Learnings from COVID-19 for future respiratory pathogen pandemic preparedness: a summary of the literature

World Health Organization

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Contents

Acknowledgements iv

Abbreviations and acronyms v

Executive summary vi

- Collaborative surveillance vi
- Emergency coordination vii
- Clinical care vii
- Access to countermeasures viii
- Community protection ix
- Collaborative learning and accountability x

Introduction 1

Lessons identified from the global COVID-19 experience 2

- Collaborative surveillance 2
- Emergency coordination 5
- Clinical care 6
- Access to countermeasures 14
- Community protection 17
- Collaborative learning and accountability 24

Conclusion 28

References 29

Annex I. Methodology 36

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Abbreviations and acronyms

ACT-A	Access to COVID-19 Tools Accelerator
CDC	United States Centers for Disease Control and Prevention
CEPI	Coalition for Epidemic Preparedness Innovations
CoV	coronavirus
COVID-19	coronavirus disease 2019
EOCs	emergency operations centres
GISRS	Global Influenza Surveillance and Response System
HCWs	health and care workers
ICS	incident command system
ICU	intensive care unit
IHR	International Health Regulations
IMS	incident management system
LGBTQI+	lesbian, gay, bisexual, transgender, queer and intersex
LMICs	low- and middle-income countries
MCM	medical countermeasure
MERL	monitoring, evaluation, reporting and learning
MERS	Middle East respiratory syndrome
OECD	Organisation for Economic Co-operation and Development
PAHO	Pan American Health Organization
PGP	Pandemic Preparedness Global Platforms
PHC	primary health care
PHEIC	public health emergency of international concern
PPE	personal protective equipment
PRET	Preparedness and Resilience for Emerging Threats
PTSD	post-traumatic stress disorder
SARS 2003	severe acute respiratory syndrome
SARS-CoV-2	severe acute respiratory syndrome coronavirus 2
SSTC	South–South and triangular cooperation
UHC	universal health coverage
UNAIDS	Joint United Nations Programme on HIV/AIDS
WHA	World Health Assembly
WHO	World Health Organization

Executive summary

Based on the scoping review of the coronavirus disease 2019 (COVID-19) pandemic, this document presents a high-level summary of lessons from the COVID-19 pandemic to inform preparedness and response for future respiratory pathogen pandemics. These lessons are collated in alignment with WHO's framework for interconnected core subsystems for health emergency preparedness, response and resilience. This framework includes the domains of emergency coordination, collaborative surveillance, community protection, access to countermeasures and clinical care (for further details, see: Strengthening the global architecture for health emergency preparedness, response and resilience) *(1)*. In addition, collaborative learning and accountability emerged from the scoping review as an important, cross-cutting domain of pandemic preparedness and was included in this document.

Fig. 1 presents key takeaway messages. Each lesson is examined in greater detail beginning on page 2. Fig. 2 (page 2) depicts each individual lesson.

Fig. 1. Key takeaway messages

1. **Preparedness works.** Investing in functional capacities, interoperable systems and critical infrastructure makes the world better equipped to respond to emergencies.
2. **Health is everyone's business.** Pandemic preparedness and response relies on whole-of-government and whole-of-society action. Political leadership, community engagement and collaboration across institutions, sectors and borders are essential.
3. **No one is safe until everyone is safe.** In an interconnected world, what happens in one community or country affects others. Public health and scientific literacy facilitate acceptance and adoption of lifesaving interventions. Vulnerable populations must be prioritized globally.
4. **Response must be agile and adaptive.** As pandemics progress, response systems must rapidly monitor new developments, consider contingencies, adapt to evolving circumstances and operationalize lessons learned.

Collaborative surveillance

Lesson 1: Stronger surveillance and laboratory capacities are essential for early detection of emerging respiratory threats. Alert and enabled health and care workers (HCWs) at the community and facility level are key to detecting and rapidly responding to an event. Enhanced public health surveillance and laboratory capacities can help public health practitioners routinely assess and monitor public health risks and support evidence-based decision-making.

- Risk is difficult to characterize early in an outbreak when evidence is sparse. Therefore, it is important that countries strengthen systems to conduct rapid assessment of the characteristics of newly emerging/re-emerging pathogens, such as transmissibility, infection severity and population immunity, to gather evidence to inform risk assessment as quickly as possible.
- Policymakers and practitioners need to implement mechanisms that integrate data from different sources across the human,

animal and environmental health sectors as well as utilize novel sources of data (e.g. mobile data, social media data). These data can be used to inform rapid risk assessments and response actions for newly emerging respiratory pathogens. In addition to data systems, decision-makers should prioritize bolstering collaboration across the human, animal and environmental health sectors to monitor, identify and sequence novel or emerging respiratory pathogens with pandemic potential.

- Countries should allocate funds to modernize surveillance and reporting mechanisms and platforms, such as through standardized electronic medical records, mobile applications and data management software. These surveillance platforms are needed to facilitate collecting and sharing health information.
- Countries should strengthen linkages among testing programmes, public health laboratories, animal health agencies and clinical institutions. These linkages support timely information sharing, case detection and investigation, risk assessment, reporting and response.
- Policymakers should allocate funds to establish and sustain robust public health laboratories, including resources to develop, validate and roll out new diagnostic tests. Where feasible, potential funding considerations may include laboratory workforce development programmes; acquisition and maintenance of high-throughput technology, reagents, collection kits and transport media; and other supplies and equipment needed to scale up sample processing during pandemics and epidemics (e.g. seasonal influenza and tuberculosis). Partnerships with private laboratories could further bolster these capacities.

Emergency coordination

Lesson 2: Strengthening operational capacities can prepare public health and other sectors – especially One Health institutions – to prevent outbreaks and respond quickly and early to emerging respiratory threats. Bolstering the capacities of rapid responders and investing in emergency response infrastructure can slow outbreaks before they escalate into pandemics.

- Countries should regularly review the functioning of their incident management/command systems and emergency operations centres (EOCs) to ensure effective coordination across agencies, sectors and multiple levels of government. During interpandemic periods, these systems can be used to address endemic threats and emergencies.
- Policymakers and practitioners should exercise plans and emergency response protocols on a routine basis. Simulation exercises offer the opportunity to test national and subnational plans for respiratory pathogen preparedness and identify areas for improvement.

Clinical care

Lesson 3: Robust surge capacities are critical components of protecting health systems, health workforces and communities. Strengthening clinical care capacities can prepare health care institutions to meet increased demands for emergency care during respiratory pandemics, while minimizing disruptions to routine care provision, protecting clinical workforces and mitigating community transmission risk.

- Health systems and clinical institutions should prepare to screen, stabilize and treat larger numbers of patients; share and shift tasks to sustain essential health services; and scale up capacities to provide routine, specialized and intensive care during respiratory pandemics, especially amid potential shortages of clinical staff, supplies and beds. Formulating crisis standards of care could also guide decision-making and resource allocation.
- Leaders should consider policies for improving HCW recruitment, training and credentialing, particularly in resource-constrained settings; enhancing workplace safety (e.g. through robust infection prevention protocols and availability of personal protective equipment (PPE)); providing fair and timely compensation,

including hazard pay; and protecting the morale and mental health of clinical workforces during respiratory pandemics.

- Clinical settings should develop and adopt robust infection control protocols to prevent both nosocomial and community transmission of respiratory pathogens to protect patients, HCWs and the broader public.
- Hospital and health system leaders should consider the ethical implications of various strategies for triaging patients, allocating scarce clinical resources and delaying or suspending routine and/or elective medical procedures to ensure continuity of hospital operations and access to emergency and intensive care for pandemic patients and those seeking care for other conditions.

Lesson 4: Close partnerships between government and nongovernmental entities can improve health response delivery, as well as ensure continuity of essential services and industries. Aligning priorities in these areas within and across countries – as well as among entities across the public sector, private sector and civil society – could enable coordinated responses to emerging threats.

- Collaborative partnerships spanning the human, animal and environmental health sectors could help identify high-priority respiratory pathogens or pathogen families to guide research and development efforts for future respiratory disease threats.
- Governments should re-examine access and benefit-sharing systems for allocating biological materials or genetic sequence data to ensure that the benefits of resultant vaccines, diagnostic tests, therapeutics and other products are shared equitably.
- Governments and private-sector partners should strengthen supply chains for both essential clinical supplies (e.g. PPE, essential medicines) and emergency vaccines, diagnostics and therapeutics.
- Policymakers should consider explicitly integrating civil society organizations and nongovernmental organizations providing essential social services to vulnerable populations into national, regional and global plans for pandemic preparedness and response.
- Governments should conduct planning and improve coordination with critical infrastructure entities across sectors (e.g. food and agriculture, transportation, energy, manufacturing) to ensure the continuity of essential societal functions during respiratory pandemics.

Access to countermeasures

Lesson 5: Expediting the development, production and authorization of emergency medical countermeasures (MCMs) and bolstering manufacturing capacities is a critical tenet of respiratory pandemic preparedness and response. Implementing measures to accelerate MCM development and production – especially in resource-constrained settings – can save lives, protect at-risk populations and prevent undue strain on health systems.

- Countries should explore strategies for harnessing the appropriate "push" and "pull" levers to catalyse early-stage research, product development and testing, robust regulatory oversight and advanced manufacturing for products that may be needed both for future pandemics and diseases that disproportionately afflict marginalized populations (e.g. pan-coronavirus vaccines, universal influenza vaccines, therapeutics for neglected tropical diseases).
- Where appropriate, countries should develop permanent manufacturing capabilities for MCMs and other biological supplies, at the national and/or regional level, to ensure greater variety in the supply chain and quicker access to such assets in an emergency.
- Policymakers, professional bodies, norm-setting institutions and standard-setting organizations should examine legal and regulatory options for ensuring equitable MCM sharing, procurement and distribution during an evolving crisis, such as mutual aid agreements, treaties, material transfer

agreements, intellectual property waivers and/or compacts.

- Regulators should explore options for streamlining MCM clinical trials and authorization for emergency use as well as collaborate with communications experts to effectively convey risks and benefits to consumers, particularly for products developed or manufactured using novel technologies as well as for adapted or non-traditional regulatory review processes. Novel technologies and products must still be carefully and regularly evaluated using post-introduction effectiveness and safety monitoring platforms.
- Governments should collaborate with MCM manufacturers to identify and implement sustainable systems to bolster workforce and production capacities in resource-constrained settings, strengthen quality assurance during emergencies and identify opportunities to repurpose (i.e. "keep warm") manufacturing facilities for routine drug, therapeutic and diagnostic test production.
- Policymakers and practitioners should evaluate the strengths, limitations and effectiveness of existing mechanisms for procuring, allocating and distributing countermeasures and increase support for MCM research, development and manufacturing in low- and middle-income countries (LMICs).
- Countries should identify options for strengthening early purchasing power in LMICs – such as through advance supply contracts and agreements – to enable them to compete with other countries and ensure more rapid and equitable access to MCMs.

Community protection

Lesson 6: Long-term, sustainable investments in routine public health and primary care services are essential to building resilient health systems and communities, which are better equipped to safeguard populations from future respiratory disease pandemics. Investing in robust systems of public health and primary care establishes healthy and resilient communities. Resilient communities, in turn, are better prepared to withstand and rapidly respond to pandemics, such as by scaling up emergency care, maintaining routine health service provision and adapting surveillance systems.

- Countries orchestrating responses to respiratory pandemics should leverage the capacities of legacy health programmes (e.g. seasonal influenza programmes, the Global Polio Eradication Initiative, the Expanded Programme on Immunization, the Global Fund) to support testing, vaccination, treatment and community outreach and engagement.
- Decision-makers should identify opportunities to leverage outbreak response funds, workforces and resources to strengthen systems for routine public health and health care activities.
- Equitable access to routine health services can also help mitigate health and economic disparities among marginalized populations.

Lesson 7: Strong social safety net policies and programmes are needed to mitigate the social and economic impacts of pandemics on vulnerable populations. These programmes and policies help protect vulnerable populations, who often bear a disproportionate share of disease, disability and death stemming from pandemics. These populations also shoulder disproportionate health, social and economic burdens from the very mitigation measures needed to protect the public's health, including loss of income, educational disruptions and barriers to accessing health care and other needed social services.

- Countries – particularly those experiencing humanitarian crises and/or conflict – should ensure that pandemic plans explicitly account for the unique challenges faced by vulnerable populations when navigating travel restrictions; complying with lockdown, isolation and quarantine measures; and accessing health and social services.
- Policymakers should ensure that pandemic mitigation measures protect the public's health without exacerbating baseline social, economic and health inequities. Robust

social safety net programmes and policies – including, but not limited to, paid sick leave, universal health coverage, paid maternal leave, affordable childcare, economic relief payments, business loans and tax relief, eviction moratoria and food assistance – can help protect vulnerable populations from disproportionate exposure to circulating infections, catastrophic health spending and preventable illness and death.

- Dedicated social mobilization and community engagement efforts, including partnerships with community organizations that support vulnerable populations, are key to identifying needs and implementing effective, culturally appropriate and nondiscriminatory pandemic preparedness and response policies and activities. Governments should support civil society organizations – including community and faith-based groups – and community HCWs as these stakeholders are best positioned to reach vulnerable populations and improve public trust in health institutions.
- Policymakers and practitioners should strengthen channels of communication with public audiences. Funds should be allocated towards hiring and training culturally competent risk communicators in both traditional and social media, as well as trusted messengers from at-risk communities. Pandemic plans should also explicitly account for the threats posed by misinformation and disinformation about the origins of emerging pathogens, MCMs and government decisions regarding pandemic mitigation and response.

Lesson 8: Stronger mechanisms for international cooperation and coordination are essential to implementing robust and equitable responses to pandemic threats. These must be considered both within the health sector and other critical infrastructure sectors – such as transportation, manufacturing, food and agriculture – to enhance pandemic response capacities at the country, regional and global level.

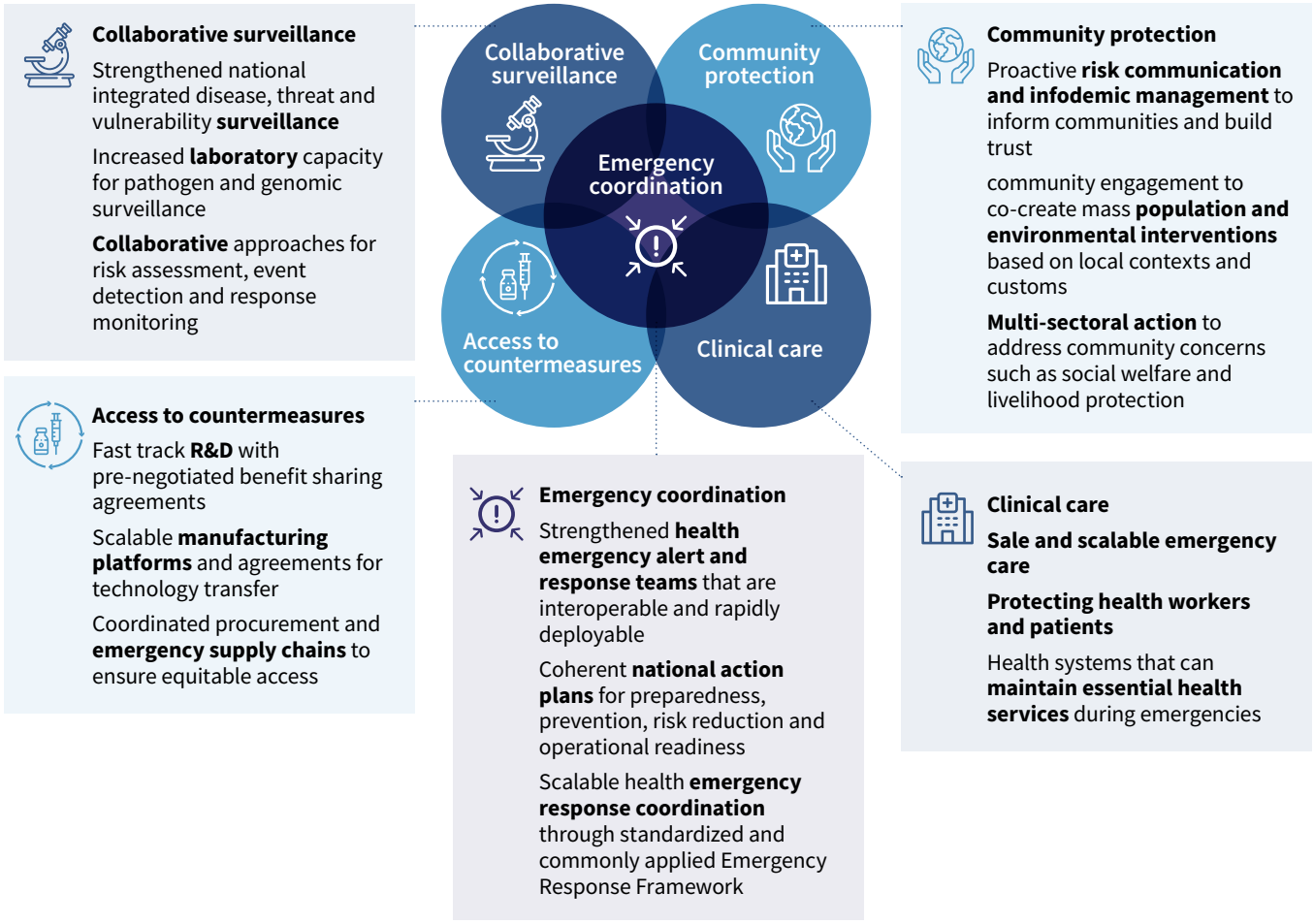
- Countries should build and sustain stronger mechanisms for bilateral and multilateral cooperation and collaboration during respiratory pandemics. Potential areas for strengthening such cooperative mechanisms include but are not limited to resource allocation; response and mitigation policies; MCM research and development, regulation and manufacturing; surveillance and reporting; and supply chain resilience.
- Political leaders and public health practitioners in LMICs should explore opportunities for international cooperation – such as South–South partnerships and triangular cooperation – to build capacities, identify best practices in respiratory pandemic preparedness and response, and share technical expertise.
- Decision-makers and political leaders should carefully consider trade-offs between regionalizing versus decentralizing public health capacities (e.g. laboratory functions, production and procurement capacity for MCMs and other materiel, disease surveillance), health care delivery (e.g. secondary and tertiary clinical services) and essential social safety net services (e.g. welfare programmes, poverty eradication initiatives). Potential benefits of decentralization include greater flexibility in implementing response activities, better-informed resource allocation and improved capacities to address the needs of vulnerable populations. However, risks include fragmentation of health service delivery, increased competition between policy priorities and weakened cross-sector coordination.

Collaborative learning and accountability

Lesson 9: Policymakers, practitioners and researchers must proactively identify and learn from past successes and failures, taking steps to institutionalize best practices in pandemic response. The COVID-19 pandemic illuminated flaws in existing systems and practices but also highlighted governments' and health systems' abilities to evolve and adapt existing policies, capabilities and programmes to enhance preparedness and response. Iteratively documenting and sharing these lessons and

opportunities could improve institutional learning and enhance readiness for future respiratory pandemics.

- Monitoring, evaluation, reporting and learning (MERL) frameworks and systems can identify best practices in respiratory pandemic preparedness, response and recovery; codify lessons identified; preserve institutional knowledge and expertise; and ensure operational readiness for future threats.
- Donors and policymakers can support pandemic plan revisions through dedicated funding, human resources and programmatic support.
- Decision-makers, practitioners and researchers should routinely assess whether current practices in respiratory pandemic preparedness are, in fact, "best" practices. Regularly exercising and testing operational plans, performing action reviews and monitoring health system capacities over time (e.g. joint external evaluations, State Party Self-Assessment Annual Reporting) could support these efforts.
- Stakeholders involved in improving preparedness for future respiratory pandemics can proactively build human-to-human connections and collaborative relationships through communities of practice, both domestically and internationally, to facilitate continuous learning and accountability, scientific and technical exchanges, and refinement of pandemic plans and response systems.



Introduction

Acute infectious disease outbreaks – particularly those caused by respiratory pathogens – pose major threats to lives, livelihoods and social fabrics around the world. Diseases like tuberculosis, severe acute respiratory syndrome (SARS 2003), Middle East respiratory syndrome (MERS), H1N1 pandemic influenza and seasonal influenza have tested the world's ability to implement a swift response. Lessons from each event have informed efforts to strengthen systems for detection, surveillance, medical countermeasure development, and other critical elements of prevention, preparedness, response and recovery. Importantly, these events have also underscored the importance of equity in pandemic preparedness, detection and response efforts, whether promoting transparency in pandemic response product pricing, facilitating technology transfers or ensuring fair, equitable and timely access and benefit sharing *(2)*.

Despite important gains made in health security capacity building and health systems strengthening, the rapid emergence and spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) illuminated critical gaps that persist in national and international approaches to respiratory pathogen preparedness and response. Broadly, the COVID-19 pandemic has demonstrated that both routine health system capacities and global health security capacities (i.e. those required to prevent, detect and respond to acute infectious disease threats) are necessary for an effective response to a respiratory pathogen pandemic. COVID-19 has also illustrated how existing inequities are magnified when epidemics and pandemics occur, and how all of society can be affected by a respiratory pathogen. Sectors that had not previously considered contingency plans for public health emergencies have now had first-hand experience preparing for such events.

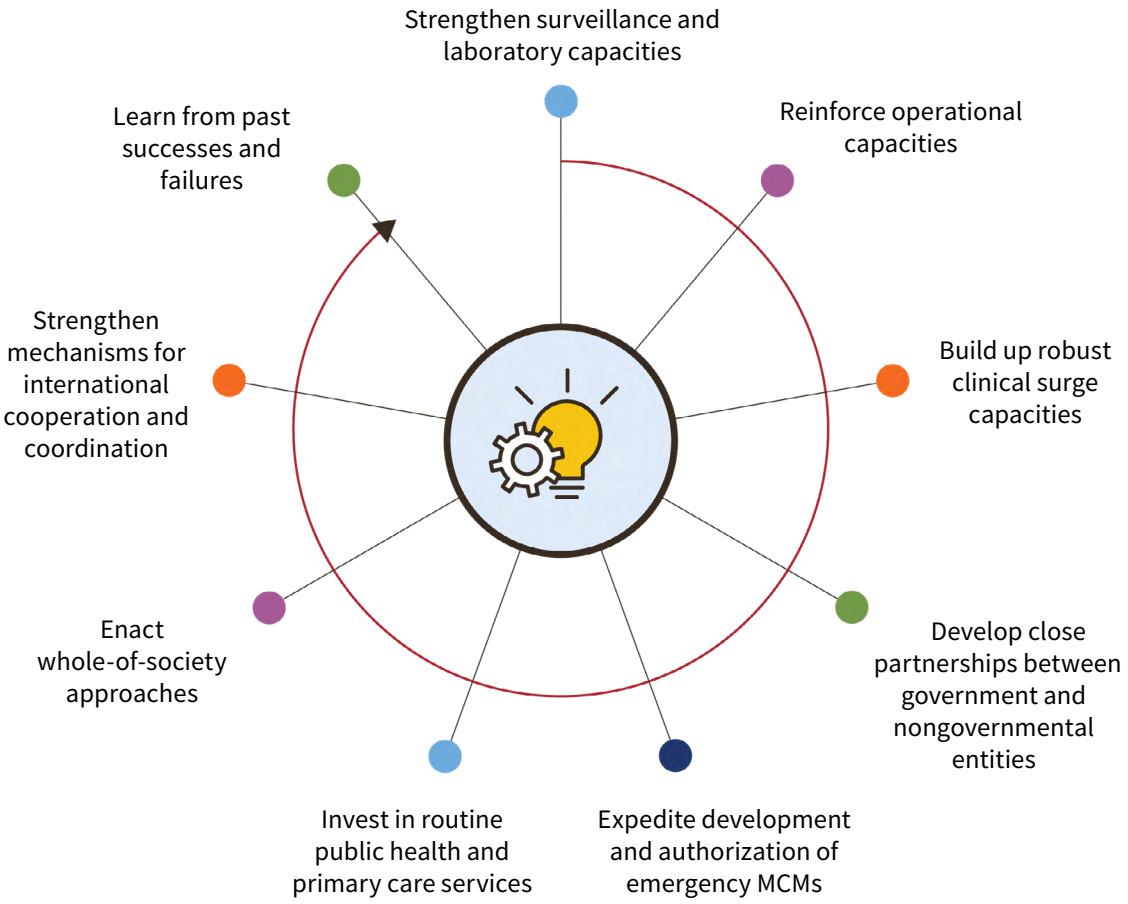
The response to COVID-19 has been protracted and all-encompassing with successes as well as challenges. It is imperative that decision-makers, political leaders, public health and health care practitioners, researchers and vulnerable communities identify and reflect on lessons from responding to the pandemic. These lessons, in turn, should inform preparedness planning for future events.

Many initiatives are underway to take stock of COVID-19 lessons and translate them into actions, including several at WHO. One such effort by WHO is an initiative to strengthen pandemic preparedness planning by mode of transmission – Preparedness and Resilience for Emerging Threats (PRET). PRET has developed respiratory pathogen pandemic preparedness guidance and tools to support countries in updating their pandemic plans. This work by WHO corresponds with World Health Assembly (WHA) resolutions WHA58.5, WHA74.7 and WHA75.7, in which WHO committed to supporting Member States with pandemic preparedness planning by providing guidance and technical assistance. PRET corresponds with national and regional requests for an integrated approach to pandemic preparedness for respiratory pathogens that aligns with the **International health regulations (2005)** (IHR) *(3)*and the **WHO guidance on preparing for national response to health emergencies and disasters** *(4)*.

To inform work by PRET, WHO commissioned the Johns Hopkins Center for Health Security to perform a scoping review of key COVID-19 lessons. This document is intended to summarize major lessons from COVID-19 which should form the core of future preparedness work.

The methodology used to develop this report is available in Annex I.

Fig. 2. High-level lessons identified from COVID-19 to inform preparedness for future respiratory pandemics



Lessons identified from the global COVID-19 experience

Collaborative surveillance

Lesson 1: *Stronger surveillance and laboratory capacities*

Stronger surveillance and laboratory capacities are essential for early detection of emerging respiratory threats. **Alert and enabled health and care workers (HCWs) at the community and facility level are key to detecting and rapidly responding to an event. Enhanced public health surveillance and laboratory capacities can help public health practitioners routinely assess and monitor public health risks and support evidence-based decision-making. Strengthening linkages across human and animal health sectors for early detection.**

Public health practitioners should collaborate with partners in the human and animal health sectors to identify, sequence and monitor novel or emerging respiratory pathogens with pandemic potential *(5, 6)*. The COVID-19 experience highlighted that all countries should invest in systems to monitor domesticated and wild animal populations that are known to carry pathogens with the ability to infect humans, and that are in regular or predictable contact with humans. Once a pathogen of concern has been detected, this information should be shared with public health laboratories, animal health agencies and clinical institutions to prompt further case detection. In this vein, many countries were able to leverage pandemic influenza plans and

capacities into strategies for COVID-19 response. In addition to leveraging operational capacities for influenza and other communicable disease threats, many countries adapted their pandemic influenza risk characterization frameworks for COVID-19 *(7)*. Through these experiences, the global scientific community has learned more about the characteristics of potential pandemic pathogens, particularly those with respiratory modes of transmission.

Many countries leveraged pandemic influenza plans and capacities into strategies for COVID-19 response.

- **Indonesia:** Public health practitioners successfully and rapidly activated their avian influenza reference laboratory network to support COVID-19 efforts *(8)*.
- **Nepal:** District-level veterinary laboratories were converted into SARS-CoV-2 testing centres *(9)*. Nepal also created standardized national guidance for preparing laboratories to serve as SARS-CoV-2 testing centres *(10)*.
- **WHO African Region:** National Influenza Centres rapidly leveraged existing testing systems to scale up SARS-CoV-2 testing capacities across the region. Countries with existing influenza laboratory-based surveillance capacity were significantly faster at introducing SARS-CoV-2 testing than other countries *(11)*.

In addition to bolstering linkages between sectors to support surveillance and sequencing, the COVID-19 pandemic also demonstrated that stronger linkages among testing programmes, public health institutions and clinical institutions are needed to diagnose potential cases. As seen during the COVID-19 pandemic, many countries' national public health laboratory systems were quickly overwhelmed amid sustained community transmission. However, countries with previous experience in responding to a respiratory epidemic often had existing mechanisms and capabilities that readily lent themselves to mitigating the threat at hand *(12)*. Countries should invest in strong public health laboratory networks with clear and established triggers and processes to incorporate private laboratories when testing demand outpaces capacity. Additionally, situating testing services in convenient locations or as close as possible to points of care is important, given that some populations may be unable or unwilling to travel to hospitals or large testing facilities for fear of falling sick.

Robust linkages between testing programmes, public health institutions and clinical institutions are needed to monitor cases during respiratory pandemics.

- **Republic of Korea**: Leveraged agreements formed during the 2015 MERS-CoV epidemic to rapidly incorporate private laboratories into SARS-CoV-2 testing efforts *(13)*.
- **Singapore:** Private and university laboratories played important roles in meeting the demands of mass testing *(12, 14)*.
- **Uganda:** Launched a decentralized testing system comprising 24 designated laboratories spanning the country, which reduced turnaround times for SARS-CoV-2 test results from 7 days to 1 day *(15)*.

Creating and maintaining sustainable workforces for laboratory readiness

The COVID-19 experience highlighted which reagents and materials are required for mass testing (e.g. certain buffers, enzymes, swabs), regardless of the causative agent. The testing delays that many countries reported during the COVID-19 pandemic may be avertable by ensuring that critical reagents, swabs and machinery are stockpiled in advance, and by releasing additional funds for laboratories following the declaration of a public health emergency *(17)*. Partnerships with private laboratories could further bolster these capacities, particularly since these entities often have access to their own suppliers, distributers and manufacturers to maintain operations *(8)*. To assist private laboratories or other non-public-health laboratories in rapidly standing up pandemic testing capacity, pre-established training guidance and standard operating procedures could help onboard new laboratory staff more rapidly *(18)*.

Countries can develop stockpiles of critical laboratory supplies ahead of the next respiratory pandemic. Policymakers should also consider allocating funds to establish and sustain laboratory workforce development programmes, as well as to purchase and maintain high-throughput laboratory technology, reagents, collection kits and other supplies required to scale up sample processing during a crisis *(16)*.

Streamlining reporting mechanisms for rapid and meaningful interpretation

In many countries, COVID-19 reporting largely relied on manual data-sharing processes, which significantly slowed reporting times. Embedding shared surveillance systems and data streams within primary health care centres and community health centres could aggregate much-needed data at the local or community level *(19, 20)*. Regardless of the system used, considerable investment in data storage, analysis and bioinformatics workforces is needed to transform raw data into actionable information for decision-makers.

Policymakers and practitioners should consider strategies for integrating data collection, reporting and analysis across the human, animal and environmental health sectors, as well as for utilizing novel sources of data (e.g. mobile data, social media data) to inform pandemic response activities *(5, 21, 22)*. WHO's Global Influenza Surveillance and Response System (GISRS) may provide countries with best practices for scaling up surveillance for emerging respiratory pathogens within existing surveillance and laboratory infrastructures: during the COVID-19 pandemic, for example, national influenza centres operating under GISRS expanded surveillance and laboratory capacities to carry out concurrent influenza and SARS-CoV-2 testing *(23)*. GISRS also provides countries with blueprints for supplying reagents, training laboratory workforces, sample sharing, setting standards and developing methodologies for laboratory testing, and performing quality assessments *(24, 25)*. To build or strengthen these capacities, countries should allocate funds to modernize surveillance and reporting mechanisms and platforms to facilitate collecting and sharing health information – such as through standardized electronic medical records, mobile applications and data management software – to rapidly provide integrated health data to the appropriate authorities.

Steps also should be taken to ensure that samples collected for sequencing and surveillance analysis are proportionally representative of the population at large and can be used to address the needs of vulnerable groups *(6)*. Countries should create standards for electronic medical records and data reporting; without these, differing methods of data collection could complicate efforts to standardize data or render it unusable *(12)*. All countries should create a central coordinating office to ensure that these systems are functional, up to date and well staffed *(26)*. At the global level, ongoing WHO-led efforts to establish a global surveillance system with inputs from different regions will include animal and environmental sampling *(27, 28)*. Such a system could further enable rapid detection of emerging respiratory pathogens with pandemic potential.

Emergency coordination

Lesson 2: *Strengthening operational capacities*

Strengthening operational capacities can prepare public health and other sectors – especially One Health institutions – to prevent outbreaks and respond quickly and early to emerging respiratory threats. **Bolstering the capacities of rapid responders and investing in emergency response infrastructure can slow outbreaks before they escalate into pandemics.**

Respiratory pandemics require robust preparedness and response operations and coordination among diverse agencies, sectors and jurisdictions. Traditional all-hazards approaches to establishing and maintaining preparedness and response capacity can provide core capacities – such as organizational and control structures, communications protocols and logistical support – that are applicable across a broad scope of emergencies and other hazards, the principles of which are outlined in the WHO's Emergency Response Framework *(29)*. The unique nature of pandemics, however, demands specialized capabilities, particularly in terms of disease surveillance and clinical patient care. Coordination is a critical component of pandemic response that enables all other functions to operate effectively. Effective coordination alone may not ensure a successful response, but poor coordination will almost certainly generate issues. Similarly, establishing necessary capacities – all-hazards or event specific – does not ensure they will be ready in the event of an emergency. These capacities must be regularly exercised and tested to remain aligned with current best practices, identify existing gaps and implement corrective actions. Effective training and exercise programmes require resources and dedicated effort to promote long-term, sustainable improvement.

Incident management systems

Beyond advance planning and relationship building – and ongoing training and exercise programmes required to establish and maintain coordination capacity during emergency response – the incident management system (IMS), or incident command system (ICS), and EOCs are key components of emergency management infrastructure. The IMS/ICS and EOCs provide operational command and communications structures necessary for implementing effective response operations. WHO has developed guidance that outlines key components of the IMS/ICS and EOCs, including considerations for public health emergencies *(30)*. The IMS/ICS facilitates coordination across agencies and sectors, while EOCs function as central nodes for linking multiple levels of government (e.g. local, state, regional or national) as well as multiple jurisdictions at the same level of government, such as neighbouring states or cities. In addition, they connect governmental and nongovernmental organizations, including those in the private sector. EOCs also house core response leadership functions, such as operations, logistics, planning, as well as finance and administration. Many EOCs also serve as central hubs to collect and analyse data from different response organizations, providing critical intelligence to support decision-making capacity for response leadership.

The utility of the IMS/ICS, EOCs and other critical pandemic preparedness and response infrastructures is not limited to pandemics. These assets can be leveraged to support routine programmes, planned events or smaller-scale responses *(31)*. Preparedness and response capacity requires considerable investment to establish and maintain, and routinely use, personnel, equipment and supplies, facilities and systems. Routine use ensures that these resources and programmes remain active and tested, so they are ready for larger emergencies.

Centralized leadership, policymaking and operational direction are critical components of success in jurisdictions around the world.

- **United States:** Delays in establishing a "coherent nationwide response" resulted in inconsistent response strategies at the state and local level *(6)*.
- **WHO Regional Office for Africa:** The office found that strong political leadership and commitment were essential to successfully coordinating and implementing COVID-19 response interventions *(32)*.

Exercises

Simulation exercises provide opportunities to test preparedness plans and capabilities, maintain operational readiness, and identify and correct gaps in advance of the next emergency *(14, 33–35)*. Two valuable components of exercises are the ability to test how capacities, policies and collaboration will function under emergency conditions and the ability to identify and correct existing shortcomings *(35)*. In many cases, preparedness programmes grew out of experiences during past emergencies – such as the 2003 SARS epidemic, the 2015 MERS epidemic in the Republic of Korea, the 2013–16 West Africa Ebola epidemic, and even volcanic eruptions and earthquakes – that illustrated shortcomings in response operations, and exercises afford critical opportunities to test newly implemented capacities *(5, 12, 15, 31, 32, 35, 36)*. Research conducted during the COVID-19 pandemic found that countries that conducted exercises in advance were better prepared to carry out the large-scale response operations required during the pandemic *(12)*.

Policy-focused exercises are an ideal format for presenting decision-makers with complex dilemmas that demand nuanced policy solutions, as well as providing opportunities to collaboratively develop solutions and identify resource gaps in advance of an emergency *(33, 34)*. In policy-based exercises, policymakers, stakeholders and other experts can discuss the technical, political, social and economic aspects of difficult decisions for which there are no perfect solutions, such as how to allocate scarce resources or balance health benefits and risks against the economic impacts of pandemics.

Clinical care

Lesson 3: Robust clinical surge capacities

Robust surge capacities are critical components of protecting health systems, health workforces and communities. **Strengthening clinical care capacities can prepare health care institutions to meet increased demands for emergency care during respiratory pandemics, while minimizing disruptions to routine care provision, protecting clinical workforces and mitigating community transmission risk.**

The COVID-19 pandemic starkly illustrated how large-scale health emergencies can overwhelm health system capacities across large geographical areas. Essentially every country was affected, leaving few excess resources at the regional or global level to provide humanitarian aid or other support to countries in need. Hospitals operating at or well above their intended capacity were reported in many countries, regardless of income status and health system quality. The sheer volume of patients during a pandemic requires space, personnel, equipment and supplies far beyond many health systems' available capacity. National response plans did not adequately account for the surges in demand for care during the COVID-19 pandemic, especially in intensive care units (ICUs) *(17)*. In some countries, hospitals and ICUs routinely operate near their design capacity, and there is little excess space for surge capacity during an emergency, let alone a prolonged event like a pandemic *(37, 38)*. Therefore, local, national and global health systems need to develop and implement practices to rapidly scale up capacity

to meet surge demand in pandemic scenarios, accounting for bed space, medical supplies and staffing. Notably, early access to clinical care and hospitalization for severely ill patients was shown to reduce the risk of negative outcomes, highlighting the importance of efficiently allocating available resources amid insufficient inventory or supply *(15)*.

Health system capacity

Acute pandemic clinical care

Early in the pandemic – amid relatively low caseloads and considerable uncertainty regarding proper infection prevention, control practices and treatment options – many hospitals utilized high-containment approaches (e.g. high-level isolation units), similar to protocols for high-consequence infectious diseases like Ebola virus disease.

When rising COVID-19 case numbers quickly exceeded these capacities, health systems had to rapidly adopt strategies more conducive to high-capacity operations, including cohorting COVID-19 patients in converted clinical spaces or establishing large-scale temporary treatment or isolation facilities *(38)*. With limited clinical surge capacity, health systems in many countries went to great lengths to expand hospital bed capacity in hopes of meeting the demand for care during pandemic peaks *(6, 39)*. Though novel approaches implemented during the COVID-19 pandemic addressed health system limitations in the short term, dedicated and innovative efforts are needed in the longer term to enhance sustainable and resilient health system "adaptive capacities" for future respiratory pandemics *(40, 41)*. This includes identifying options for community-based decentralized care as described in the section below on essential health services.

Government-led action to scale up clinical management capacities – often in collaboration with private, nongovernmental and international organizations – was essential to preventing health care facilities from being overwhelmed by COVID-19 cases.

- **China:** The government constructed two modular hospitals in Wuhan, a measure that bolstered local hospital capacities by more than 2 500 beds (+22%) within 12 days *(15)*.
- **Germany:** Prior to COVID-19, the number of hospital beds per capita in Germany was already twice the Organisation for Economic Co-operation and Development (OECD) average. Based on epidemiological forecasts during the early days of COVID-19, however, Germany proceeded to expand its national intensive care capacity from 28 000 beds equipped with ventilators to 40 000 beds *(15)*.
- **Republic of Korea:** Hospital beds were reserved for patients with severe COVID-19, while patients with milder cases convalesced in dormitories. Additionally, patients with confirmed disease, regardless of nationality, were treated free of charge *(42)*.

Health care workforce

Insufficient staffing prior to the COVID-19 pandemic and attrition during the pandemic response – both voluntary and due to COVID-19 illness and death – led to major workforce shortages across the world. In some cases, HCW shortages were driven by funding cuts to public health care institutions made prior to the pandemic *(43–45)*. These shortages, in turn, led to difficulties in managing escalating hospitalizations amid shortages of other health care resources like beds, supplies and equipment. These effects were even more pronounced in health systems operating in resource-constrained settings, as well as in places battling humanitarian crises, armed conflict and other health emergencies *(46)*.

Governments implemented a variety of emergency approaches to address these shortages during a crisis, such as by reassigning HCWs from nonemergency specialties to supplement COVID-19 patient care. In contrast to previous health emergencies, the combination of global impact and prolonged response meant that excess personnel could not be redeployed from unaffected areas, resulting in health systems competing for limited personnel. Many countries also attempted to supplement the existing workforce by recruiting additional personnel, including retired HCWs, students, researchers, foreign HCWs and military personnel, and in some cases allocated large pools of emergency funding to hire new HCWs *(5)*. Notably, this posed some challenges regarding these individuals' degree of expertise and experience. In some countries, for example, personnel working in sectors that shuttered during periods of intense "lockdown" or other restrictions (e.g. commercial airlines, hospitality) worked in a "nonmedical capacity" in health care facilities *(12)*. In some cases, onboarding new personnel required regulatory flexibility to issue, extend or reactivate required licences and certifications *(12, 18, 19, 47, 48)*. The literature also noted that improving training programmes, financial compensation, physical health and mental well-being support, workload and other factors can improve employee retention and mitigate barriers to reallocating personnel during a health emergency *(49)*. However, more sustainable, flexible and resilient HCW training and staffing models are urgently needed to protect health systems during a broad scope of acute and prolonged health emergencies, including respiratory pandemics *(35, 41, 50)*.

Essential health services

Beyond clinical capacity for COVID-19 patients themselves, many health systems faced challenges providing non-COVID-19 services during the pandemic. Constrained by limited bed space, staffing, supplies and equipment, health systems were forced to suspend procedures, screenings and other preventive services *(18, 38, 41, 49, 51–55)*. Associated delays and barriers to accessing care contributed to increased excess mortality during the pandemic, much of which may have been preventable under routine conditions *(50)*. Conditions like cancer, for example, may not require urgent care on a routine basis but may require early detection and intervention; as such, delays in screening or treatment can drastically affect patients' long-term prognoses *(37, 53)*. Dentistry, psychology and psychiatry, addiction treatment, midwifery and other fields providing non-COVID-19 health services were similarly impacted *(37, 53, 56)*.

Existing health clinics and programmes established through capacity building for other health priorities – such as Ebola, tuberculosis, malaria, HIV/AIDS, routine immunizations, and maternal and child health – were repurposed to support the COVID-19 response, redirecting personnel and other resources or suspending operations *(41, 50, 56–58)*. One analysis estimated that a 6-month disruption in HIV/AIDS services and care could result in an additional 300 000 AIDS-related deaths in sub-Saharan Africa over the following year, a nearly 70% increase and a return to mortality not observed since 2011. This disruption was also projected to cause a 40–80% increase in childhood HIV infections in high-burden countries *(58)*. Unsurprisingly, highly vulnerable populations were at greater risk of losing access to essential health services during the COVID-19 pandemic, further exacerbating existing health disparities *(18, 20, 56)*. Inadequate patient capacity and barriers to health service access resulted in untold excess morbidity and mortality for non-COVID-19 conditions during the pandemic, as patients were unable to receive the care they needed *(52)*.

Efforts to expand remote or virtual health care services, relax prescription restrictions to permit multi-month prescriptions or accelerated refills and implement at-home care – including for mild COVID-19 cases – provided some relief. Many countries reserved limited urgent care and emergency department resources for severely ill patients, but these measures are not suitable for all conditions or procedures *(8, 18, 37, 41, 53, 56, 58–61)*. COVID-19 also highlighted the importance of bolstering capacities for community-based management of mild-to-moderate infections

during respiratory pandemics, a particularly important consideration in settings with fragile health systems *(58)*. For example, countries can implement measures such as community-led education on disease prevention. To prevent transmission, countries can engage with places of work, worship and recreation and support for individuals in quarantine or isolation. These activities could help preserve health system capacities as demand for facility-based care escalates during a crisis *(58)*.

Measures to support community-based case management, home care and self-managed care are essential for preserving health system capacity during a respiratory pandemic.

- **Home-based health care:** Primary care providers in Albania and Bulgaria provided at-home consultations and treatment for confirmed COVID-19 cases, referring patients to hospitals as needed; likewise, Kyrgyzstan, Montenegro and San Marino deployed mobile teams to follow up on patients convalescing at home *(18)*. Health workers in Germany also made home visits to patients convalescing outside of health facilities *(15)*.
- **Red Cross organizations:** In the Czech Republic, local branches of the Red Cross trained volunteers to support hospitals and care homes. The Serbian Red Cross deployed volunteers to check on vulnerable populations (e.g. individuals experiencing homelessness, Roma families). Dutch Red Cross volunteers also supported government helplines to assist people with COVID-19-related anxiety *(18)*.
- **Telehealth:** Prior to COVID-19, Germany made considerable investments in expanding telemedicine capacities, which proved effective during the pandemic *(15)*. Similarly, Hungary, Ireland and Malta set up triage telephone lines to remotely register complaints, monitor symptoms and refer suspected cases for SARS-CoV-2 testing *(18)*.

Patient triage

During respiratory pandemics, patients will have varying levels of disease severity. Health systems must be able to triage patients so that they receive the appropriate level of care in a timely manner. Because providing ICU care is highly resource intensive, it should be reserved for the highest-need patients to maximize limited resources *(12, 42, 62)*. During the COVID-19 pandemic, some hospitals without ICU space were able to transfer severely ill patients to neighbouring facilities or jurisdictions with excess capacity, but this was not an option in many parts of the world *(43)*. In addition to ICU capacity, medical equipment (e.g. mechanical ventilators, extracorporeal membrane oxygenation) and clinical supplies (e.g. medical-grade oxygen, PPE) were in short supply across many health systems *(15, 36, 40, 43, 50, 55, 63–65)*. Thus, evidence-informed crisis standards of care are needed to promote efficient, equitable and ethical allocation of scarce medical resources *(26, 43, 66, 67)*.

Integrated health systems can facilitate centralized tracking of patient demand and available beds, thereby enabling patient triage to facilities with sufficient space and expertise *(12)*. Some countries established COVID-19 and non-COVID-19 facilities to concentrate clinical care resources for COVID-19 patients and maintain essential services at other facilities *(12, 42, 51, 66)*. Regional-level coordination can provide the ability to triage patients and make more efficient use of available resources across a larger geographic area and affected population *(68)*. To reduce the burden on urgent care centres and emergency departments, many health systems also established dedicated testing clinics *(15)*. Treating patients with mild COVID-19 at home or outside of hospitals also provided flexibility for struggling health systems by enabling them to reallocate resources for severely ill patients *(12, 58)*. In many LMICs, however, community-based care was also necessary for more severely ill patients, due to limited health system capacity *(58)*.

Infection prevention and control

Nosocomial transmission of respiratory pathogens poses a major risk to HCWs, who often are at high risk of infection by virtue of their proximity to sick patients *(35, 46, 69)*. This holds especially true for newly emergent pathogens without reliable, evidence-based guidance regarding clinical management or available MCMs, and during periods of high patient surge, when space at health facilities, personnel, equipment and other medical resources are in limited supply. The COVID-19 pandemic illustrated the critical importance of effective infection prevention and control (IPC) programmes and practices in health care settings to protect HCWs, essential workers and patients, particularly in the absence of effective MCMs *(8, 46, 55, 62, 70, 71)*.

Interruptions to national and global supply chains amid historic levels of demand severely constrained the availability of PPE (e.g. gloves, surgical masks and respirators) during the COVID-19 pandemic *(72)*. Many health systems were forced to ration available PPE, such as by extending HCWs' use of respirators to multiple patients *(72)*. Extraordinary efforts were required to develop, test and authorize procedures to disinfect and reuse critical PPE, including respirators. As a result, some experts have called for modernizing PPE, such as by designing respirators that are reusable and more comfortable for prolonged use *(73)*.

Beyond the availability of critical PPE supplies, training programmes on proper IPC practices – such as disinfection, PPE donning and doffing, and respirator fit testing – are necessary to ensure IPC efforts are having the desired effect *(5, 38, 41, 66)*. Many hospitals and traditional health care settings have robust IPC cultures and training programmes, but other types of health facilities, such as long-term care facilities and nursing homes, did not necessarily operate to the same standards during the COVID-19 pandemic. Increased attention and investment from health care leaders is needed to establish and maintain effective IPC cultures outside of hospitals, especially in facilities caring for high-risk patients *(74)*. Dedicated facilities for treating patients with high-severity or highly transmissible respiratory diseases have advanced isolation capabilities and stringent IPC protocols, but this capacity is limited and often rapidly exhausted during large-scale or prolonged health emergencies like pandemics *(5)*. Traditional IPC capabilities and principles must be core capacities for any health care facility *(75)*.

Personnel training, support, safety and mental health

HCWs faced serious mental health challenges during and after the pandemic response that, at times, rivalled or increased the risks to their physical health *(12, 76)*. Intense, prolonged stress resulting from continual exposure risk, strenuous workload, isolation from friends and family, insufficient supplies and equipment, as well as witnessing perpetual suffering and death, contributed to a broad scope of mental and emotional health issues. HCWs also faced stigma, discrimination and other negative reactions from friends, family and the broader public, sometimes because of perceptions about their risk of infection while treating patients *(35, 56)*. Additionally, the frenetic pace of the response did not afford HCWs the time necessary to process stress and grief, particularly amid repeated waves or surges *(77)*. Many HCWs were also required to work outside their specialty or area of expertise, which caused further stress *(41, 70)*. Mental health conditions included anxiety, grief, depression, fatigue, "burnout", moral injury, post-traumatic stress disorder, sleep disorders and substance abuse *(78, 79)*. Health systems faced a self-amplifying cycle during the pandemic, in which insufficient staffing led to overworked personnel, which drove burnout and attrition, in turn creating even more staffing shortages *(12)*. Thus, to maintain a healthy, motivated health and care workforce during a fast-moving respiratory pandemic, programmes and resources must be in place to protect HCWs both physically and mentally.

Peers and direct supervisors often act as the first line of defence against the adverse effects of stress and mental health injury *(35, 41, 77)*. Regular screening and check-ins can

proactively mitigate stressors and identify early signs of mental health issues *(76)*. Additionally, representation across disciplines and types of HCWs (e.g. physicians, nurses, technicians) in health system and pandemic response leadership can provide a forum for HCW advocacy *(80)*. Some health systems employed psychologists to provide professional mental health support for personnel *(53, 76)*. Like telehealth services for physical health, "telemental health" was found to improve access to mental health services *(12, 53, 76)*. In hopes of preventing workforce attrition and worsening staff shortages, some governments offered financial incentives to frontline HCWs as acknowledgement of their hard work, personal risk and sacrifice *(32, 41, 71)*. Regardless of the approach, perhaps the most critical component of addressing health workforce burnout is ensuring that personnel feel safe and protected and are aware that they can seek mental health support without fear of reprisal *(48)*. During pandemic periods, countries can make efforts to mitigate mental health risks by ensuring scaling up staff and providing supportive supervision and resources *(12)*.

Lesson 4: Partnerships between government and external entities

Close partnerships between government and nongovernmental entities can improve health response delivery, as well as ensure continuity of essential services and industries. **Aligning priorities in these areas within and across countries – as well as among entities across the public sector, private sector and civil society – could enable coordinated responses to emerging threats.**

Establish multisectoral collaborative mechanisms to facilitate rapid response measures

Scientists rapidly published the initial genetic sequence of SARS-CoV-2 online; however, sharing sequences is significantly easier than sharing samples, due to constraints imposed by export barriers and sample-sharing frameworks. During the 2013–16 West Africa Ebola epidemic, sharing of biological materials proved to be difficult due to Ebola's classification as a high-risk pathogen. Many countries reported the same challenges during the COVID-19 pandemic.

Countries should take steps to ensure that existing plans, frameworks and export laws account for similar challenges posed by future respiratory pathogen threats. Governments should re-examine regulatory tools, policies and mechanisms for sharing biological materials (e.g. clinical specimens, genomic data) during respiratory pandemics, and ensure that the benefits of resultant vaccines, diagnostic tests, therapeutics and other products are shared equitably. Existing frameworks negotiated by countries, such as the Pandemic Influenza Preparedness (PIP) framework, have helped address this challenge for a specific pathogen and can serve as a model *(81, 82)*.

In some countries, institutions with strong sequencing capacities acted as regional hubs for SARS-CoV-2 variant tracking, sequencing and characterization.

- **India:** The Council of Scientific and Industrial Research in New Delhi played an important role in monitoring and characterizing the Delta variants of SARS-CoV-2 during and after India's COVID-19 surge in spring 2021 *(83)*.
- **South Africa:** The Network for Genomic Surveillance in South Africa – part of a laboratory network spanning the continent – first alerted the world to the spread of the Omicron variant of SARS-CoV-2, having identified the variant in sequencing data from Botswana *(84)*.

Collaboration is also needed across sectors. Governments should conduct planning and improve coordination with critical infrastructure entities outside the health sector (e.g. food and agriculture, transportation, energy, manufacturing) to ensure the continuity of essential societal functions during respiratory pandemics. Many countries did not have measures in place to adequately protect essential workers in these sectors *(85)*. In many countries, essential workers also are more likely to be economically or physically vulnerable *(85)*. Policymakers should therefore explicitly plan for the continuity of critical infrastructure during respiratory pandemics across both the public and private sectors. Such plans might include activities like stockpiling MCMs for essential workers outside the health sector, procuring PPE and prioritizing these workforces for vaccination and testing.

Finally, collaborative partnerships among sectors spanning human, animal and environmental health could help identify high-priority pathogens or pathogen families to guide research and development efforts for future respiratory threats. Professional training programmes and academic curricula focusing on One Health – a collaborative, multisectoral approach to optimizing health outcomes that recognizes the interconnectedness among people, animals, plants and the environment – are not only central to respiratory pandemic prevention but could also help raise awareness of pandemic threats across the human, animal and environmental sectors *(49, 86)*. By preventing viruses from spilling over from animal to human populations – such as by reducing habitat loss, slowing or halting land degradation and monitoring livestock populations – countries can avert the immense health and socioeconomic costs associated with respiratory pandemics *(27)*.

Plan for intentional incorporation of the private sector into public health emergency response

In many settings, private-sector entities have a strong track record of proactive engagement with government during large-scale public health emergencies. The private sector played an enormous role during the COVID-19 pandemic, with many pharmaceutical companies beginning to develop therapeutics and vaccine candidates before national governments initiated these efforts. The Coalition for Epidemic Preparedness Innovations (CEPI) is one example of a high-profile alliance among public, private, civil and philanthropic entities that aims to finance and coordinate development of new vaccines to combat infectious disease epidemics. During the COVID-19 pandemic, CEPI funded development of numerous SARS-CoV-2 vaccine candidates and spearheaded the 100 Days Mission to identify strategies for accelerating pandemic vaccine development, testing and deployment *(87)*.

Governments should incorporate national private sector stakeholders into pandemic planning. Policymakers should consider explicitly integrating civil society organizations and nongovernmental organizations (e.g. community and faith-based organizations) providing essential social services to vulnerable populations into national, regional and global plans for pandemic preparedness and response. Many countries reported that even a robust supply of countermeasures was not enough to protect population health from COVID-19 if the most vulnerable individuals were unable to access them. As a result, civil society, philanthropic, and community and faith-based organizations played critical roles in reaching populations without access to vaccines, therapeutics and/or reliable information about COVID-19.

The COVID-19 pandemic gave rise to many successful models of public-private collaboration in countries across the world.

- **Singapore:** The country formed a COVID-19 task force to coordinate information sharing across public and private entities, thereby enabling rapid decision-making *(12)*.
- **South Africa:** The country's National Incidence Management Team undertook training, resource sharing and technical exchanges with the private sector to enhance working knowledge of best practices in COVID-19 mitigation *(31)*.
- **United States:** The Operation Warp Speed programme facilitated the rapid development, manufacturing and administration of millions of doses of novel SARS-CoV-2 vaccines through complex coordination among many federal agencies and vaccine manufacturers *(88)*.

Countries reported many encouraging examples of civil society, community and faith-based organizations leveraging existing networks to deliver essential services to vulnerable communities during the COVID-19 pandemic.

- **Ghana:** The Christian Health Association of Ghana, Caritas Ghana, the Faith in Ghana Alliance, the Media Foundation West Africa, the Ghana Federation of Disability Organisation and many other faith-based and community organizations were enlisted to disseminate COVID-19 risk messaging, promote vaccination and other protective measures, and combat misinformation about the pandemic *(71)*.
- **Oman:** Civil society organizations that worked with elderly and disabled communities were trained by public health authorities to provide health education and work with communities to decrease COVID-19 transmission *(89)*.
- **West and Central Africa:** The Civil Society Institute for HIV and Health in West and Central Africa reported that most HIV-focused organizations in the region were able to raise COVID-19 awareness among their served populations without receiving COVID-19-specific funding *(58)*.

Access to countermeasures

Lesson 5: Medical countermeasure development, authorization and manufacturing

Expediting the development, production and authorization of emergency medical countermeasures (MCMs) and bolstering manufacturing capacities is a critical tenet of respiratory pandemic preparedness and response. **Implementing measures to accelerate MCM development and production – especially in resource-constrained settings – can save lives, protect at-risk populations and prevent undue strain on health systems.**

Diversifying and maintaining MCM manufacturing capabilities

COVID-19 highlighted the fragility of global supply chains and the difficulty of converting manufacturing efforts. Where feasible, countries should establish permanent manufacturing capabilities for MCMs and other biological supplies, both at the national and/or regional level, to ensure greater variety in the supply chain and quicker access to such assets in an emergency *(90)*. Policymakers should consider offering monetary incentives for manufacturers to retain some capacities within their businesses to rapidly convert to MCM development during a public health emergency of international concern (PHEIC) *(90)*. There also must be a balance between investing in regional and national manufacturing capabilities. In countries with small populations but high technological capabilities, there may be the opportunity to establish or expand production capabilities such that local and international needs are rapidly addressed. In some countries with limited technological capabilities, it may not be feasible to build and permanently sustain national MCM manufacturing facilities, particularly during interpandemic periods. Such countries may find it more practical to participate in bilateral, multilateral and/or regional mechanisms for accessing countermeasures – such as joint procurement agreements for MCMs or regional manufacturing platforms – as appropriate. Still, while regional capabilities can help serve large swathes of a given population and facilitate cost-sharing among nations, national capacities for manufacturing certain products (e.g. masks, swabs, test kits) will remain important for fulfilling immediate response needs *(91, 92)*. By identifying the appropriate strategy for investing in national and regional manufacturing and procurement modalities, countries will be able to access and distribute MCMs more rapidly and affordably.

Regional mechanisms for manufacturing, procuring and distributing both medical and nonmedical countermeasures are essential for respiratory pandemic readiness and response.

- **African Union:** The regional body has pledged to invest in regional MCM manufacturing facilities *(90)*. To date, there are very few manufacturing plants housed in Africa, with many such facilities undertaking only “fill and finish” orders and not equipped for end-to-end manufacturing *(54)*.
- **mRNA vaccine technology transfer hub:** Located in Cape Town, South Africa, the hub aims to build capacity in LMICs to produce mRNA vaccines. The hub is supported by WHO, the Medicines Patent Pool and the Access to COVID-19 Tools Accelerator (ACT-A)/COVAX, and includes Afrigen Biologics, the South African Medical Research Council and Biovac, a South African vaccine producer *(93)*.
- **Pan American Health Organization (PAHO):** PAHO launched the Regional Platform to Advance the Manufacturing of COVID-19 Vaccines and Other Health Technologies to address the product distribution delays their region experienced *(94)*.

However, it is not enough to simply construct MCM manufacturing facilities. Governments must collaborate with MCM makers to sustainably expand workforce and production capacities in resource-constrained settings, strengthen quality assurance during emergencies and identify opportunities to repurpose (i.e. "keep warm") manufacturing facilities for routine drug, therapeutic and diagnostic test production *(43, 47)*. Proactively planning to scale up production capacities at facilities already producing MCMs for routine health threats (e.g. influenza, HIV) can help ensure that capacity conversion during future respiratory pandemics will take place more expeditiously than was observed during the COVID-19 pandemic *(33)*. To accomplish this, manufacturers and biological suppliers will need standing agreements and robust funding streams to enable sustainable production *(27)*.

Supporting rapid development of safe and effective MCMs through regulation and research

Countries should explore strategies for harnessing the appropriate "push" and "pull" levers to catalyse early-stage research, product development and testing, robust regulatory oversight and advanced manufacturing for products that may be required both for future pandemics and diseases that disproportionately afflict marginalized populations (e.g. pan-coronavirus vaccines, therapeutics for neglected tropical diseases) *(95)*. Governments should decide on a set of triggers for the release of funding for countermeasure development at the onset of a PHEIC *(33, 90)*. Having a mechanism to release funding on "Day 0" of a future pandemic will accelerate the process of developing, testing and distributing MCMs. MCM development should not simply be a reactive response to an emergent threat. Rather, countries should continuously invest in research and development activities for both known and emerging respiratory threats, including those for antivirals, pan-coronavirus and pan-influenza vaccines, diagnostics and other therapeutics *(28, 90)*. The United States' Antiviral Program for Pandemics and CEPI, among others, are planning to invest in the discovery of new antiviral candidates for future public health emergencies, which will be important to decrease mortality until effective vaccines become available *(20, 28)*.

To move safe and effective countermeasures from research to market, regulators from all countries should explore options for streamlining MCM clinical trials and standards for emergency use authorization *(96)*. WHO evaluated COVID-19 vaccine candidates by a comprehensive standard that enabled many governments to refine their own approved lists of vaccines *(97)*. Similarly, regulators in the United States made changes to their normal protocols to allow for data to be reviewed on a rolling basis, thus expediting authorization of products that continually demonstrated safety and efficacy *(33, 98)*. Post-introduction safety and effectiveness monitoring systems must provide timely and actionable information to regulators to ensure that the new products meet all standards.

Risk communications and infodemic management must be a key part of vaccine introduction preparations if vaccination campaigns are to be successful *(56)*. As observed during the COVID-19 pandemic, without a clear and thoughtful risk communication strategy, uptake may remain low or moderate at best *(99)*. The COVID-19 experience underscored the importance of culturally relevant, community-led engagement and risk communication to bolster public trust and increase uptake of MCMs, particularly for products developed or manufactured using novel technologies or authorized via non-traditional regulatory review processes. Oman's Healthy Villages and Community Support Groups volunteer programmes – previously established to enhance community-level health – were successfully converted for COVID-19 needs *(89)*. In many countries, too, known "influencers" and trusted officials supplemented grassroots efforts by communicating about complex topics or combating misinformation. Successful and equitable MCM distribution and uptake, therefore, require sustained focus and resources. Programmes with established capacity and delivery systems include HIV programmes, routine immunization programmes, community health centres, and trusted community

champions and institutions can be key to reaching vulnerable populations. In India, for example, street vendors and small retailers were engaged by the COVID-19 Action Collaborative to help distribute MCMs *(39)*.

Equitably meeting the needs of the global community for MCM access

Policymakers, norm-setting institutions and standard-setting organizations should examine legal and regulatory options for ensuring equitable MCM sharing, procurement and distribution during an evolving crisis. These may include mutual aid agreements, treaties, material transfer agreements and compacts. One challenge reported during the COVID-19 pandemic was a sudden scramble to decide upon allocation frameworks at the national, regional and global level. Decisions about MCM allocation in an equity framework should be made and agreed upon in advance of the next respiratory pandemic *(6)*. Developing such a decision framework in tandem with strengthened emergency response protocols could help ensure that response speed is not prioritized over the needs of the most vulnerable populations. Vulnerable communities should be empowered to participate in the creation of allocation and distribution frameworks to further ensure MCM access and uptake *(58)*. In assessing responses to COVID-19, policymakers and practitioners should evaluate the strengths, limitations and effectiveness of existing mechanisms for procuring, allocating and distributing countermeasures (e.g. COVAX, ACT-A, the PIP Framework) to identify an approach that could work for future pandemics.

There were also successes in regionalizing and pooling purchasing power and logistics during the pandemic. The World Bank and the African Union cosponsored the Africa Vaccine Acquisition Task Team, which was tasked with purchasing and distributing vaccines for 400 million people across the continent *(90, 100)*. In the Region of the Americas, PAHO leveraged its Revolving Fund for Access to Vaccines, an initiative with 40 years of experience, to support COVID-19 vaccine purchasing within ACT-A and COVAX *(90, 101)*. Among other objectives, the Revolving Fund consolidates regional demand to purchase vaccines in bulk at lower prices.

Such initiatives, whether newly developed or already established, should be maintained and supported to strengthen regional access to MCMs. They also strengthen early purchasing power in LMICs, thereby enabling these countries to compete with higher-income nations and ensure more rapid and equitable access to MCMs. However, more options for strengthening LMIC purchasing power are needed; such options could also raise the profile of LMICs as critical investors in MCM development and lower barriers for allocation in the future. Some experts have proposed an “advance commitment facility” that all countries pay into ahead of the next respiratory pandemic. This facility, in turn, would automatically purchase MCMs and other essential supplies for distribution to LMICs, much like ACT-A, for distribution to LMICs and purchase by self-financing countries *(90)*.

Regardless of the MCM procurement and distribution model chosen, agreement clauses like cost-plus pricing for LMICs and technology transfers to third-party manufacturers could help LMICs access MCM supply and intellectual property to empower in-country or regional manufacturing. In fact, CEPI already employs many such clauses in their agreements to improve MCM access for LMICs *(90)*. Decision-makers in these settings might also consider ensuring that procurement structures retain some MCM supplies, as appropriate, to ensure readiness and to support their biomedical industries *(90)*. Finally, future planning for respiratory pandemics should ensure that leaders and experts from LMICs should remain in central priority-setting and decision-making roles in MCM research and development, manufacturing and distribution.

Community protection

Lesson 6: Investment in routine public health and primary care services

Long-term, sustainable investments in routine public health and primary care services are essential to building resilient health systems and communities, which are better equipped to safeguard populations from future respiratory disease pandemics. Investing in robust systems of public health and primary care establishes healthy and resilient communities. Resilient communities, in turn, are better prepared to withstand and rapidly respond to pandemics, such as by scaling up emergency care, maintaining routine health service provision and adapting surveillance systems.

The COVID-19 pandemic severely disrupted routine health service provision and preventative care worldwide: cancer diagnoses and referrals plummeted; HIV/AIDS, tuberculosis and malaria programmes were disrupted; health care procedures were delayed; and childhood immunization programmes were set back by more than a decade *(37, 41)*. These devastating impacts – which were observed both in wealthy and resource-constrained settings – underscore the importance of investing in robust systems of public health and primary care as a strategy for cultivating and sustaining healthy, resilient communities. Resilient communities, in turn, are better prepared to withstand and rapidly respond to pandemics, such as by scaling up emergency care, maintaining routine health service provision and adapting surveillance systems. Ensuring affordable access to high-quality health care can also improve overall baseline community health, bolster public trust in health systems and protect at-risk populations from catastrophic out-of-pocket health expenditures during emergencies. The Joint United Nations Programme on HIV/AIDS (UNAIDS) also affirms that guaranteeing the right to health – provided through accessible, acceptable and high-quality health services and information, as well as adequately resourced public health infrastructure – is the best safeguard against pandemics *(56)*.

Leveraging legacy health programmes

The literature highlighted several precedents for leveraging legacy health programmes (e.g. Expanded Programme on Immunization, President's Emergency Plan for AIDS Relief, Global Fund, Gavi, Global Polio Eradication Initiative and seasonal influenza vaccination programmes) to support testing, vaccination, treatment, decision-making, and community outreach and engagement both before and during respiratory pandemics. HIV/AIDS experts across Africa, North and Central America, Asia and the Middle East, for example, have played critical roles in national decision-making on COVID-19 planning, coordination and response *(56)*. Additionally, many elements of COVID-19 response – from laboratory testing and surveillance to contact tracing and health workforce training – are rooted in public health and health care infrastructure developed through investment in HIV/AIDS programmes *(56)*. Future pandemic response initiatives may also benefit from building partnerships with chronic disease programmes, which often work with populations at high risk of severe illness or death from respiratory infections.

Leveraging the capacities, networks and expertise of legacy health programmes can help countries identify cases and monitor vulnerable populations during respiratory pandemics.

- **Morocco:** During the pandemic, a network of 17 HIV treatment reference centres began to operate as first-line COVID-19 treatment facilities *(58).*
- In countries as diverse as **Nigeria, Republic of Moldova and Tajikistan**, HIV laboratories contributed to the collection and testing of samples for SARS-CoV-2 *(58).*
- **South Africa:** The government deployed over 28 000 community HCWs to perform house-to-house searches for COVID-19 cases in high-risk communities, using existing protocols for tuberculosis control and community contact tracing to monitor COVID-19 transmission *(15).*

Investing in public sector primary health care

Resilient health systems constitute the front line of defence against epidemics and pandemics caused by respiratory pathogens *(55)*. In fact, analyses of health system functioning in the Middle East, North Africa and South Asia indicate that declining investments in the health sector leading up to the COVID-19 pandemic diminished national capacities to provide health services to vulnerable populations, created shortages of medical personnel and resources, and slowed health system responses to growing caseloads *(43, 50, 102)*. By contrast, in Europe, countries with robust health sectors weathered the initial period of rapid community transmission effectively, while those with shrunken or highly decentralized national health systems struggled *(103)*. In some cases, countries that transitioned to privatized models of care exacerbated health care access disparities among vulnerable populations relying on increasingly under-resourced public health care sectors *(44)*.

Thus, in addition to harnessing the capacities of legacy health programmes, targeted investments in robust systems of primary health care may offer another path towards enhanced preparedness for respiratory pandemics. WHO and the United Nations Children's Fund define PHC as "a whole-of-society approach to health that aims at ensuring the highest possible level of health and well-being and their equitable distribution by focusing on people's needs and as early as possible along the continuum from health promotion and disease prevention to treatment, rehabilitation and palliative care, and as close as feasible to people's everyday environment" *(104)*. The United Kingdom's Pandemic Preparedness Partnership also recommends that multilateral development banks continue providing fiscal support to routine health systems strengthening activities as part of their core business *(28)*. And, as health systems respond to emerging or ongoing respiratory pandemics, policymakers and practitioners should identify strategic opportunities to leverage outbreak response resources to concurrently strengthen systems for delivering PHC *(105–107)*. In adopting this approach, disease-specific priorities and activities during an ongoing pandemic must be weighed against longer-term considerations for strengthening PHC programmes and systems *(54)*.

Robust primary health care systems can help cultivate and sustain healthy, resilient populations that are prepared to withstand and rapidly respond to respiratory pandemics.

- **Oman:** Community participation is a major component of Oman's PHC facilities, which are the building blocks of the country's health system. During the COVID-19 pandemic, existing community participation mechanisms became important platforms for engaging communities in pandemic response, promoting protection and mitigation measures, and facilitating communication between communities at risk and government authorities *(89).*
- **Qatar:** The government made robust investments in primary health centres, workforce development, health information management and quality of care to build a resilient, integrated system equipped to implement an agile response to COVID-19 *(20).*
- **United States:** The National Diabetes Prevention Program, which offers valuable inroads into small or independent medical practices, can help identify hard-to-reach patient populations and support data sharing and public outreach during public health crises *(19).*

Advancing access to care

Ensuring affordable access to high-quality health care can also improve overall baseline community health, bolster public trust in health systems and protect at-risk populations from catastrophic out-of-pocket health expenditures during emergencies. To improve equitable access to both routine and emergency care, policymakers should consider options for ensuring availability and access to high-quality care. Dismantling financial barriers to routine health services can also help reduce community transmission during pandemics, as well as mitigate health and economic disparities among marginalized populations; these, in turn, may reduce their risk of sickness, disability and death during such crises *(21)*. Providing a publicly subsidized package of essential services could help increase health coverage, particularly in fragile, conflict-affected or other vulnerable settings *(108)*. Waiving user fees, insurance contributions or other such obstacles could also increase financial protection against catastrophic health spending and encourage greater health system utilization during pandemics *(41)*. During the COVID-19 pandemic, eliminating administrative barriers (e.g. reimbursement for services), providing services for free or low cost at the point of care, coupling universal health coverage (UHC) with strong systems of social protection and codifying the right to health in legal and regulatory mechanisms helped protect populations in high-, middle- and low-income settings alike *(60)*.

Improving access to health care can help protect populations from preventable infection, illness, disability and death during respiratory pandemics.

- **Iceland:** A nationalized health service – consisting of state-run hospitals and primary health centres – played an important role in COVID-19 response by guaranteeing universal access to health care, with minimal fees for patients at the point of care *(15).*
- **Portugal:** *I*n 2020, more than 356 000 immigrants in Portugal were granted temporary citizenship to enable access to the national health service and other social services during the early days of the pandemic *(109).*
- **Republic of Korea:** The Republic of Korea offers citizens a universal health insurance scheme. During the COVID-19 pandemic, the government covered the cost of all testing, isolation and treatment services *(15).*
- **Viet Nam:** As of 2018, 73% of the country's population had access to essential health services provided through the public sector. The government made COVID-19-related quarantine and treatment free of charge for all citizens *(15).*

Lesson 7: Strengthening social safety net policies and programmes

Strong social safety net policies and programmes are needed to mitigate the social and economic impacts of pandemics on vulnerable populations. **These programmes and policies help protect vulnerable populations, who often bear a disproportionate share of disease, disability and death stemming from pandemics. These populations also shoulder disproportionate health, social and economic burdens from the very mitigation measures needed to protect the public's health, including loss of income, educational disruptions and barriers to accessing health care and other needed social services.**

The literature highlighted numerous populations that bore a disproportionate share of disease, disability and death stemming from COVID-19, such as people with disabilities and chronic illnesses, individuals belonging to racial and ethnic minority groups, low-income populations, individuals who are lesbian, gay, bisexual, transgender, queer and intersex (LGBTQI+), and migrants and undocumented persons *(37, 61, 110)*. Simultaneously, these groups shouldered inequitable health, social and economic burdens from the mitigation measures required to protect the public's health, including loss of income (e.g. through unemployment or underemployment), educational disruptions, increased occupational risk of infection and barriers to accessing health care and other needed social services. Concerningly, the pandemic also resulted in increases in unpaid caregiving among women, greater rates of domestic violence and immigration bans in some countries *(58)*. In light of these conditions, the Independent Panel for Pandemic Preparedness and Response has dubbed COVID-19 "a pandemic of inequalities and inequities". Given that pandemics do not affect the health sector alone, strong social safety net policies, social protection programmes and whole-of-society and whole-of-government efforts are essential to protecting population health during respiratory pandemics with widespread community transmission *(21)*. Concurrently, policymakers must ensure that pandemic mitigation measures safeguard population health without exacerbating baseline social, economic and health inequities.

Advancing social protection and social safety net programmes

Robust social safety net measures are urgently needed to protect vulnerable populations

from disproportionate exposure to circulating pathogens, catastrophic health spending and preventable illness, disability and death *(15, 49)*. Such measures might include but are not limited to paid sick leave, UHC, paid maternity leave, affordable childcare, economic relief payments, business loans and tax relief, eviction moratoria and food assistance. Disinvestment from programmes meeting basic social and economic needs could reduce compliance with pandemic mitigation policies, jeopardize livelihoods and potentially violate civil rights. This phenomena was observed in some countries that deployed overly strict lockdown measures during the COVID-19 pandemic without concomitant social support mechanisms, thereby preventing at-risk populations from accessing resources for basic survival *(51, 56, 111)*.

Strong social safety net programmes can support populations weathering respiratory pandemics by preserving access to essential public services for meeting basic social and material needs.

- **Germany:** *T*he government passed an emergency budget to subsidize expanded childcare benefits for low-income parents, provide income support for the self-employed and award grants to small business owners *(15)*.
- **Jordan:** The government issued orders stipulating partial salary support for roughly 400 000 households – including many members of its significant refugee population – along with subsidy payments to daily wage workers and tax deferrals *(102)*.
- **Republic of Korea:** The government disbursed social welfare payments to patients without employer-provided sick leave. Both the national and local governments also covered emergency living expenses for individuals who had lost their jobs due to COVID-19 *(15)*.
- **Sweden:** The government provided temporary exemptions from tax payments and other social expenses, in addition to streamlining procedures for sick leave *(40)*.

In addition to protecting the health of vulnerable populations, a strong social safety net can help ensure the continuity of essential services and activities. For instance, one analysis noted that companies should implement measures to reduce occupational infection risks and offer paid sick leave to minimize disruptions to humanitarian supply chains during pandemics *(112)*. Beyond the acute phases of pandemic response, social protection and safety net programmes can also help catalyse equitable pandemic recovery. Survivors and communities may require long-term assistance to navigate post-pandemic challenges, including lifelong disability; psychosocial trauma, grief, stigma and loss; workforce attrition; and revitalization of social, economic and civic institutions *(113)*.

Improving environmental conditions in home, at work, at school, in childcare settings and in community gathering spaces to improve health and reduce respiratory pathogen transmission

Improving indoor environmental quality in residential, school and childcare, workplace and community gathering settings can mitigate the transmission of future respiratory pathogens with pandemic potential. One study found that increased ventilation in schools reduced COVID-19 transmission by almost 80% *(114)*. If indoor air quality can be improved significantly in many settings, it may make closures and cancellations of these environments and gatherings less necessary during future epidemics and pandemics. Therefore, increasing indoor environmental quality in these settings will strengthen resilience and reduce the social and financial burden of future epidemics and

pandemics. In addition, better indoor air quality in these settings will help reduce illness from other seasonal respiratory pathogens like influenza and measles, as well as from other conditions related to non-infectious diseases, such as asthma and allergies *(115)*.

Earning public trust and combating mis- and disinformation through infodemic management, risk communication and community engagement

To ensure uptake of social safety net services among vulnerable populations during pandemics or other emergencies, countries should take steps to proactively identify these groups, explicitly account for their needs in preparedness planning and routine public health practice, and tailor pandemic mitigation measures accordingly. Safety net measures should be designed in collaboration with target populations to ensure they are delivered in an accessible, nondiscriminatory and culturally appropriate manner *(37)*. Close collaboration among the public, private and civil society sectors can accelerate progress towards this goal *(12, 58, 64)*. Strengthening health workforces to include community HCWs – a vital link between underserved populations and needed social services – could further improve access and uptake *(56)*.

Robust community engagement is another essential component of delivering social safety net services and encouraging use of both medical countermeasures as well as public health and social measures (e.g. masking, vaccination, physical distancing). Engaging widely and early with relevant community stakeholders can help responders anticipate potential challenges in implementing pandemic mitigation measures, centres the rights and concerns of affected populations, and earns public cooperation with needed measures *(56)*. Following such consultations, a broad range of mechanisms are available to governments seeking to engage with vulnerable and underserved populations, such as memoranda of understanding, contracts and mutual aid agreements with community and faith-based organizations, as well as other civil society institutions *(116)*.

Notably, investments in risk communication and community engagement capacities could support ongoing efforts to combat the growing threats of misinformation and disinformation during respiratory pandemics. During the COVID-19 pandemic, for example, rumours about the safety and effectiveness of prescribed medical countermeasures as well as public health and social measures – combined with low or eroding trust in government authority – led to preventable infections, illnesses and deaths. This undermined mitigation measures and prolonged the crisis. In many cases, mis- and disinformation about emerging respiratory infections could stigmatize vulnerable populations at disproportionate risk of infection. Countries across the world – including Australia, Egypt, France, Jordan, Malaysia, Philippines and Thailand – passed emergency laws and decrees criminalizing the spread of misinformation about SARS-CoV-2. However, such punitive approaches also risk compromising transparency, such as through censorship of details about caseloads, transmission, mitigation measures and the emergence of new variants *(111)*. By contrast, Jalloh et al. advocate for supplementing these "top-down" measures deployed by government authorities with "bottom-up" approaches to combating mis- and disinformation, such as by leveraging social influence within vulnerable communities, operationalizing grassroots persuasion principles and ensuring that mitigation measures account for cultural values and traditions *(117)*.

Lesson 8: International cooperation and coordination

Stronger mechanisms for international cooperation and coordination are essential to implementing robust and equitable responses to pandemic threats. **These must be considered both within the health sector and other critical infrastructure sectors – such as transportation, manufacturing, food and agriculture – to enhance pandemic response capacities at the country, regional and global level.**

Infectious disease threats do not respect national borders. This phenomenon underpins the idea

that "a disease threat anywhere is a disease threat everywhere" *(118)*. Collective threats like pandemics demand collective global action and underscore an imperative to ensure that every country possesses the resources, systems and capacities to respond. As such, strengthening ties among countries, sectors and institutions – both within and across regions, as well as globally – is essential. These efforts can expedite responses to emerging and evolving respiratory threats, foster cooperation across sectors, and facilitate technical exchanges and sharing of best practices for responding to future pandemics. Yet, as seen during the COVID-19 pandemic, global health systems are fragmented *(6, 27)*.

Strong bilateral and multilateral mechanisms can facilitate collaboration around shared priorities for pandemic preparedness and response; MCM research, development, regulation, production and distribution; surveillance and reporting; and supply chain resiliency.

- **Mexico:** The country drew on lessons from its successful response to pandemic influenza in 2009 to orchestrate responses to COVID-19, reporting that collaboration with global partners was essential to harmonizing international standards and building response capacities *(17, 119)*.
- **South Africa:** The country reported considerable success in coordinating cross-sector COVID-19 response activities both regionally and globally, such as by harnessing a global network of diagnostic laboratories and carrying out training and resource-sharing activities with private-sector and nongovernmental partners *(31)*.
- **WHO Regional Office for Africa:** The office organized regional meetings, developed a response road map and established joint operational platforms to coordinate procurement activities across the continent during the early days of COVID-19 *(51)*.

Alternative models of collaboration during pandemics

Alternative models of international collaboration – such as South–South and triangular cooperation (SSTC) – may enhance efforts to build pandemic preparedness and response capacities both nationally and regionally *(120)*. SSTC has been cited as a potential strategy to guide future vaccine development, ensure equitable resource sharing and distribution across LMICs, and encourage collaboration between sectors and communities of practice across different geographic regions *(121, 122)*. For example, the Medical Association of South East Asian Nations – a civil society organization formed during the COVID-19 pandemic – helped accelerate regional information sharing among its member states *(5)*. The literature also highlighted a need for international cooperative mechanisms that focus on threat identification and prevention in addition to response, citing the Intergovernmental Panel on Climate Change as a potential model *(37)*. Other models for incentivizing cooperation around respiratory threats include One Health task forces to facilitate horizontal coordination across the human, animal and environmental health sectors *(37)*.

Decentralization

Though multilateralism and cross-sector cooperation hold enormous promise for strengthening respiratory pandemic preparedness and response, decentralized approaches to respiratory pandemic management could also prove effective. The literature highlighted a range of cases wherein decentralization could produce improved health outcomes. Decentralized

pandemic management models – wherein decision-making around health service delivery, funding, resource allocation, surveillance and staffing was consigned to subnational leaders – were adopted in settings as diverse as Burkina Faso, Cameroon, China, Germany, Indonesia and Kenya *(5, 15, 32)*. In many of these cases, decentralization enabled more flexible response activities and better-informed resource allocation. In other cases, however, decentralization worsened cross-sector coordination, fragmented health care delivery, increased competition among policy priorities and undermined efforts to implement cohesive, whole-of-society and whole-of-government responses to the collective threat of COVID-19 *(8, 13, 32, 44, 123)*. As such, decision-makers and political leaders must carefully consider trade-offs between regionalizing versus decentralizing public health capacities, health care delivery and social protection programmes.

Decentralized approaches to respiratory pandemic preparedness may prove effective in select areas of respiratory pandemic preparedness and response. However, it is essential to consider potential trade-offs associated with decentralized governance, funding and planning.

- **Dominican Republic:** A decentralized model of public health response enabled the country to carefully consider the needs of women, youth, LGBTIQ+ persons, people living with HIV and migrants, emphasizing the importance of including these groups in decision-making and priority setting *(61)*.
- **Germany:** The country has a decentralized governance structure, with 16 state governments overseeing health affairs. During the COVID-19 pandemic, each state government developed its own pandemic plan, resulting in a "patchwork of rules" at the onset of the pandemic *(15)*.
- **Kenya:** Though Kenya adopted a decentralized funding approach to COVID-19, it encountered challenges in rapidly disbursing funds from the national government to counties, and subsequently to health facilities at the front lines of response *(32)*.
- **South Africa:** The COVID-19 response was decentralized to provinces, districts and subdistricts by creating provincial incident management teams that operated in a similar manner to their national counterpart, with numerous workstreams working synergistically *(32)*.
- **Uruguay:** A decentralized network of 24 laboratories cut down testing times from several days to less than one *(15)*.

Collaborative learning and accountability

Lesson 9: Learning from past successes and failures

Policymakers, practitioners and researchers must proactively identify and learn from past successes and failures, taking steps to institutionalize best practices in pandemic response. **The COVID-19 pandemic illuminated flaws in existing systems and practices but also highlighted governments' and health systems' abilities to evolve and adapt existing policies, capabilities and programmes to enhance preparedness and response. Iteratively documenting and sharing these lessons and opportunities could improve institutional learning and enhance readiness for future respiratory pandemics.**

During the COVID-19 pandemic, WHO encouraged intra-action reviews (IARs) to identify gaps and improve response during the crisis *(31)*. Critically, lessons from the COVID-19 pandemic apply not only to the activities, programmes and coordination during the response but also to the investments, capacities and policies that existed prior to the onset of the pandemic. COVID-19 recovery should not aim to return to a pre-pandemic state of normality; rather, it should emphasize improvements to systems and capacities that increase resilience to future respiratory threats across all sectors and communities *(6, 55, 73, 113)*. Recognizing the value of these efforts, WHO Member States completed 136 IARs between 2020 and 2022 *(124)*.

The COVID-19 pandemic exposed major shortcomings in local, national and global preparedness for large-scale health emergencies, but governments and individuals demonstrated they could adapt to mitigate a fast-moving respiratory threat *(52)*. In the wake of previous emergencies, numerous after-action reviews and other analyses have identified "lessons learned". Yet, governments and other stakeholders in pandemic preparedness and response – from scientists and political leaders to health officials and clinicians – have often failed to operationalize these lessons in public health practice, policymaking and research *(5, 12, 15)*. In many cases, lessons identified through action reviews are not sufficiently institutionalized or adopted, whether through acquiring necessary resources; establishing new capabilities or capacities; correcting gaps in preparedness and response policies and protocols; or strengthening collaboration among agencies, jurisdictions or levels of government. Several notable exceptions include South-East Asian countries impacted by the SARS 2003 and MERS 2015 epidemics, as well as African countries that have grappled with Ebola and HIV/AIDS epidemics. These countries responded proactively to the emerging threat of SARS-CoV-2, implementing robust mitigation and testing measures to improve health outcomes *(5, 12, 15)*.

Operational research, action reviews, technical exchanges and other methods of real-time monitoring, evaluation, research and learning are crucial to implementing adaptive, agile responses to respiratory pandemics.

- **The Islamic Republic of Iran:** The country had begun developing a national influenza pandemic preparedness plan in 2019, which was subsequently informed by gaps and challenges identified iteratively throughout the course of the COVID-19 pandemic. Following a series of multisector consultative workshops with stakeholders, the plan will be tested through a national tabletop simulation exercise *(125)*.
- **Pacific Island Countries and Territories:** Many implemented a coordinated approach to COVID-19 mitigation, forming a Joint Incident Management Team, developing and disseminating technical guidance throughout the region and deploying experts to support preparedness and response efforts in the region *(126, 127)*.

In terms of mitigating the risk of repeating local, national and global COVID-19 failures in future emergencies, merely identifying lessons is not sufficient. Robust and formal MERL frameworks – implemented at all levels of government and nongovernmental organizations – provide critical platforms for identifying and addressing these challenges *(128)*. MERL frameworks are used to gather information (monitor), assess outcomes (evaluate) and compare performance against target goals to identify opportunities for improvement (report), with the ultimate goals of incorporating those lessons and taking corrective action to improve future responses (learn) *(129)*. Lessons from COVID-19 should be implemented collaboratively and include input from responders and government agencies, nongovernmental and private-sector entities, and community

organizations and the public. This approach could help ensure that health systems, governments and other entities involved in pandemic preparedness and response comprehensively identify lessons across all affected sectors and populations. MERL frameworks should also include standardized metrics and indicators for use across jurisdictions *(128)*.

Sustainable funding for the long term

Any discussion of evaluating and improving response practices and policies would be incomplete without addressing funding and other resources. Complacency regarding pandemic risks have left local, national and global public health and health care systems chronically underfunded and, in turn, woefully underprepared *(6, 20, 21, 33, 36, 43, 44, 50, 60, 130–132)*. Waning political will and funding in the wake of emergencies lead directly to weakened critical infrastructure and deteriorating workforces when the next emergency strikes *(37, 45, 60, 73, 96, 133)*.

Large-scale emergencies require the rapid infusion of emergency funding, whether to scale up response operations and services; purchase equipment and supplies, including MCMs; or provide social support for individuals or businesses. However, long-term, sustainable funding is the key to establishing and maintaining core capacities to prevent, detect, respond to and recover from crises of all sizes *(134)*. Long-term funding also can enable development of emergency pools to immediately provide funds for scaling up response capacity, including MCM development and production *(90)*. Unfortunately, long-term funding during non-emergency periods is among the earliest victims of "neglect", as policymakers prioritize near-term programmes and initiatives, a particularly common phenomenon in LMICs facing additional budgetary limitations *(27, 33, 133, 135)*. Critically, recipients must also be prepared to process and rapidly disburse funds to meet the demands of the crisis at hand.

Notably, routine investments in preparedness cost substantially less than emergency response funding *(27, 36, 55)*. For example, an analysis by Nobel laureate Michael Kremer found that an investment of US$ 60 billion in vaccine manufacturing capacity – plus an additional US$ 2.2 billion to maintain it – would require an emergency investment of US$ 1.6 trillion to achieve the same benefit. Some estimates project a 25% probability of another pandemic occurring within the next 10 years and 50% over the next 25 years, illustrating the high likelihood that these investments will yield returns in the not-too-distant future *(90)*. Another analysis projected that the collective global financial losses during the COVID-19 pandemic could cover 500 years of pandemic preparedness investments *(21)*. A revolution in national and international funding mechanisms is necessary to ensure adequate and sustainable, long-term funding for the tools and capacities necessary to prevent, detect, respond to and recover from a pandemic in a collective and equitable fashion *(21)*.

Identifying and operationalizing best practices

Existing literature and analyses of "best practices" in COVID-19 response focus almost exclusively on gaps and successes associated with preparedness and response activities and programmes, with innumerable efforts to determine how to improve them in future emergencies. Many of these reports also identify needs or call for nonspecific improvements in capacity and programmes but do not include recommendations for achieving these goals. Many organizations and governments will be able to learn from their experiences and improve on the effectiveness of their pandemic response activities and policies, but they likely have not assessed whether their preparedness and response plans are utilizing best practices.

Existing standards (e.g. IHR (2005)) and assessment frameworks (e.g. joint external evaluations) provide decision-makers and planners with tools and metrics to measure existing preparedness and response capacities, identify gaps and implement associated corrective actions across a broad scope of agencies and functions. Notably, however, IHR standards and pre-pandemic assessments did

not necessarily correlate with the relative success of national COVID-19 responses *(21, 37, 54, 60, 108, 134, 136–138)*. Thus, the COVID-19 pandemic should trigger new approaches for gauging preparedness and functional capabilities to provide an accurate picture of national, regional and global pandemic preparedness *(6)*.

Dedicated efforts are required to evaluate the broad scope of practices implemented before and during the COVID-19 pandemic and assess which are the most appropriate to implement under a given set of circumstances. This may be a particularly daunting task, as the effectiveness of any given practice depends on a broad range of factors, including political and social will, resource availability, pathogen characteristics and even chance. Crucially, the best practices in one jurisdiction or under one set of circumstances may not be the best in another environment. To account for these differences, leadership at all levels and in all organizations must continually assess not only how they implement the practices outlined in their pandemic plans but also whether these are the best practices for their respective situations. To perform better during the next event, best practices should be established, assessed, implemented and exercised throughout the interpandemic period *(6)*.

Conclusion

Drawing from the global COVID-19 experience, this review identified lessons for respiratory pandemic preparedness from currently available peer-reviewed and grey literature and supplemented them with inputs from public health experts and practitioners. Though some lessons may not be relevant in every population context, they present decision-makers with important considerations for strengthening health system capacities. Additional lessons and best practices are also likely to emerge from ongoing action reviews and other assessments of COVID-19 response efforts. Future analyses of political power and decision-making, health system governance and cross-sector coordination during public health crises could also inform efforts to enhance pandemic readiness globally.

The COVID-19 pandemic has illustrated the unique threats that emerging respiratory viruses pose to population well-being and global health security. The immense health, socioeconomic and political consequences of this global crisis have underscored the urgency of ensuring that the world is prepared for the next major respiratory pandemic. To achieve this goal, countries must commit to ending the cycle of panic and neglect that has historically characterized pandemic preparedness and response efforts. Identifying hard-won lessons from COVID-19 is an important first step towards building institutional knowledge and pandemic response capacities – and ensuring countries are prepared to respond to emerging threats.

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Annex I. Methodology

The lessons presented in this review were synthesized through an iterative three-phased process. This approach incorporated published materials (peer review publications and summary reports) as well as consultation with a range of WHO experts and partners involved in the COVID-19 response and/or pandemic preparedness activities.

Review of the literature

The first phase was a scoping review of the peer-reviewed and grey literature published between 30 December 2020 and 30 September 2022 as follows. Peer-reviewed literature databases included Embase, PubMed, and Scopus. In addition, grey-literature databases and document libraries reviewed included:

- Brookings Institution
- Council on Foreign Relations
- Global Index Medicus
- Global Preparedness Monitoring Board
- Johns Hopkins Center for Health Security
- National Academies of Sciences, Engineering, and Medicine
- OAIster
- Think Tank Search (Harvard)
- United Nations Digital Library System
- United States Agency for International Development
- CDC stacks
- WHO dashboard of COVID-19-related recommendations
- World Bank

The documents were collated using Covidence. All titles and abstracts were reviewed to ensure their relevance to lessons from the COVID-19 pandemic. Irrelevant documents were discarded. Documents chosen for full-text review underwent qualitative coding using NVivo software, in line with the themes of WHO's white paper on strengthening the global architecture for health emergency preparedness, response and resilience (1). Despite the extensive list of databases reviewed, the review was limited to documents in English.

Reflection on global and context specific learnings

The second phase of this process aimed to address the limitation posed by the English-based search. During the second phase, the report drafting team organized virtual consultations with WHO experts and external stakeholders in respiratory pathogen pandemic preparedness. The members of the Preparedness and Resilience for Emerging Threats (PRET) internal Steering Committee were consulted during the review process to share global, regional, and national learnings from the COVID-19 response. The Steering Committee is composed of 22 WHO headquarters, 19 regional, and 10 national technical experts and meets monthly to coordinate and guide WHO's pandemic preparedness planning activities. These WHO experts working in different countries, in different languages, and in different contexts ranging from high- to middle- and low-income countries were asked to reflect on the findings from the literature review and share additional insights.

To ensure partner perspectives were also reflected, members of WHO's external partner engagement forum on respiratory pathogen pandemic preparedness were also consulted in the process from August to October 2022. The purpose of these consultations was to allow stakeholders to review the literature review findings, determine whether they resonate with COVID-19 responders and consider the lessons identified from an operational perspective.

Validation of findings

The final phase of this analysis was a series of consultations with WHO technical teams at headquarters to assess the alignment of lessons identified with current technical guidance on pandemic preparedness, risk assessment and response. These activities were conducted from August to December 2022.

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