 million VHV's to disseminate and amplify messages widely in communities.</p> <p>Mexico: utilized an innovative way of storytelling by using characters from Sesame Street to explain how the virus spreads and teach prevention measures like practicing good hand hygiene and cough etiquette.</p>	<p>Russia: on social media, the Russian Ministry of Health launched a flash mob #ОборонаОтКороны (#DefenceFromCorona), which was supported by celebrities. The essence of the flash mob was to appeal to the citizens of the Russian Federation to adhere to the personal hygiene rules and to observe preventive measures during the spread of COVID-19.</p> <p>Egypt: the government has set up a communication center (website) where COVID-19 information is publicly available, including infographics on how to stop the spread of the virus and protect people. The government also provided a hotline for COVID-19 and a WhatsApp number to answer questions.</p>
Government providing a channel for feedback on national strategies	<p>Thailand: online survey to monitor perception toward information, misinformation and knowledge, attitude and behavior of residents regarding COVID-19 and assessing communication capacity. The survey showed that 82% of participants identified misinformation regarding COVID-19 in social media and that the Thai population had high trust in health agencies disseminating information.</p>	<p>Sri Lanka: in April 2020, the government introduced a hotline for the public to submit complaints on difficulties in receiving essential services due to strict public health measures. The Operation Centre was tasked with following up on complaints and taking necessary action.</p> <p>United States: in collaboration with multiple federal agencies, the Census Bureau is undertaking a Household Pulse Survey to understand citizens' experiences regarding employment status, food security, housing, physical and mental health, access to healthcare and educational disruption.</p>	<p>Japan: conducted an online survey in April 2020 to understand compliance with social distancing measures. Results were used to inform response strategies.</p> <p>Mexico: in April 2020, researchers from the National Institute of Public Health (INSP), the Government of Mexico City and mobile phone operators Movistar and Telcel, joined forces to carry out a study on how much the inhabitants of Mexico City adhere to measures of physical distancing and isolation; up to 200,000 mobile phone users will be invited weekly to answer a survey via text messages (SMS) on the behaviors observed in their homes.</p> <p>New Zealand: conducted the COVID-19 Health and Wellbeing Survey to provide the government with information on how New Zealanders are coping, financial impacts and the level of understanding and compliance with regulations.</p>

Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. VHV, village health volunteer.

Table 3 | Examples of health service delivery approaches

Subdomain	Snapshot of health systems resilience measures in reviewed countries		Countries in the middle category in terms of deaths per 100,000 population
	Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million	
Construction of new treatment facilities	<p>China: large specialty field hospitals (for example, Leishenshan and Huoshenshan) were rapidly constructed to deliver respiratory care services.</p> <p>Niger: Médecins Sans Frontières constructed a 50-bed treatment center at the Amirou Boubacar Diallo National Hospital in Niamey, with the potential to accommodate up to 100 beds should case numbers increase.</p> <p>Vietnam: anticipating high demand following the Danang outbreak in July 2020, Vietnam converted a sport stadium into a 1000-bed field hospital.</p>	<p>Argentina: in May 2020, the government built 12 modular hospitals in 20 d, mostly in the Buenos Aires suburbs; hospitals have 76 beds, of which 24 are for intensive care and are provided with respirators, and the rest of the beds have oxygen. They are also equipped with primary-care rooms, guardrooms, shock rooms, clinical analysis laboratories, consulting rooms and diagnostic imaging areas.</p> <p>Brazil: worked with football clubs to transform stadiums into field hospitals.</p> <p>China: converted large public venues into specialty hospitals (for example, Fangcang) to deliver respiratory care services.</p>	<p>Nigeria: The United States Department of Defense Africa command donated four field hospital tents that have negative-pressure isolation facilities and can house up to 40 patients. The facilities were assembled by an all-Nigerian team.</p> <p>Russia: prefabricated modular infectious disease centers were built across the country, for example, the Ministry of Defence of the Russian Federation built 29 multifunctional medical centers using prefabricated modular structures in 23 constituent entities of the Russian Federation with a total capacity of more than 3,000 beds.</p>
Converting public venues into treatment facilities	<p>Vietnam: anticipating high demand following the Danang outbreak in July 2020, Vietnam converted a sport stadium into a 1000-bed field hospital.</p>	<p>Brazil: worked with football clubs to transform stadiums into field hospitals.</p>	<p>Germany: the first specialized treatment centers for patients with COVID-19 and patients with respiratory symptoms were set up by the Regional Association of Statutory Health Insurance (SHI) Physicians in North-Rhine Westphalia. Some diagnostic centers have been converted into specialized centers and are designated for suspected and confirmed cases.</p>
Reconfiguring existing medical facilities	<p>Thailand: reconfigured many tertiary hospitals to increase the number of negative-pressure rooms and equipment to deliver respiratory care services.</p>	<p>United States: some tertiary hospitals augmented COVID-19-related services and built more negative-pressure rooms and integrated a separate heating, ventilation and air-conditioning channeling system.</p>	<p>South Korea: reconfigured designated tertiary hospitals into respiratory split hospitals that effectively segregate suspect and positive cases from non-respiratory disease so that these facilities can continue to provide essential tertiary-care services.</p>
Postponement of elective medical procedures	<p>Mozambique: yes.</p>	<p>United Kingdom: yes.</p>	<p>New Zealand: yes.</p>
Increased usage of digital health technologies for regular consultations	<p>Vietnam: Hanoi Medical University Hospital introduced the 'digital hospital' to provide services remotely, and the 'remote health and examination' project was also approved to trial and promote similar digital initiatives.</p>	<p>United States: the government developed a new website for telehealth guidance during COVID-19 for patients and providers. The website was developed in collaboration with the Health Resources and Services Administration, an agency working on programs that provide healthcare to people who are geographically isolated and economically or medically vulnerable.</p>	<p>Singapore: actively expanded telemedicine services following an increased demand that came with implementing social distancing measures.</p>
Primary-care providers as the first point of contact before triaging to onward care	<p>Vietnam: local commune centers provide primary-care services to the community. They help provide information on prevention and identify potential cases and cases for triaging to other care facilities.</p>	<p>United Kingdom: clinical commissioning groups work with general practitioners in primary-care networks to implement a total triage and remote consultation model during the pandemic to ensure that every patient is triaged before an appointment is made.</p>	<p>Japan: Public health centers began to systematically allocate patients to a wider network of hospitals, including privately owned facilities, matching patients to appropriate designated or non-designated hospitals by symptom severity and resource availability while urging mild and asymptomatic patients to stay at home or in converted hotels without a mandatory hospitalization.</p>

Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. IPC, infection prevention and control; PHPC, public health preparedness clinic.

Table 4 | Examples of health workforce approaches

Subdomain	Snapshots of health systems resilience measures in reviewed countries			
	Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million	Countries in the middle category in terms of deaths per 100,000 population	
Strategies to rapidly expand health workforce capacity	<p>Uganda: additional healthcare manpower including epidemiologists, doctors, anesthetists, nurses, laboratory technologists, psychiatric clinical officers, ambulance assistants, drivers, emergency care assistance, among others, were contracted for 6 months and deployed to COVID-19 treatment centers and to support districts and points of entry for surveillance purposes.</p> <p>China: in the initial stages of the pandemic, medical workers from all parts of China were reallocated to provide medical care for the people of the Hubei province.</p>	<p>Mexico: a national call was made to recruit specialized personnel in intensive care, emergency, internal medicine, pneumology, infectious and anesthesiology to address the pandemic. The government also considered contracting foreign health workers as necessary to augment domestic health workforce capacity.</p> <p>Brazil: The Brazilian Health Ministry hired more health workers, including reinstating medical licenses for Cuban medical professionals who remained in Brazil from the Mais Medicos (More Doctors) program and to permit final-year medical students to bolster the existing medical workforce.</p>	<p>New Zealand: a nationally coordinated online system was set up for retired or nonpracticing health workers to register to rejoin the workforce to assist in outbreak management. More than 2500 doctors, nurses, midwives and laboratory scientists came out of retirement or parental leave. A system was put in place to match returning health workers with suitable positions.</p> <p>India: the government had called on retired doctors, armed forces medical staff and private sector medical professionals to join the public health facilities. Over 30,000 responded to the government's appeal. Final-year medical students and paramedical students were also deployed to conduct screenings, contact tracing and vaccination.</p>	
Reallocation of healthcare professionals	<p>Vietnam: after receiving training, 97 senior medical students volunteered with the Hanoi Center for Disease control to conduct epidemiological investigation of cases; duties include providing counseling to people over the phone, collecting samples from suspected community groups, importing data into computers and cleaning and disinfection of congregate settings.</p>	<p>United States: with its predominately private healthcare system and federal states, the United States implemented measures to increase staff in hot spots. Many states developed guidelines to allow recent medical graduates and health workers from other states to practice in hot spots. This was needed as different states in the United States have different licensure for practice.</p>	<p>Uruguay: to alleviate the lack of intensive care physicians, the Uruguayan Society of Intensive Medicine (SUMI) and the Society of Anesthesiology announced an agreement that anesthetists can assist in critical-care tasks to augment intensive care manpower.</p> <p>Spain: medical doctors from other specialties such as internal medicine, anesthesiology, pneumology and geriatrics, as well as trained nurses, teamed up with intensive care specialists to increase care capacity for people with severe or critical COVID-19.</p> <p>South Korea: government employees from non-healthcare sectors were reassigned. Contact tracing was performed by repurposed low-level to middle-level government employees or those who were underemployed. It expanded its usual workforce of Epidemic Intelligence Service officers by quickly training these staff at approximately 250 local public health centers.</p>	
Pandemic-related training for healthcare professionals	<p>China: in Wuhan in January 2020, onsite training for infection control and patient management was provided to all health workers based on the 'guideline for COVID-19 management and control' and the 'guideline for hospital infection of COVID-19' before they started working in COVID-19 units.</p> <p>Sri Lanka: WHO worked with the Ministry of Health and Indigenous Medical Services and the Sri Lankan College of Microbiologists to design a set of training modules for health workers on IPC guidelines related to COVID-19 in Sri Lanka.</p>	<p>Argentina: online training was provided to health workers on critical COVID-19 treatments involving ventilators, intubations and extubations, among other relevant skills for treatment of patients with COVID-19. Both entry-level and advanced training were available.</p> <p>United Kingdom: free one-on-one support sessions with accredited psychologists or mental health experts available to NHS staff. A tool kit was also developed by the NHS to encourage conversation in the workplace and talk about mental and emotional health.</p>	<p>Russia: almost 1.6 million medical specialists were trained (remotely) to provide medical care to patients with COVID-19.</p> <p>Peru: military and civilian health professionals were trained through a Ministry of Defense initiative. The course is a 16-h theoretical and hands-on session to orient students to care for patients with severe COVID-19. The initiative started in May 2020, with service member-only classes that expanded to include civilians from June 2020.</p> <p>Singapore: increased training of nurses for intensive care to bolster existing intensive unit staffing. Former and current professionals and personnel with no qualifications were trained for support and testing, while medical students and nurses were trained for specific tasks to augment the existing health workforce.</p>	
Mental health support for health workforce	<p>China: several measures were implemented to ensure the care of medical personnel and their families, such as regulations on shifts and leave arrangement to relieve frontline medical workers.</p>	<p>United States: the CDC advised that healthcare facilities establish a plan for providing additional support for health workers, considering aspects such as mental health, parenting, meals and nonpunitive sick policies.</p>	<p>New Zealand: Health Care New Zealand provides free counseling services for frontline healthcare workers and staff who seek mental health and well-being support. Help will be rendered through an appointment-based system with an experienced therapist, which will be kept confidential.</p>	<p>Sweden: the government proposed funds to support staff in regional and municipal healthcare and elderly care in its autumn budget amendment for 2020. This provides additional funding for crisis support, counseling and trauma support during the pandemic.</p>
Financial support for health workforce	<p>Thailand: offered financial support to health workers in case of adverse events: for death or permanent disability: THB 240,000–400,000 / USD 7,684–12,807; for organ loss or disability, incentives offered to health workers were THB 1,500/USD 48 per shift for doctors and THB 1,000/USD 32 per shift for nurses and other paramedical staff.</p>	<p>Argentina: financial incentives granted to healthcare workers who managed and were exposed to patients with COVID-19 included four bonuses, in both the public and private sectors.</p>	<p>Russia: since the beginning of the pandemic, incentive payments to health workers for special working conditions and additional workloads have been introduced or increased on a federal level; the government allocated more than USD 64,900,000 to pay medical workers increased vacation pay or compensation for vacation, which they had to give up due to the situation with the coronavirus.</p>	<p>Germany: care workers can claim tax benefits of up to EUR 1,000/USD 1,200. The federal government announced it would expand the bonus payments given to nurses and care professionals in hospitals fighting COVID-19 to all hospital staff during the pandemic. Bavaria was the first state to announce a reward for all nursing and care staff in healthcare, long-term care, rehabilitation, emergency services and institutions for disabled people of a EUR 500/USD 600 bonus.</p>

Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020.

Table 5 | Examples of approaches using medical products and technologies

Subdomain	Snapshot of health systems resilience measures in reviewed countries	
	Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million
Preexisting national stockpiles	China: the central and local government's emergency stockpile of commodities, necessities and medical supplies was activated to meet the immediate demand during the earlier stages of the pandemic. Thailand: the government rapidly built up a national stockpile over the first few months of the pandemic while also sourcing external alternatives and domestic production alternatives.	United States: the Department of Health and Human Services mobilized the Strategic National Stockpile to provide medical essentials to combat the pandemic. United Kingdom: the Department of Health and Social Care activated the nation's emergency stockpile to augment existing supplies at NHS facilities.
Measures to increase in domestic production volume	Thailand: Board of Investment (BOI) approved 12 ventures in March 2020 to produce face masks, adding to the already 13 BOI-approved garment and textile companies that are producing medical masks and gowns. Vietnam: promoted inter-industry transfers of technology to produce more innovative and portable ventilators at a faster rate to bolster overall production volume in the country.	United States: The Defense Production Act allowed the president to direct private companies to prioritize orders from the federal government during national emergencies. An example was the federal government requesting automakers to manufacturer ventilators to increase overall domestic production volume. United Kingdom: several brewers contributed to the production of hand sanitizers by taking the alcohol from their production lines to bolster the local and regional supply of hand sanitizers.
Measures to facilitate the import of medical products	China: temporary decrease in import tariffs for medical devices to stabilize domestic supplies especially during the start of the pandemic. Sri Lanka: elimination of import duties and taxes on masks and disinfectants to facilitate movement of these products into the country.	Argentina: the government established a zero-percent rate to import taxes, applied to alcohol, laboratory and pharmacy equipment, gloves, disinfectants and sanitary supplies. Peru: temporary implementation of export authorization requirements on face masks, gloves and other PPE to regulate outwards movement of essential medical resources.
Measures to restrict the export of medical products	Vietnam: Drug Administration of Vietnam initially prevented the export of 37 drugs to be reserved for domestic healthcare facilities. China: initial prohibition on exporting test kits and medical supplies manufactured by uncertified companies was downgraded to export restriction upon authorization.	Argentina: released a decree that prohibits the export of critical medical merchandise such as oxygen therapy devices, their parts and accessories. United Kingdom: banned the export of essential medicines such as insulin and hydroxychloroquine over fears of domestic shortages.
Receiving donations of medical products	Uganda: the WHO, with funding from the Irish Government, delivered USD 250,000 worth of equipment to the Ugandan Ministry of Health, which included 60 handheld pulse oximeters, 49 oxygen concentrators and 31 high-flow nasal cannulas. Sri Lanka: China provided a USD 90 million grant to Sri Lanka in October 2020 for an array of uses including medical care.	Fiji: Japan together with the Asian Development Bank and UNICEF provided USD 11 million worth of medical equipment to Fiji. Peru: Germany gave over USD 1 million worth of oxygen concentrators, digital thermometers, oximeters and more than 32,000 coronavirus tests for health professionals with the aim to help 90,000 people from underserved communities in the indigenous and rural areas of Peru's Amazon.
Securing grants or loans for procuring medical products	Sri Lanka: China provided a USD 90 million grant to Sri Lanka in October 2020 for an array of uses including medical care. Uganda: the UK government released GBP 1.322 million/USD 1.84 million to support various aspects of Uganda's fight against COVID-19. Activities funded by the UK grant are being implemented by the WHO and the International Organization for Migration.	Mexico: the United States donated more than USD 1.8 million in Migration and Refugee Assistance funds to Mexico to assist the country's most vulnerable populations. Argentina: The World Bank provided emergency cash transfers and loans under its COVID-19 Fast Track Facility to Argentina.
		Countries in the middle category in terms of deaths per 100,000 population Singapore: drew on lessons from previous the SARS outbreak, and the government ensured adequate national stockpiles of PPE and essential medicines for up to 6 months. South Korea: Seoul had maintained the largest amount of PPE stockpiles (around 16,000 Level D coveralls, 5,200 Level C coveralls and 2,000 powered air-purifying respirator hoods).
		Countries in the least deaths category in terms of deaths per 100,000 population Singapore: a government-affiliated engineering company was tasked to start a production line for face masks by securing equipment, training manpower and protecting supplies of raw materials for the manufacturing processes. Japan: Ministry of Trade Economy and Industry, through the Subsidy Project for Supporting Businesses in Introducing Facilities for Producing Face Masks, had encouraged manufacturers to supply 100 million face masks per week by introducing new and enhanced equipment in manufacturing lines for face masks. Nigeria: federal government approved a waiver for import duties and VAT on all medical equipment and supplies into the country from May 2020 onwards. Fiji: elimination of import duties and VAT on medical supplies to promote movement of medical products necessary to combat the pandemic. Pakistan: authorities imposed restrictions that prohibit the exports of antimalarial drugs and other essential medicines.
		Countries in the most deaths category in terms of deaths per 100,000 population Pakistan: China donated 1,000 ventilators to Pakistan in August 2020. Other donations included PPE, test kits and face masks. Nigeria: the United States donated 200 ventilators to Nigeria, which contributed to its membership in the Every Breath Counts Coalition, which aims to combat pneumonia, hypoxemia and COVID-19. Pakistan: the COVID-19 Active Response and Expenditure Support program secured USD 500 million from the Asian Development Bank to import equipment and medical supplies. Liberia: The World Bank approved a USD 3.75 million grant and USD 3.75 million concessional International Development Association credit for Liberia to strengthen immediate healthcare capacity and longer-term outbreak response.

Continued

Table 5 | Examples of approaches using medical products and technologies (continued)

Subdomain	Snapshot of health systems resilience measures in reviewed countries		
	Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million	Countries in the middle category in terms of deaths per 100,000 population
Guidance principles released for the rational use of medical products	<p>Uganda: rational-use guidance documents released by health authorities accompanied by videos on how to properly don PPE.</p> <p>Mozambique: released rational-use guidance integrated into its Environmental and Social Management Framework for COVID-19 Response to maximize existing supplies of PPE and ensure safe and effective usage.</p>	<p>United States: CDC and Occupational Safety and Health Administration released guidelines on the proper use of PPE for frontline workers, which includes donning, repairing, washing, storing and disposing of PPE.</p> <p>Brazil: guidelines used as recommendations so that the unnecessary use of equipment is reduced and contingency is established in case of shortages. Hand and respiratory hygiene are emphasized strongly in the guidelines.</p>	<p>South Korea: during the earlier stages of the pandemic in South Korea, when PPE supplies were insufficient, hospitals changed Level D coveralls to disposable plastic gowns and N95 respirators to KF94 masks. Although KF94 masks cannot ensure airtight seals due to the ear-loop structure, their filtration capacity is similar to the N95, and the KCDC recommended the KF94 or KF99 for health workers.</p> <p>India: in the initial months of the pandemic, PPE and masks were procured centrally due to import challenges. Once domestic manufacturers were developed and standards defined, vendors were onboarded to the Central Government e-Marketplace and states encouraged to buy standard and fair price essential commodities from this platform.</p>
Advance-purchase agreements with pharmaceutical companies	<p>Vietnam: the government had engagements with Russia to buy 150 million doses of Russian vaccine (Sputnik V) and 30 million doses from AstraZeneca.</p> <p>Thailand: purchase arrangements secured to obtain 2 million doses of Sinovac vaccine and 61 million doses from AstraZeneca to be manufactured in collaboration with Siam Bioscience.</p>	<p>Spain: secured multiple agreements through the European Commission's Advance-Purchase Agreements with vaccine producers including Pfizer-BioNTechArm, AstraZeneca, ModernaARNm, Johnson & Johnson, Sanofi and GSK and CureVac to ensure sufficient access to approved vaccines.</p> <p>Mexico: signed an advance-purchase agreement for 35 million doses of Chinese firm Can Sino Biologics' COVID-19 vaccine while solidifying arrangements in January 2021 to procure 24 million doses of Russia's Sputnik COVID-19 vaccine.</p>	<p>Japan: made multiple investments in many potential vaccine candidates. In August 2020, the health ministry started negotiations with Moderna to secure enough vaccines from the drug firm to cover 20 million people within the first half of 2021, with Pfizer to cover 60 million people and with AstraZeneca for 120 million doses.</p> <p>India: as the largest buyer of vaccines, India has already purchased 196 million doses of domestically manufactured vaccines from Serum Institute and Bharat Biotech of India. It has also supported R&D efforts of local manufacturers. It is in talks to secure 1.6 billion doses of other vaccines once Indian trials conclude (Sputnik V and Novavax).</p>
Participation in the COVAX facility	<p>Mozambique: part of the COVAX Advance Market Commitment and will receive vaccines to cover an average of 20% of the population.</p> <p>Thailand: did not pledge to the COVAX facility opting to acquire directly from manufacturers.</p>	<p>United Kingdom: helped raise USD 1 billion for COVAX AMC through match-funding other donors, which was added on to the initial amount the United Kingdom had pledged.</p> <p>Peru: to receive approved COVID-19 vaccine from the COVAX AMC in early 2021.</p>	<p>Sweden: pledged SEK 100 million/USD 119 million to the COVAX facility and will receive a predetermined number of vaccine doses.</p> <p>Singapore: co-chaired the Friends of the COVAX Facility initiative with Switzerland to promote vaccine multilateralism and contributed USD 5 million to the facility in return for a predetermined number of vaccine doses.</p>
Platforms to monitor supply chains	<p>China: the Ministry of Industry and Information Technology established a platform for mobilizing resources nationwide. This platform aims to ensure the production and allocation of sufficient medical supplies to regions in need.</p> <p>Uganda: The Emergency Logistics Management System (Eelimis) provided real-time feedback on medical resource availability at national and subnational levels. The digital system rapidly collects, shares and analyzes information on supplies to guide a coordinated response to allocate medical resources.</p>	<p>Brazil: regarding price monitoring, the Health Price Bank (BPS) system and the Material Catalog (CATMAT) for public health managers and control bodies helps the government procure reasonably priced drugs and other medical supplies from credible suppliers after price comparisons.</p> <p>United Kingdom: a parallel supply chain distribution mechanism set up to augment the NHS supply chain system for the rapid and organized distribution of medical essentials guided by the principles of plan, source, make, order and deliver.</p>	<p>India: in the state of Odisha, the supply chain is normally managed using the Government e-Marketplace. During the pandemic, special interdepartmental committees were set up to rapidly finalize purchase indents, audit documents and track movements of medical products.</p> <p>Japan: medical facilities reported information on their operating status, bed occupancy rates in general wards, infectious disease wards, ICUs and utilization rates of ventilators and ECMO support, to the Gathering Medical Information System. This platform helps allocate and coordinate the movement of medical resources nationwide.</p>

Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. ECMO, extracorporeal membrane oxygenation.

Table 6 | Examples of public health functions

Subdomain	Snapshot of health systems resilience measures in reviewed countries		
	Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million	Countries in the middle category in terms of deaths per 100,000 population
Diagnostic testing strategies	China: in Wuhan, two rounds of community-based mass screening were carried out with tests administered free of charge, resulting in 4.21 million households receiving the test to rule out potential sources of infection.	Vietnam: the country had performed targeted testing. Initially, those with a travel history, who were close contacts of confirmed cases and those who showed symptoms were tested. This was later expanded to mass testing in entire hot spots or high-risk areas.	New Zealand: testing was performed for all symptomatic individuals or people who were identified as being in close contact with a positive case. Border testing was also mandatory. The government ensured access to testing was effective and equitable for all groups, in particular Māori and Pacific islanders.
Increasing laboratory capacity	Vietnam: increased the number of testing laboratories nationwide from 3 in January 2020 to 112 by April 2020.	Mozambique: national testing capacity from public laboratories increased from around 60 tests per day in April 2020 to 3,186 tests per day across the country in November 2020. Expanded laboratory capacity to seven of eleven provinces either through open PCR platforms or through existing platforms in clinical laboratories.	Pakistan: the National Disaster Management Authority worked with the National Institute of Health to increase the number of laboratories from 15 to 144 as of November 2020, thus increasing the number of tests conducted per day.
Contact tracing policies	China: all cases undergo contact tracing; county/district level CDC staff should complete contact tracing within 24 h after receiving the reports of suspected or confirmed cases.	Vietnam: 'Four Tier' contact tracing process based on the degree of contact from the infected individual (F0), to the person who had close contact (F1), to the person who had close contact with F1 (F2+), all the way to F5.	Japan: conducted retrospective contact tracing (14 d before symptom onset) to identify the source of the infection and break up clusters.
Contact tracing teams	Mozambique: contact tracing is carried out by staff at the National Institute of Health with assistance from medical residents, and students from the master program on Field Epidemiology and Laboratory Training, supported by the Centre for Disease Control.	Sri Lanka: contact tracing is carried out by community physicians, regional epidemiologists and nearly 900 medical officers of health from 357 Ministry of Health areas in late January 2020.	Liberia: contact tracers were recruited from communities and trained on their roles and responsibilities.
Quarantine strategies	Thailand: close contacts or those suspected to be infected are mandated to be quarantined either at home or in a state facility, under the close supervision of health workers. They are tested twice—on 7th day and 14th day.	Uganda: implemented auto-monitoring of case contacts for 14 d. The person under auto-monitoring measures his or her temperature twice a day and makes sure there are no breathing problems or coughing. During auto-monitoring, normal activities can be continued.	Nigeria: the International Organization for Migration will construct, manage and maintain self-quarantine shelters to quarantine internally displaced persons and host community members with travel and contact history, as well as new arrivals from other towns.
Self-isolation strategies (home-based)	Mozambique: institutional isolation in a health establishment if therapeutic criteria are met. If the symptoms are mild, they will be isolated at home for recovery.	Uganda: auto-isolation applies to people who have symptoms of COVID-19 but whose infection is not confirmed. They are required to stay home for 7 d from the onset of symptoms and avoid contact with other people if possible. Once the symptoms have resolved, they must stay at home for another 24 h.	Egypt: once diagnosed, those with mild symptoms go home, while those with medium to serious symptoms remain in the hospital.

Continued

Table 6 | Examples of public health functions (continued)

		Snapshot of health systems resilience measures in reviewed countries			
Subdomain		Countries with the least deaths per 100,000, with a population of over 20 million	Countries with the most deaths per 100,000, with a population of over 20 million	Countries in the middle category in terms of deaths per 100,000 population	
Self-isolation strategies (designated facilities)		China: all confirmed cases will be isolated and treated at COVID-19 designated hospitals and treatment facilities. Thailand: government-subsidized hotels, public or private dorms were modified to isolate asymptomatic cases.	United States: isolation strategies vary by state. In New York, officials collaborated with hotels to provide shelter for people not ill enough to be admitted at the hospital and for patients who had been discharged but not quite recovered.	Fiji: community isolation centers are used to isolate people with mild symptoms and who were determined as low risk for developing severe COVID-19. Japan: asymptomatic cases and patients with mild symptoms who do not require hospitalization can recuperate at designated lodging facilities.	
Social and economic support for the general public to aid adherence to public health interventions		Sri Lanka: the Presidential Task Force collaborated with cooperative societies and supermarket chains to offer home delivery of food to prevent uncontrolled gathering of people at marketplaces. Niger: implemented price controls for essential goods for food distributions and 2 months of free utilities to vulnerable households. The Council of Ministers declared the implementation of state support for electricity and water bills for the months of April and May 2020.	Argentina: the government prohibited basic public service companies, such as those providing electrical energy, water, gas, mobile telephones, internet and TV cable, from suspending their services due to lack of payment by certain people, for up to three periods of payment. United Kingdom: over 1 million food boxes have now been delivered to those most at risk from coronavirus through the shielding program.	Uruguay: subsidy of up to 50% of rent for individuals enrolled in the unemployment insurance. Flexible agreements on mortgage payments either with a discount or with deferral of installments, with further deferrals for pensioners or retirees. Russia: citizens with a mortgage or consumer loan could take advantage of debt standstill for the period of up to 6 months in the event of a decrease in income by 30% or more; citizens of the Russian Federation who lost their jobs due to the COVID-19 pandemic had the maximum unemployment benefit, regardless of the length of service and level of earnings.	
Surveillance strategies		Sri Lanka: the Ministry of Health requests mandatory case reporting by all healthcare institutions. Active surveillance in communities is conducted through contact tracing. Mozambique: multiple surveillance strategies, involving sentinel surveillance, serological surveillance, active surveillance at entry points and through contact tracing.	United States: the CDC deploys multiple surveillance systems, including case reporting, syndromic surveillance and epidemiological surveillance. System for Viral Respiratory Diseases of the Mexican Ministry of Health. Mexico: case reporting by 475 Viral Respiratory Disease Monitoring Units and medical units, which reported cases to a centralized system called the Epidemiological Surveillance System for Viral Respiratory Diseases of the Mexican Ministry of Health.	New Zealand: multisource surveillance systems, involving mandatory case reporting, sentinel surveillance, syndromic surveillance, serological surveillance and scenario modeling. Japan: multiple surveillance strategies, including case reporting by healthcare providers, active surveillance of suspected cases, and monitoring the use of medical consultation hotlines among the public. Additionally, LINE Corporation also implemented its own COVID-19 syndromic surveillance system that collects demographic information and reported symptoms.	
Contact tracing technologies		Vietnam: NCOVI mobile app creates a 'neighborhood watch system' for citizens. It includes a map of positive cases and clusters, enables users to declare their health status and report suspected cases. Thailand: Thai Chana online platform launched to facilitate monitoring of customers at shops; those who come in close contact with infected people are notified and called for testing.	Spain: Radar COVID app is based on the DP-3T protocol and uses the Apple/Google API for contact tracing. United Kingdom: NHS COVID-19 contact tracing app allows users to scan official NHS QR code posters at businesses, venues and transport hubs for contact tracing purposes. Mexico: coronavirus information hotline, mobile app and text services are made available for questions and self-assessment of COVID-19.	Russia: 'Stopcoronavirus: My Contacts,' scans the user's surroundings in a 10-m radius and measures how close and for how long they interact with other users. Users who become infected will voluntarily notify the app, which then sends alerts to all others who were in close proximity to them. Singapore: TraceTogether, a mobile app or token-based proximity tracing tool (non-location based) using Bluetooth technology to identify contacts of people with confirmed COVID-19.	
Online or phone-based case management tools for the public		Niger: the Urgent Medical Aid Services have set up a green line. All callers with symptoms of COVID-19 will be redirected to the center, examined and tested. China: the China CDC launched a web-based surveillance system that allows real-time reporting of COVID-19 cases by healthcare providers.	Spain: mobile app for citizens to self-assess their health status, provide recommendations and direct to onwards care. United States: data on COVID-19 cases is sent to the National Notifiable Disease Surveillance System managed by the CDC.	Russia: implemented a hotline for COVID-19-related information and also a source of triaging potential cases. At the request of the Rosпотребнадзор, all regions have established their own hotline. Fiji: The SORMAS (Surveillance, Outbreak Response, Management and Analysis System) is deployed for real-time digital surveillance and early detection of outbreaks.	
Surveillance databases		Vietnam: an online COVID-19 reporting system was developed, which allows the Ministry of Health to access and analyze epidemiological and development across the country in real time.			

Countries were selected according to the recorded number of deaths attributed to COVID-19 per 100,000 inhabitants on 6 November 2020. API, application programming interface.

symptoms of COVID-19 to onward care²⁴. Additionally, some countries complemented digital technology with proactive deployment of existing and new community health resources²⁵. Community-based approaches developed with deep knowledge of local contexts are crucial to pandemic response and health systems resilience, particularly given the disproportionate impact of the pandemic on vulnerable groups^{15,26}. While outside the reach of the health system in many countries, there have been extensive outbreaks in long-term care homes with devastating impacts on the health and well-being of high-risk older adults, long-term care patients and their families²⁷. In response, most countries reviewed prioritized long-term care facilities and older adults for testing, surveillance and vaccine distribution, although often not until there had been high rates of mortality in these settings.

Health workforce. Resilient health systems manage crises by having an adequate, trained and willing workforce. Yet, in many countries, COVID-19 has spread quickly among health workers as they have been the most exposed to the virus, with data indicating that they have been disproportionately affected by the pandemic²⁸. Health workforce challenges during COVID-19 include low staffing levels (particularly among nurses) and uneven geographical distribution, shortages of adequate personal protective equipment (PPE), limited testing capacity, insufficient training, social discrimination and attacks and poor mental health²⁹.

As cases surged globally, most reviewed countries reallocated healthcare professionals, including primary-care workers, to emergency care wards, intensive care units (ICUs) and diagnosis and surveillance activities. Several recruitment strategies were implemented to increase the healthcare workforce. Retired, student or nonpracticing medical and paramedical professionals were asked to volunteer for healthcare tasks. For example, medical and nursing students were recruited and allowed to perform supervised work in different COVID-19 response capacities in countries such as Germany, Russia, Spain, the United Kingdom and Vietnam. Given these new roles or expanded job scopes, there was an immediate need for rapid and high-quality pandemic-related training of front-line healthcare workers, which was accomplished through virtual training courses in many countries.

Further measures were taken by countries to maintain, protect and support their healthcare workers in light of the physical and psychological strain of the pandemic. In some countries (for example, Japan, Mozambique, Singapore and South Korea), healthcare professionals were supported by measures such as organization of shifts to avoid extended hours without rest, leaves from duty for mental and physical recovery, accommodation near their workplaces to protect their families, and childcare. Additionally, most countries reported giving some form of financial support to their health workers, such as monetary incentives, bonuses, insurance, tax benefits, overtime pay, meal allowances, classification of their infections as an occupational disease or injury and declaring cause of death as work related. Several countries reported making psychological support available for health workers, such as counseling or trauma support, to maintain well-being and morale. Frontline staff and their families were especially vulnerable and were targeted for psychological interventions. Moreover, some countries launched social media campaigns that encourage people to show their pride, admiration and gratitude for healthcare workers to promote solidarity.

Medical products and technologies. High-quality prevention, diagnosis and management of COVID-19 require the ongoing development, production and sustained distribution of mass quantities of medical products and technologies. However, overreliance on a few countries for production, competition among countries and supply chain disruptions have caused global supply shortages. Some countries reviewed had national or regional stockpiles of PPE, including

masks, gloves, face shields and gowns, which were used as a buffer while awaiting imported supplies or scale up of domestic production. Singapore, for example, drew from experience responding to SARS and preserved a national stockpile of medical products for up to 6 months³⁰. To replenish stockpiles in Japan, medical product manufacturers were urged to boost production output, resulting in the tripling of production volume as factories operated 24h a day³¹.

Governments also worked beyond the typical health sectors and developed guidelines and specifications for non-health sectors to supplement the existing medical product manufacturing lines. In India, automotive manufacturers were repurposed to produce low-cost ventilators and PPE³². Beyond industry, communities in some countries mobilized to bolster medical product supplies. Several countries had also relied on purchasing consortia, like the UN COVID-19 Supply Chain System and Africa Medical Supplies Platform, donations from development partners or grants and loans from other countries and international financial entities (that is, The World Bank and Asian Development Bank) to secure medical supplies^{33–37}. Vaccine procurement is also an essential part of the medical supply chain, and countries have either made advance-purchase agreements or participated in the COVAX facility to ensure prompt access to the vaccine for their populations, although concerns remain about equitable access to vaccines in short supply.

In response to increased demand driven by widespread community transmission, countries enacted laws to prevent hoarding and exploitative pricing, as well as policies prohibiting export of medical supplies, while relaxing import licensing requirements and tariffs³⁸. Within health facilities, measures including rational-use guidelines, per WHO recommendations, and postponement of nonemergency medical procedures helped stretch existing medical inventories³⁹. Although supply chains began to stabilize during 2020, many points of care globally faced uncertain stocks and reports of counterfeit medical essentials highlighting the need for secure supply pipelines. Platforms that assist in monitoring logistics networks are integral in ensuring a steady and rapid flow of medical products and technologies, promoting transparency and ensuring better management of supply chains.

Public health functions. Public health interventions embedded within communities, such as testing, contact tracing, quarantine or self-isolation, and surveillance are crucial functions to break chains of transmission⁴⁰. However, in many health systems, public health and health service delivery systems are siloed: their coordination is limited or ineffective, and they have separate referral processes and reporting systems, all of which serve to undermine health systems resilience⁴¹. Testing and contact tracing are a case in point that clearly illustrates why public health and health systems must act together in a coordinated manner.

Diagnostic tests to identify whether a person is, or has been, infected are foundational to infectious disease responses to pinpoint locations of spread, and provide care and treatment if it exists. Testing strategies are broadly classified as passive or proactive. Many of the countries reviewed relied on passive testing strategies, where symptomatic individuals self-present to a healthcare facility for testing after meeting certain criteria. However, some countries adopted proactive testing strategies characterized by programs tailored to the unique needs of specific populations as an important tool toward breaking chains of transmission and offering a clearer epidemiological picture^{42,43}. Additionally, many countries rapidly decentralized testing capacity by strengthening or developing new laboratory networks.

Proactive testing must be accompanied by comprehensive contact tracing in partnership with communities. Contact tracing is the systematic process of following up with individuals who may have been exposed to COVID-19⁴⁴. It can be characterized as either forward, aiming to find 'downstream' individuals who have been in

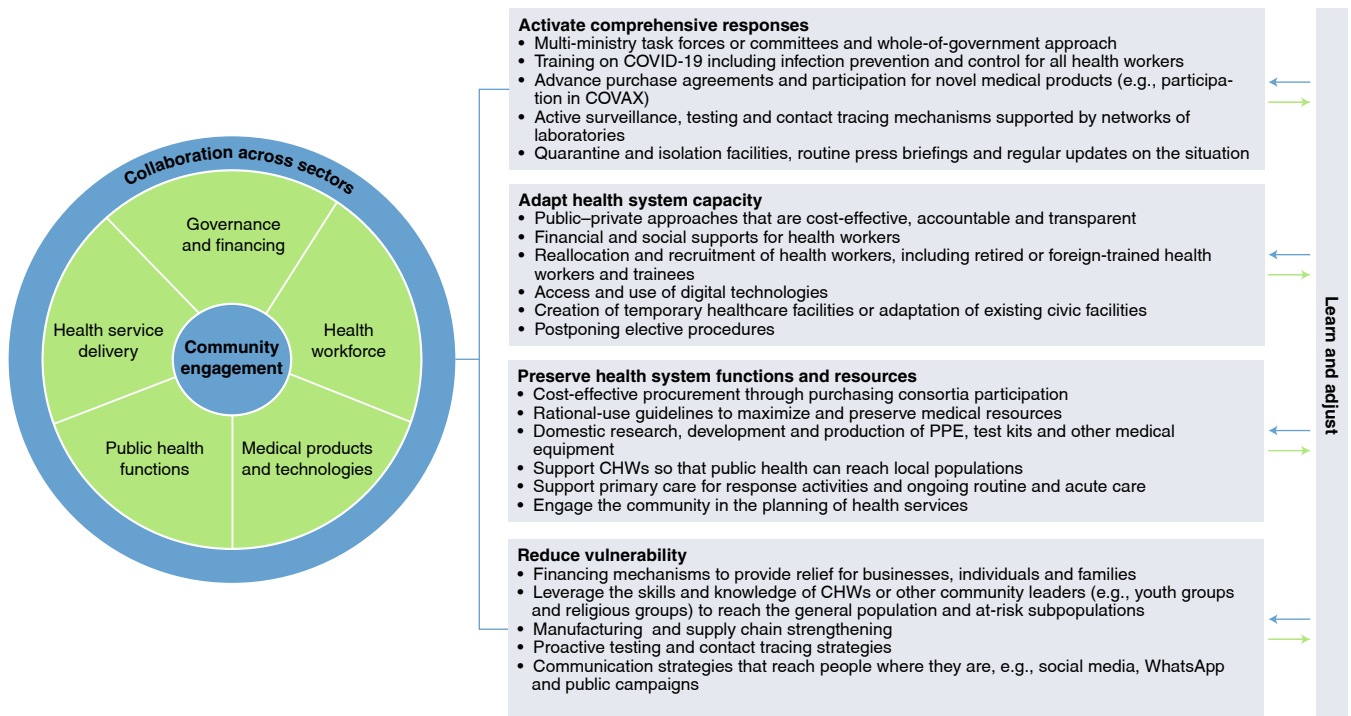


Fig. 3 | Four resilience elements of highly effective country responses. The framework presented expands upon and applies the determinants of health systems resilience framework to identify four resilience elements characteristic of highly effective country responses to COVID-19.

contact with a person with COVID-19, or backwards, aiming to find an ‘upstream’ source of infection⁴⁵. While most countries reviewed conducted forward contact tracing, Japan conducted backwards contact tracing measures aimed at identifying and ‘busting’ clusters by working with individuals to trace 14 d before symptom onset⁴⁶. Contact tracing, particularly backwards tracing, is labor and time intensive and may be stigmatizing if not done with community engagement and consideration of at-risk and vulnerable groups⁴⁷. The majority of countries reviewed introduced digital contact tracing tools. Even when fully operational, they may not be accessible, acceptable or feasible for use among those with limited access to, or concerns in using, adequate technology such as migrants, refugees or those experiencing homelessness, among others⁴⁸.

Once cases and contacts are identified, self-isolation and quarantine measures are crucial to prevent onwards transmission and identify emergent cases. All countries reported on quarantine and isolation protocols. While necessary to outbreak management, unless done in coordination with communities, quarantine measures can have negative impacts on mental health and well-being, become a source of stigma and be deployed at the significant cost of human rights⁴⁹. Some countries have implemented policies to provide social and economic assistance to those who must self-isolate or quarantine. Social supports range from services that ensure food and necessities during quarantine to dedicated quarantine or isolation facilities (for example, converted hotels, public facilities or purpose-built quarantine hospitals). Such self-isolation supports are recognized as integral to mitigating transmission, particularly among younger people and those working in high-exposure occupations, living in overcrowded housing or without a home⁵⁰. However, to avoid negative unintended consequences, such facilities must be operationalized with a human rights focus⁵¹.

These efforts are enhanced by surveillance, including testing in areas or settings with outbreaks, to rapidly limit community circulation⁵². Given the high transmissibility of severe acute respiratory syndrome coronavirus 2, surveillance needs to be geographically

comprehensive to provide accurate depictions of disease burden and epidemiology to prevent and mitigate community transmission^{53–55}. As recommended by WHO guidelines, nearly all countries have adapted existing surveillance system infrastructure to collect information on COVID-19 cases⁵⁵. However, surveillance based on case reporting may underestimate the epidemiological characteristics of COVID-19, given that stigma or other barriers may limit healthcare seeking, particularly in vulnerable populations^{56,57}. Therefore, New Zealand, Sweden and the United States have additionally deployed syndromic surveillance, which monitors cases that meet the clinical definition of COVID-19 without confirmation by testing. By implementing active surveillance approaches, countries have expanded surveillance coverage from healthcare settings into communities, such as through primary care, thereby strengthening epidemiological surveillance among vulnerable populations.

Timely sharing of case-based data between public health and healthcare sectors is key to early detection of outbreaks, identification of changes in epidemiological trends and planning of health services⁵⁸. This was facilitated by the use of innovative digital technology. For example, the China CDC launched a web-based infectious disease reporting system that allows real-time reporting of confirmed and suspected COVID-19 cases by healthcare providers^{59,60}. Similar real-time surveillance and information systems are also used in Fiji, India, Japan and Vietnam.

Discussion

Assessing health systems resilience is vital in helping policymakers plan for sustainable recovery and strengthen systems to better prepare and respond to current and future crises. Using an adapted and improved resilience framework, our review highlights many parallels in the measures implemented by countries in response to COVID-19. The similarities across countries with divergent health outcomes makes clear that there is no one silver bullet toward a resilient health system. Nevertheless, there are a number of characteristics of well-performing countries across the resilience

determinants that stand out. These are summarized as four elements of resilience that are featured in highly effective country responses. These elements draw on the concept that resilient health systems are systems that: (1) activate comprehensive responses, which are responses that consider and address health and well-being as intertwined with social and economic considerations; (2) adapt capacity within and beyond the health system to meet the needs of communities; (3) preserve functions and resources within and beyond the health system to maintain pandemic-related and non-related routine and acute care; and (4) reduce vulnerability to catastrophic losses in communities, both in terms of health and well-being, as well as individual or household finances; all while continually learning, monitoring and adjusting in light of emerging evidence or the evolving epidemiological situation (Fig. 3).

High-performing countries. High-performing countries activated comprehensive responses across the determinants' domains, including through whole-of-government approaches and the creation of multi-ministry task forces, to ensure adequate translation of evidence into policy and practices that preserve health system capacity, while protecting public health and livelihoods. Specific measures taken include training health workers, bolstering public health functions (including offering designated isolation facilities, either for all or for those unable to safely self-isolate at home) and preparing for new technologies and medicines through purchase agreements, while also engaging communities through routine communications on the epidemiological situation and emergent policies.

These countries also learned from emerging evidence and adapted the capacity of their health system in response to the evolving epidemiological situation. This was achieved by increasing capacity in hospitals, through construction of makeshift hospitals or repurposing of existing health facilities or civic spaces. The health workforce in high-performing countries was expanded through reallocation and recruitment and supported through financial and social supports.

These countries took action to preserve health system functions and resources through purchasing consortia and rational-use guidelines to maximize available material resources such as PPE, as well as investing in domestic research, development and production of medical supplies, test kits and vaccines. Additionally, these countries protected health and well-being more broadly by ensuring health system functioning for non-COVID-19-related health services. High-performing countries supported primary care and CHWs to conduct COVID-19 screening, assessment and/or referral, while providing ongoing routine and acute care in communities.

High-performing countries also sought to reduce vulnerability across the resilience determinants by providing financial relief and social supports to complement proactive and robust testing and contact tracing in partnership with communities to ensure public health measures and safety net supports reached all groups.

Building resilient health systems. While some countries have demonstrated elements of resilience, as we highlight above, progress is limited in developing resilient health systems overall. Our review highlights six areas requiring urgent action to build resilient health systems globally.

First, COVID-19 responses provide a clear illustration of the importance of governance supported by scientific evidence and leadership willing to learn and adjust course for successful health systems that protect health and well-being. Enhancing resilience to future disease outbreaks requires longer-term work to create high-quality healthcare systems and build community trust. Our review emphasizes that governments are well advised to address COVID-19, and any future disease outbreak, through a whole-of-government approach that incorporates all sectors, engages relevant actors across all levels, including community and

local authorities, and is based on strong and clear coordination that extends beyond early-stage emergency management⁶¹. Crucial to health systems resilience is that governance must consider the intersections of gender, racialization and human rights, and their impact on health and well-being before, during and after crises^{62–64}. Urging governments to adopt such an approach, which COVID-19 has made clear is essential, is not a new proposal. Yet, our review highlights a lack of uniform appreciation or adoption of such an approach by countries.

Second, health systems need appropriate financing, not only to prepare for new pandemics, but also to ensure that at all times, all people have access to the health services they need, when and where they need them, without financial hardship, regardless of ability to pay⁶⁵. This is the foundation of UHC. While many countries have provided subsidized COVID-19 testing and treatment, more must be done to ensure people are not pushed into poverty due to out-of-pocket spending on health. Investing in UHC not only protects people from health threats but also mitigates the social and economic burdens that have characterized COVID-19. Countries will have to revisit the thresholds of health expenditure that they are willing to invest to build resilient health systems, promote population health and protect communities against financial risk.

Third, while country capacities varied, the pandemic has demonstrated a need to invest in improving both the quantity and quality of health workers to better prepare for and respond to future pandemics. Our review highlights that resilient health systems are those that not only invest in pandemic-related planning and training of health workers, but also ensure their physical, mental and economic protection in the workplace and beyond. Emphasis should also be placed on community mobilization where adequately trained and supported CHWs are equipped to play substantial roles in outbreak response and community engagement, much as they have played a crucial role in tuberculosis and HIV/AIDS response efforts globally for decades⁶⁶.

Fourth, in terms of access to medicines and products, the pandemic has made visible, yet again, the clearly identified and thoroughly debated challenges to global supply chains for medicines and products. These challenges range from limited manufacturing capacities to financing to equity in access. The early experience of COVAX, with some high-income countries bypassing the initiative, has demonstrated the glaring limitations in the current system.

Fifth, health service delivery, including non-COVID-19-related health services, has been directly threatened, and often compromised, at all levels by the demands of the pandemic, even in traditionally high-performing health systems. Our review emphasizes that bolstering system capacity requires strong and well-funded primary care, with a skilled and protected workforce, to ensure that high-quality care is delivered in communities, with strengthened linkages to public health systems. Similarly, the long-term care sector, and care for older adults, must be prioritized and better integrated into health service delivery and public health functions. This must be underpinned by a renewed commitment to UHC to ensure high-quality care for all.

Finally, public health functions, such as testing and contact tracing, that are delivered in coordination with the health service system, are cornerstones for successful COVID-19 responses. These approaches often depend on innovative digital technologies, which bear their own challenges, including the potential to exacerbate inequalities and be the vehicle for human rights violations^{67–70}. As such, future investments in these technologies requires a more holistic approach—one that engages communities, particularly the most vulnerable—that takes into account the potential risks and considers how health systems can minimize harms from their use⁷¹.

Importantly, our analysis of country responses points toward foundational debates on how we understand and think about resilient health systems. Health system resilience as a concept must

expand beyond technical and biomedical knowledge and actions, to engage with the broader social, economic and political factors in society. Such comprehensive understanding of resilience requires a systems approach and should be guided by equity concerns, which include concerns for gender, human rights and racialization in health and healthcare^{12,72}. Further, resilience cannot be achieved solely through unidirectional and top-down approaches by governments and other entities. Resilience requires community engagement as much as regulations and hospital capacity. Community engagement and its interlinkage with community resilience is fundamental to managing not only health threats but also other threats, such as climate and environmental change⁷³. Importantly, health systems resilience requires countries worldwide to be open to exchange of knowledge and expertise from regions such as Asia and Africa, which have effectively mobilized CHWs and communities to extend the reach, capacity and quality of their health systems.

Conclusion

Our findings and recommendations are not new, and there have been prior incremental moves to expand what constitutes, influences and governs health and healthcare. COVID-19 demands dynamic systemic transformation. The pandemic has fundamentally challenged health systems and the communities they serve globally. The effect of a major shock represented by the pandemic is to manifest the points where the system is weakest, and to demonstrate the interdependencies of a range of health, social and economic structures. While the evidence of system failures has come at a huge cost in human and monetary terms, it has also pointed to what needs to change. With over 3 million global deaths and pervasive social and economic costs, the pandemic must serve as a call for transformation and investment toward resilience and people centeredness, beginning with health systems. COVID-19 provides a renewed prospect for solidarity, both within and between countries. It also serves as a reminder that health is more than healthcare and that a whole-of-government approach to health and well-being is needed to create healthy populations able to collectively prevent and respond to crises, leaving no one behind.

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Author contributions

V.H., C.D.F., S.A., A.-S.J. and H.L.-Q. conceived and designed this Review. V.H., C.D.F., S.A., A.-S.J., M.M.J.T., S.W., A.C., M.V., P.S., S.M.T. and H.L.-Q. collected the data. V.H., C.D.F., S.A., A.-S.J., M.M.J.T., S.W., S.S. and H.L.-Q. analyzed the data and drafted the manuscript with input from all authors. All authors contributed to revision of the manuscript.

Competing interests

All authors declare no competing interests.

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