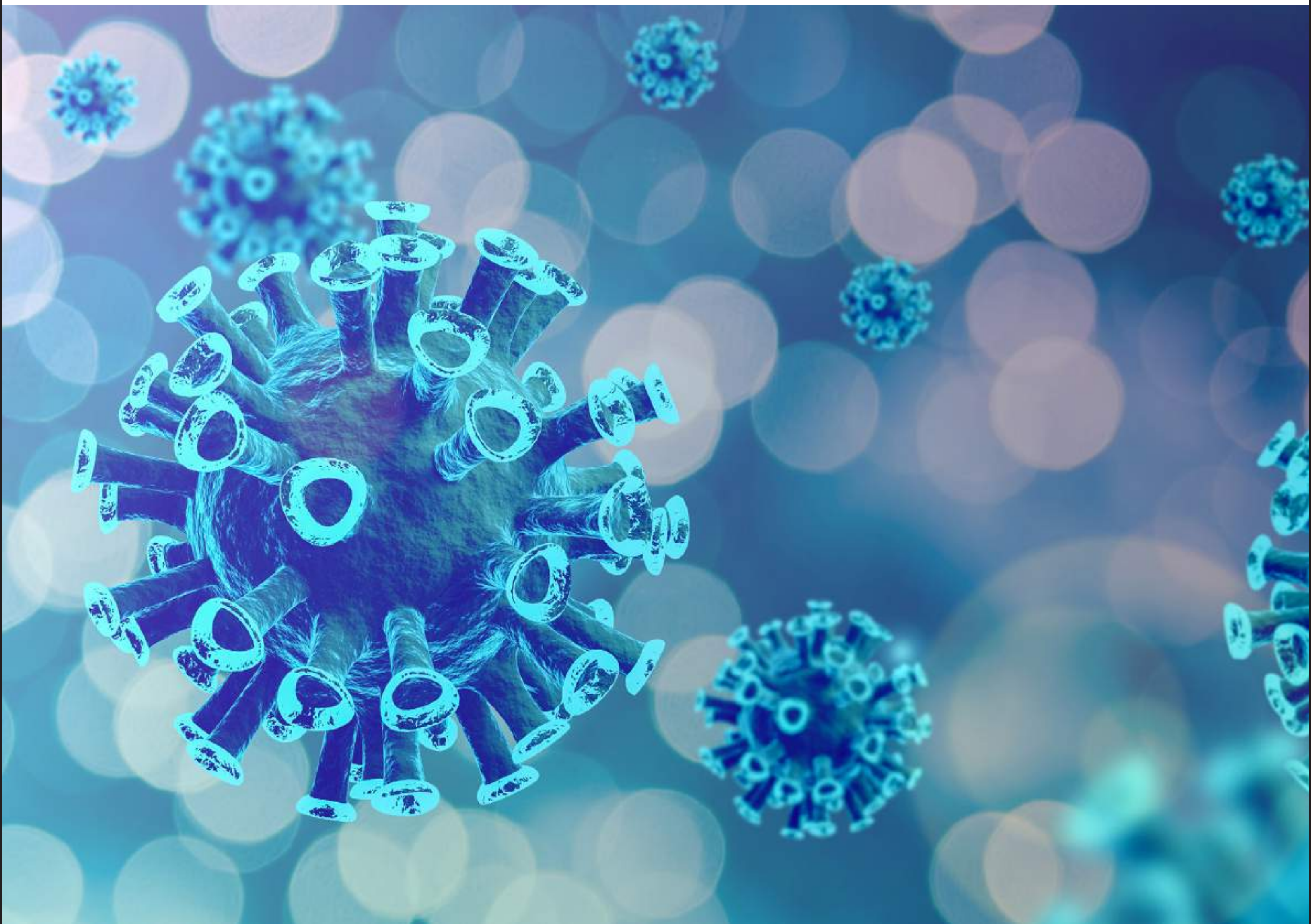
Research report of the Working Group on Epidemic Management

Importance of ICT and Global Cooperation for Future Epidemic Management

A Look into the ICT-Enabled Responses in the Early Part of the Covid-19 Pandemic

May 2022



BROADBAND COMMISSION
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on Epidemic Management

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Disclaimer

This research report, titled *Importance of ICT and Global Cooperation for Future Epidemic Management: A Look into the ICT-Enabled Responses in the Early Part of the Covid-19 Pandemic*, is based on data and material accessible as of 31 July 2021 and may not reflect circumstances thereafter.

This report has been prepared, with the support of experts under the supervision of Dr Suk-Zoon Huh (KT), by the members of the Broadband Commission Working Group on Epidemic Management chaired by Dr Hyeonmo Ku, Chief Executive Officer, KT Corporation.

The ideas and opinions expressed in this publication do not necessarily reflect the views of the Broadband Commission members or their organizations. This Working Group report does not commit the Broadband Commission for Sustainable Development.

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The Working Group met online on a quarterly basis, reviewed material, exchanged insightful ideas and discussed the strategic trajectory of the report. The views expressed in this report do not necessarily reflect the position of the Broadband Commission members, or their affiliated organizations. As such, the views expressed here are not attributed to any one organization or individual.

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Foreword

Dr Hyeonmo Ku

Chief Executive Officer, KT Corporation

Chair, Broadband Commission Working Group on Epidemic Management

COVID-19 triggered an ongoing global health crisis of an unprecedented scale from early 2020, also prompting socio-economic shocks. Economies contracted sharply whereas government debt soared. The suspension of public services including education undermined the well-being of people around the globe.

Meanwhile, COVID-19 served as a reminder of the pivotal role of ICT in sustaining the socio-economic system during pandemic situations. Governments, health institutions, research institutes, and businesses took advantage of ICT for the Test, Trace, and Treatment Strategy of COVID-19. Telework, e-commerce, telemedicine, and other ICT-based services contributed to essential and public services during social distancing and lockdowns, generating the concept of a contactless economy. However, the extensive use of ICT also highlighted the digital divide, impacting developing countries and vulnerable groups the most.

The Broadband Commission for Sustainable Development focused on the role of ICT in its "Preventing the Spread of Epidemics Using ICT" report by the Epidemic Preparedness Working Group in 2018, before the onset of the pandemic. Succeeding the 2018 Working Group, the Epidemic Management Working Group was organized to analyse international efforts and best practices as well as lessons learned from the response to COVID-19, and to present collaborative approaches to overcome future pandemics. To this end, the Working Group studied a global framework that includes ICT-based pandemic control measures and explored solutions to mitigate humanitarian and social loss by using ICT, in support of SDG3: Good Health and Well-Being.

To fulfill the Working Group's objective, the report starts out by examining the current status of COVID-19 and the need for a pandemic response framework. It then looks into the response strategies of 14 countries in Europe, the Americas, Asia, and Africa from various contexts, including governance and legal systems, disease control and socio-economic policies, vaccination strategies, and public compliance with policies. It also examines the best practices from among COVID-19 responses that utilize ICT. Based on this analysis, the Working Group has come up with the following insights. First, extended use of ICT for disease control and freedom of movement should be accompanied by expanded ICT infrastructures to guarantee access by developing countries and vulnerable groups. Second, relevant data and network regulations should be designed to be flexible to allow timely and effective use of ICT for epidemic management purposes – whilst ensuring that privacy is safeguarded. Finally, a global public-private governance is required to share data on the pandemic and coordinate policies between countries.

As the Working Group Chair, KT has been developing ICT solutions for global epidemic management and collaborating with governments and local communities. The proposals of this research are in conjunction with KT's efforts and vision to offer new opportunities for growth and innovation through new digital technologies. I look forward to having the results of this research generate insight and contribute to further ICT deployment.

Lastly, I express my gratitude to the Broadband Commissioners and external experts for their contributions to the Working Group based on their expertise and everyone else whose efforts and dedication have brought this report to fruition. KT will remain committed to its engagement in the global initiative for future epidemic responses and its cooperation with governments, international agencies, and other businesses.

Dr Hyeonmo Ku
Chief Executive Officer, KT Corporation

Executive Summary

Background

Since its initial detection in December 2019, COVID-19 has spread at an alarming pace, infecting 197 million people and causing 4.2 million deaths worldwide as of the time of writing (3 August 2021). Governments and cross-sections of society sought measures to control the spread of the virus, exploring non-pharmaceutical interventions (NPIs) pending the development of vaccines and treatment. NPIs are public health measures designed to control the spread of infectious diseases without the use of pharmaceutical drugs. They include a range of recommendations from the individual level (e.g. hygiene, hand-washing and mask-wearing) to the societal level (e.g. social distancing, school closures, social gathering restrictions and lockdowns). NPIs also involve such measures as quarantines, isolation of confirmed cases, testing and contact tracing, and regular cleaning of public spaces using specific protocols.

NPIs adopted since March 2020, when COVID-19 was declared a pandemic by the World Health Organization (WHO), varied across countries and regions but many involved the use of information and communications technologies (ICTs, used in this report to include Internet connectivity). The intent of this report is not to assess the effectiveness of NPIs but to explore the approaches that were assisted or enabled by ICTs, to gain insights on how the technologies (particularly those leveraging connectivity) were used for pandemic management. This report focuses only on selected number of countries and does not provide an exhaustive list of ICT-based or ICT-enabled tools and approaches. It recognizes the crucial role of NPIs in the pandemic response, particularly in the face of uneven vaccine roll-out and vaccine hesitancy in many places. It also looks into what might be most instructive to the global community as the pandemic continues, and contributes to knowledge that would be helpful in responding to future challenges.

Necessity of a pandemic response framework

The COVID-19 outbreak revealed some flaws in existing pandemic response systems and inefficiencies in health care and other systems. The Global Preparedness Monitoring Board (GPMB), co-convened by the WHO and the World Bank in response to the 2017 recommendations of the UN Secretary General's Global Health Crises Task Force, focused its first annual report in 2019 on pandemics and epidemics. It called attention to its central finding that "the world needs to proactively establish the systems needed to detect and control potential disease outbreaks" (GPMB, 2019). In its 2020 annual report, it identified a "collective failure" in prioritizing pandemic prevention, preparedness and response, and advocated for changes in the educational, social, and economic systems to make them more resilient (GPMB, 2020).

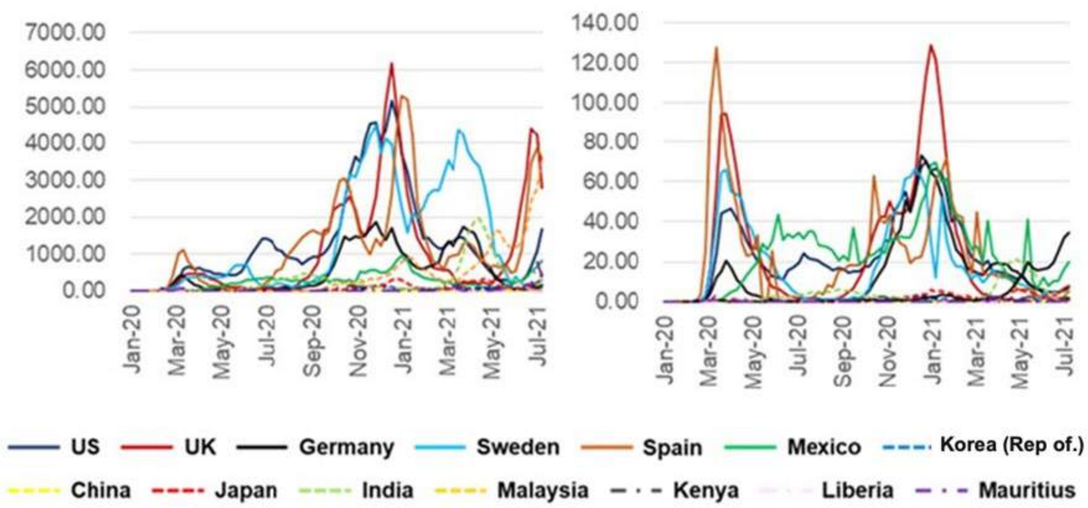
The 2018 report of the Epidemic Preparedness Working Group of the Broadband Commission for Sustainable Development also warned of the increased risk of epidemics and highlighted the need for a global data-sharing and monitoring system (Broadband Commission for Sustainable Development, 2018a). Pre-emptive consideration is necessary to ensure pandemic preparedness through new response systems and action plans. The proactive and inclusive deployment of ICTs in particular will be a key factor in building a successful response system.

Digital technologies used in strategic ways can help countries detect, prevent, respond to, and recover from COVID-19 (OECD, 2020). Efforts need to carefully guard against potentially increasing or exacerbating inequalities and address those that may arise by guaranteeing fair and affordable access to ICT for vulnerable groups and countries with weak capacities. The UN Secretary-General's Roadmap for Digital Cooperation report issued in June 2020 emphasized the importance of digital inclusiveness. This is echoed by the Broadband Commission for Sustainable Development's Agenda for Action, which recommends guaranteeing flexible, affordable, and safe access to online services. Digital technology is contributing significantly to the effectiveness of pandemic response strategies. Studies highlight that the potential use of ICT has been harnessed through technological developments including billions of connected mobile devices and large volumes of online datasets, as well as low-power computing, machine learning, and natural language processing. The adoption of digital technologies was significantly increased during the pandemic (Budd et al., 2020).

National response strategies for COVID-19

The impact of COVID-19 varies by country. This report looks at 14 countries - Mexico, the United States of America, Germany, Spain, the United Kingdom, China, India, Japan, Republic of Korea, Malaysia, Kenya, Liberia, and Mauritius - in terms of the characteristics and effects of their control and prevention measures. The countries were selected as comparative examples of both developed and developing countries in the Asian, European, North American, and African regions.

Weekly COVID-19 cases (left) and deaths (right) per million people



Source : adapted from Our world in data (2021)

The countries' figures for confirmed cases and deaths per million display similarities in seasonal patterns for sharp hikes, but show significant differences in terms of the pandemic's onset between countries in Europe and the Americas versus those in Asia and Africa. The pandemic's spread also shows huge disparities even between neighbouring countries. To understand the differentiated impact of COVID-19 across regions, this report looked into the governance, legislation, control measures, vaccination, economic policies to mitigate economic shocks, and public approval levels in select countries. The approach involved analysing news reports, government statements and press releases, reports on COVID-19 responses, statistics on COVID-19 cases and deaths, and socio-economic indices.

1. Governance

For governance, policy coordination between the response bodies was particularly important, with countries such as Germany, Republic of Korea and China faring better than countries that lacked coordination. In terms of legislation, countries in Asia and Africa swiftly responded to the pandemic based on their existing legislation from previous epidemic responses, whereas countries in Europe and America struggled in the initial response stages. Some countries (e.g. Republic of Korea and Malaysia) were able to take advantage of ICT services, such as social networks and text messaging, to deliver public health information.

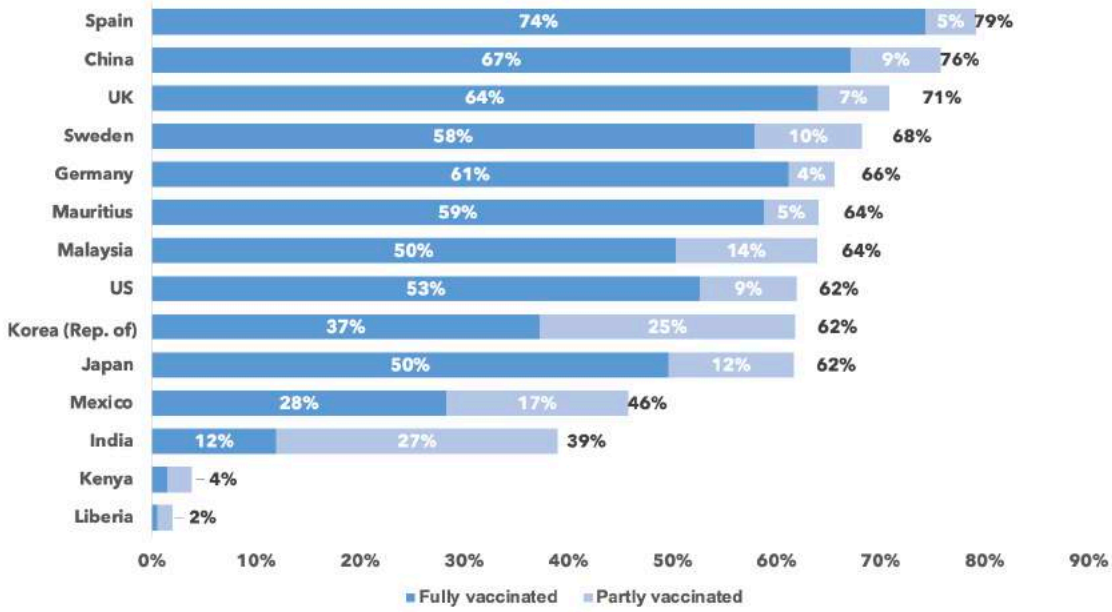
2. NPI policies (3T, social distancing) and the use of ICT

From the early stages of the pandemic, when no vaccine or treatment was available, countries responded with NPI policies such as the 3Ts (test-trace-treat) and social distancing to control the spread of the virus. ICTs contributed immensely to the efficiency and efficacy of these policies. Of the 3Ts, the testing capacity failed to keep up with the surging incidences in several countries during the early stages, which led to further transmission from untested cases. When it comes to the second T, countries that have been actively deploying digital tracing using mobile phone records (e.g. Republic of Korea and China) since the initial phases of the pandemic appear to be containing the virus. Meanwhile, low- and middle-income countries (LMICs) are struggling to introduce digital contact tracing, owing to the low penetration rate of digital devices and weak public health infrastructure. With respect to treatment, Republic of Korea classified their patients based on big data from insurance companies, whereas the United States relieved the burden on the health system through ICT (e.g. telemedicine). A common phenomenon observed in multiple countries is that the effect of social distancing policies was weakened owing to public fatigue and waning compliance. Nonetheless, ICT services, such as online education, e-commerce and virtual meetings played an important role in enabling social distancing more broadly. In LMICs, constraints related to ICT infrastructure, contributed to difficulties in enforcing and complying with social distancing policies.

3. Vaccination

The development of vaccines was led by nations that were hit the hardest by the pandemic – European countries, the US, China, and India – with vaccinations also being rolled out at a fast rate. LMICs, particularly in Africa, faced difficulties in securing vaccines, many of which were beyond their control. Although developed countries in Europe and America saw a rapid decrease in cases and deaths as more than 50 per cent of population became vaccinated, this trend is being reversed due to stagnant vaccination rates and the emergence of the Delta variant.

National vaccination rates (30 July 2021 - 8 September 2021)



Source : Our world in data (2021)

4. Fiscal and monetary policies

Countries executed various fiscal and monetary policies to mitigate the economic impact of social distancing. Countries with advanced economies and high credit ratings were able to implement large-scale fiscal policies, whereas developing countries struggled with broader economic challenges. Mitigation measures included monetary policies, such as lower interest rates and large-scale quantitative easing, which also depended on the economic level of a country. Meanwhile, digital identification systems such as India's Aadhaar boosted the effectiveness of fiscal policies, which enabled the efficient and effective deployment of governmental support.

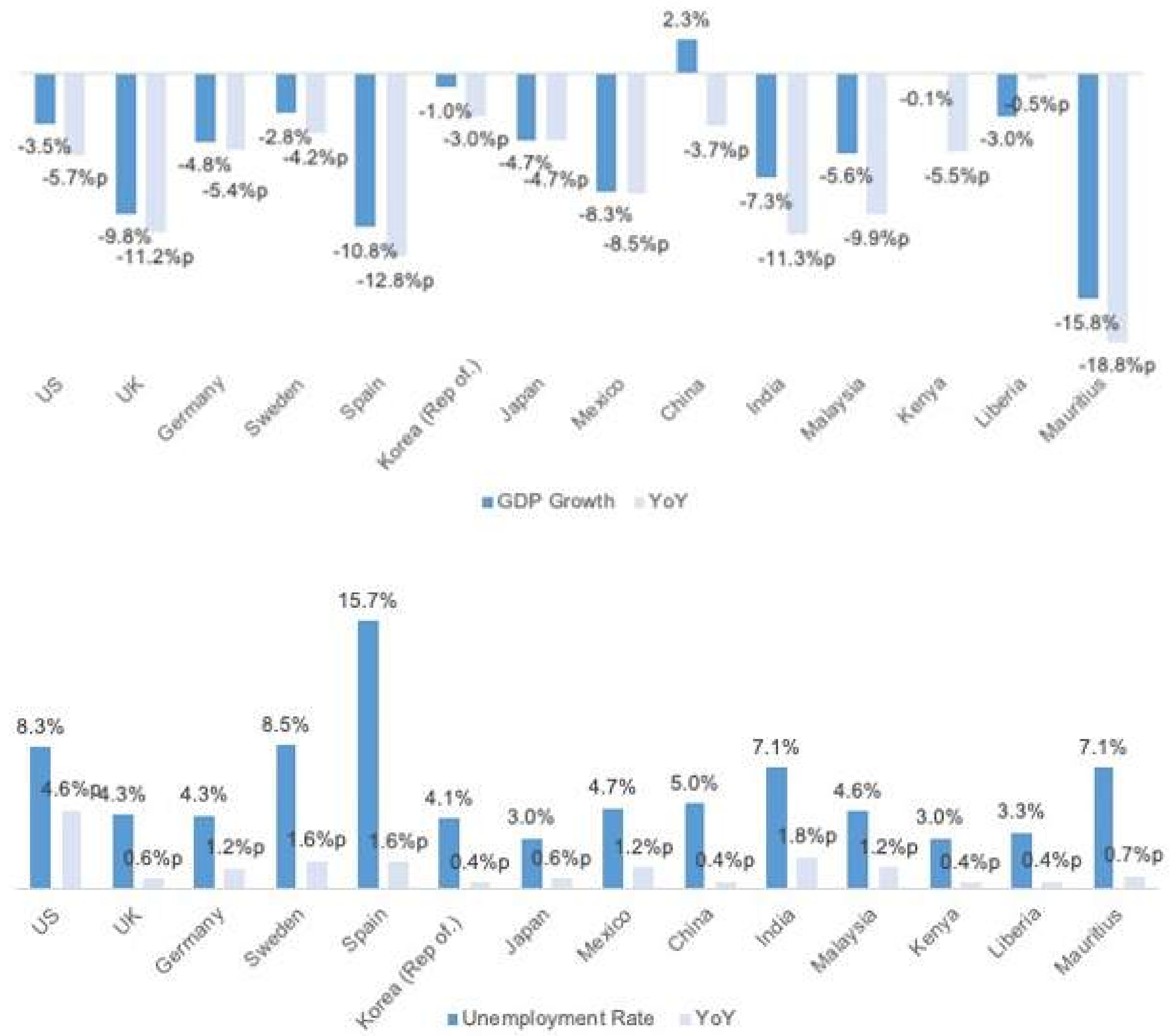
5. Public approval of disease control policies

As for the public's approval of disease control policies, opinion polls (Ipsos MORI, 2020; YNA, 2020) indicate that most countries displayed better compliance with prevention rules in the early stages. The approval level fell starting in the latter half of 2020 owing to heightened public fatigue, leading in some countries to protests and litigation against policies such as lockdowns that restricted movement and gatherings.

6. Socio-economic impact of COVID-19

The socio-economic impact of the pandemic played out differently between countries and income levels within countries. Countries analysed in the report recorded negative GDP growth and high unemployment rates in 2020, but some countries in Asia that were better able to control the spread of the virus were less affected than advanced economies in Europe and the United States. However, the economies of some LMICs experienced greater shocks despite having more successful infection control than advanced economies.

2020 GDP growth (top) and unemployment rate (bottom), year on year (YoY)

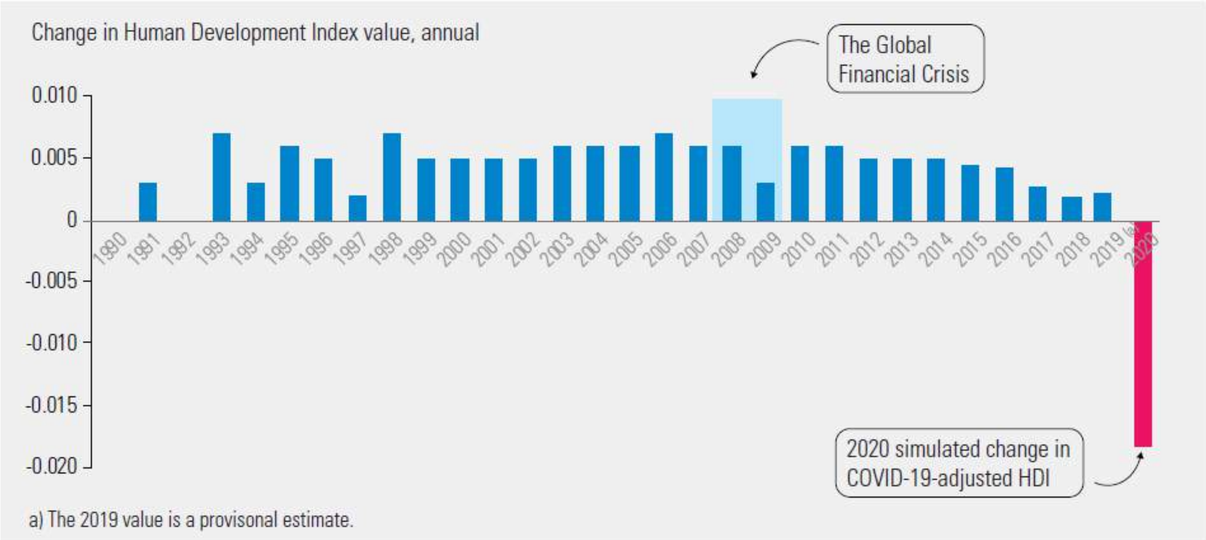


Source : Growth rates from IMF (2021b), Unemployment rates from ILO (2021)

According to the Enhancing Access to Opportunities (2020) report (IMF & World Bank, 2020), social distancing measures and suspension of public services have hit disadvantaged groups the hardest. For instance, low-skilled workers could not work from home and did not have proper access to digital tools. The closure of schools also caused turmoil. The Human Development Index (HDI) fell at an unprecedented rate in 2020, offsetting six years of progress.

One key factor in the decline was the shock to the education sector. Countries with low or medium human development are expected to have experienced the most severe difficulties, with alternatives such as online education drastically constrained due to insufficient ICT accessibility (computers, Internet and broadband).

Sharp decline in HDI from COVID-19



Source : UNDP (2020a)

There is also a greater risk of hunger and malnutrition. The analysis by the United Nations Development Programme (UNDP) in Leaving No One Behind (2021) suggests that by 2030 an additional 12.8 million people could suffer from malnutrition due to COVID-19, with the number of malnourished children increasing by 1.6 million. Global poverty increased for the first time in 20 years because of the pandemic (UNDP, 2021a). The World Bank estimated in 2020 that the number of people in extreme poverty rose by 97 million, with developing countries in South Asia and sub-Saharan Africa most affected, and this figure was expected to reach 155 million in 2021 (World Bank, 2021a).

Choices made now could alter this dire scenario, and changing course becomes harder as time passes with serious challenges left unaddressed. UNDP has identified an ambitious – but feasible – set of targeted investments in governance, social protection, the green economy and digitalization. Through this 'SDG Push', 100 million people in low- and medium-income countries could be lifted out of poverty by 2030 (UNDP, 2021a).

7. ICTs are tools and enablers, not panaceas

ICTs were important in the COVID-19 response, and are likely to play a crucial role as countries recover – and build forward better – from the pandemic. However, ICTs in any context are complements, augmenters, and amplifiers of human ingenuity and commitment. This is particularly the case in public health responses, which are founded on an extensive and dedicated workforce – from in-hospital healthcare professionals to last-mile community health workers. For example, digital contact tracing does not only require smartphones; it also requires the deployment of public health professionals who can design an approach as well as analyse and respond to the data that the processes generate. Similarly, as this report highlights, tools such as AI played a key part in accelerating vaccine discovery and driving pharmaceutical responses to the pandemic. However, this too built on the talent, expertise, and focus of researchers, scientists, policy-makers, regulators, and countless others across national and international civil society, research and development communities, governments, and the private sector.

8. Sub-conclusion for the analysis of national response strategies

This review of national response policies and outcomes demonstrates the importance of early detection and containment, and prior efforts to build an epidemic response system. The epidemic response system would entail governance for control and accountability over various sectors, appropriate use of ICT for efficient epidemic responses, and transparent communication to increase the public's receptiveness to policies and prevent the spread of disinformation. Moreover, citizens of LMICs and vulnerable groups are the most likely to be negatively impacted by the wide adoption of ICT to enable social distancing. Therefore, an important consideration for future epidemic responses would be to determine the ICT infrastructure that these people have access to and design context-specific approaches. Solutions that can be deployed in areas with weak ICT infrastructure should be explored.

COVID-19 response of international organizations

UN bodies, including the WHO, and international organizations such as the World Bank and the IMF, presented recommendations for the global community's response to COVID-19 and provided a wide range of support. The below summary does not aim to be exhaustive. At the onset of the crisis, the UN quickly deployed a comprehensive response with three pillars addressing the health, humanitarian and socio-economic impact (UN, 2020b). The health response was led by the WHO and included measures for controlling the virus, strengthening preparedness, and supporting the development of vaccines, diagnostics and treatment. The humanitarian pillar, coordinated by UN OCHA (Office for the Coordination of Humanitarian Affairs), focused on multi-sectoral needs in over 50 vulnerable countries. The third pillar, on addressing the socio-economic impact of the pandemic, involved the UNDP serving as the UN system's technical lead. Efforts focus also concentrated on recovery processes that pursue a better post-COVID world by tackling the climate crisis, inequalities, exclusion, gaps in social protection systems and the many other fragilities. Financial institutions and multilateral development banks (e.g. the World Bank and IMF) have offered emergency assistance to developing countries, and organizations (e.g. the WEF and International Chamber of Commerce) provided advice on COVID-19 responses.

In terms of vaccine development and distribution, the WHO was engaged in the research and development, manufacturing, regulation, and evaluation of COVID-19 vaccines. The UN joined the ACT-Accelerator, launched in April 2020, to ensure access to vaccines for all, which includes the COVAX Facility – a programme for group vaccine purchase. The IMF and World Bank created a fund for vaccine supplies and the World Trade Organization (WTO) has offered policy support for vaccine distribution.

The ITU is proactively deploying ICT in its COVID-19 responses and is engaged in the following efforts in conjunction with the WHO and UNICEF: sending text messages on COVID-19 infection control to people in countries lacking a proper telecommunications infrastructure; promoting the importance of digital solutions in disease response to the G20 Health Ministers; building a global network-recovery platform to deal with the heavy increase in telecommunication demand; and supporting students who have no Internet access and are unable to take part in online classes. In addition, the REG4COVID platform was built to share best practices in the digital response to COVID-19.

Responses to the COVID-19 outbreak also resonate deeply also at the heart of UNESCO's mission. The experience of COVID-19 tells us that scientific cooperation is key when dealing with a global public health issue. It tells us that continued education must be ensured when so many children today cannot go to school. It is a stark reminder of the importance of making reliable, quality information available when rumours are flourishing. It speaks to the power of culture and knowledge to strengthen human fabric and solidarity, at a time when so many people around the world must maintain social distancing and stay at home. UNESCO is fully committed to supporting governments' facilitation of distance learning, open science, and the sharing of knowledge and culture, as fundamental means of standing together and tightening the bonds of our common humanity. Among UNESCO's responses, the Global Education Coalition (GEC) was established as an international multi-sector partnership to meet the urgent and unprecedented need for continuity of learning as the pandemic disrupted education systems across the world. In addition, UNESCO's #CoronavirusFacts project addresses the wave of disinformation that threatens to destabilize democracy, sustainability, and stability amidst COVID-19, and communicates the necessary accurate messaging. Also, UNESCO and the WHO have worked together to conceive and produce radio output to provide reliable health information and deconstruct myths about transmission, infection, and vaccination.

Meanwhile, there is a need for more COVID-19 models that are tailored to enable LMICs to propose and explore relevant containment strategies and inform data-driven decision-making. The CoMo (COVID-19 Modelling) Consortium, created by researchers at the University of Oxford, endeavours to develop such models and enhance their contextual relevance through collaboration with local experts.

Similarly, refugee and internally-displaced-person (IDP) settlements present high-risk environments for the rapid spread of disease. UN Global Pulse, the UN Secretary General's innovation initiative and a member of the Broadband Commission for Sustainable Development, has collaborated with multiple UN agencies and academic groups to generate a new simulation tool for understanding the effects of NPI policies by conducting epidemiological modelling of the Cox's Bazar settlement in Bangladesh. This tool has since been adapted to inform decision-making in other settings; however, there is still a need to improve the support available to these highly vulnerable people.

Importance of ICT in future epidemic responses

ICT is instrumental in both non-pharmaceutical (e.g. 3T and social distancing) and pharmaceutical (e.g. treatment and vaccines) measures to respond to health crises such as the COVID-19 pandemic. The areas where ICT contributions are key include: digital epidemiological surveillance (using AI and other tools); medical image analysis and screening candidates for vaccines and treatment; symptom questionnaires through apps or other digital data-collection approaches; data extraction and visualization; contact tracing through mobile phone records and Bluetooth data; public communication through social networks; and telemedicine.

Budd et al. (2020) proposes a framework of five ways in which ICT was used at different levels of disease response: digital epidemiological surveillance, rapid case identification, interruption of community transmission, public communication, and clinical care. They are summarized in the following table along with a sixth use, pharmaceutical intervention (PI).

Table: ICT-based approaches in COVID-19 response by purpose

Purpose	ICT-based approaches
Digital epidemiological surveillance	Prediction of infectious disease using AI and big data surveys through SNS (Social Network Services)
Rapid case identification	Analytics-based thermal detection solution Digital credentials to support safe and convenient travel Early diagnosis through wearable devices
Interruption of community transmission	3T-based contact tracing
Public service delivery, communication and socio-economic engagement	Emergency alert text messages Online public education service E-commerce
Clinical care	Telemedicine
Pharmaceutical intervention	Development of vaccines and treatment using AI Digitalization of vaccine cold chains

Examples of approaches leveraging ICT in COVID-19 responses

This report looks into ICT-based approaches that contributed to the COVID-19 response using the six categories above.

1. Digital epidemiological surveillance

BlueDot, a Canadian start-up company, detected the new virus using AI on 30 December 2019 – nine days earlier than the official announcement by the WHO. The AI4I (AI for Impact) of GSMA helped LMICs such as the Democratic Republic of the Congo (DRC), Rwanda, Benin, and Burkina Faso, to devise response policies based on the analysis of mobile big data. Meanwhile, Facebook teamed up with Carnegie Mellon University to help collect survey data on COVID-19 in the United States and with the University of Maryland to carry out a global survey.

2. Rapid case identification

Nokia announced an automated, zero-touch, elevated-temperature detection solution designed to help spot potential COVID-19 infection in facilities with thousands of people. KT developed an airport screening app, Safe2Go, which offers a range of infection control services for the departure process to support travel during the pandemic, taking into account its serious toll on the tourism industry. Meanwhile, Fitbit developed an algorithm to identify the initial signs of COVID-19 through its wearables, which was based on joint research with the Scripps Research Institute and Stanford Medicine.

3. Interruption of community transmission

The KT GEPP (Global Epidemic Prevention Platform) is Republic of Korea's representative public-private project for pandemic response. The platform features an app that is connected to the government's integrated information system and supports its 3T response. In addition, KT's call check-in service allows visitor logs for restaurants and other public areas to be managed with just a phone call, addressing systemic problems with credibility, data security, and digital poverty.

In Sri Lanka, trackers and apps to monitor COVID-19 were produced within a short timeframe based on the DHIS2 (District Health Information Software 2) developed by the HISP (Health Information Systems Programme). This was done following a request by the Sri Lankan Ministry of Health. These tools were used to quarantine and monitor travelers. The data were analysed on the individual, regional, state, and national levels while guaranteeing both security and privacy protection.

4. Public service delivery, communication and socio-economic engagement

ICT contributed to the accurate, fast, and transparent communication of epidemiological information to the public, leading to greater approval of policies and screening of disinformation. The Republic of Korea utilized its existing emergency-alert texting system to deliver updates on cases and outbreak locations, enabling people to take the necessary measures such as seeking tests. Many other countries also resorted to social network services, text messages, and radio broadcasts in their public communication of COVID-19 information. In addition, digital platforms for online learning and e-commerce allowed for uninterrupted essential services during social distancing and lockdowns. The suspension of public education became an issue as concerns over the spread of COVID-19 led to the complete or partial closure of schools. Online education serves as a means to overcome such, but there are challenges in delivering inclusive and effective learning experiences via digital channels. The ITU launched the Giga initiative with UNICEF to help solve the problem of inadequate access to online education in developing countries. Meanwhile, e-commerce platforms supported SMEs (small and medium-sized enterprises) in providing essential food and products, and preventing unemployment during lockdowns. Jumia in Africa, for instance, provides COVID-19 response services in partnership with the UNDP for countries such as Uganda.

5. Clinical care

New York State declared an emergency in March 2020 and relaxed its regulations to expand its remote mental health services and offer uninterrupted care to citizens suffering from isolation and patients who had being receiving psychiatric care. The United States government also underwent deregulation efforts to promote telemedicine, such as permitting the use of universal applications (e.g. Facetime and Facebook Messenger), to lessen the burden on the healthcare system. The proportion of telemedicine users increased significantly from 11 to 46 per cent of all healthcare users

6. Pharmaceutical intervention

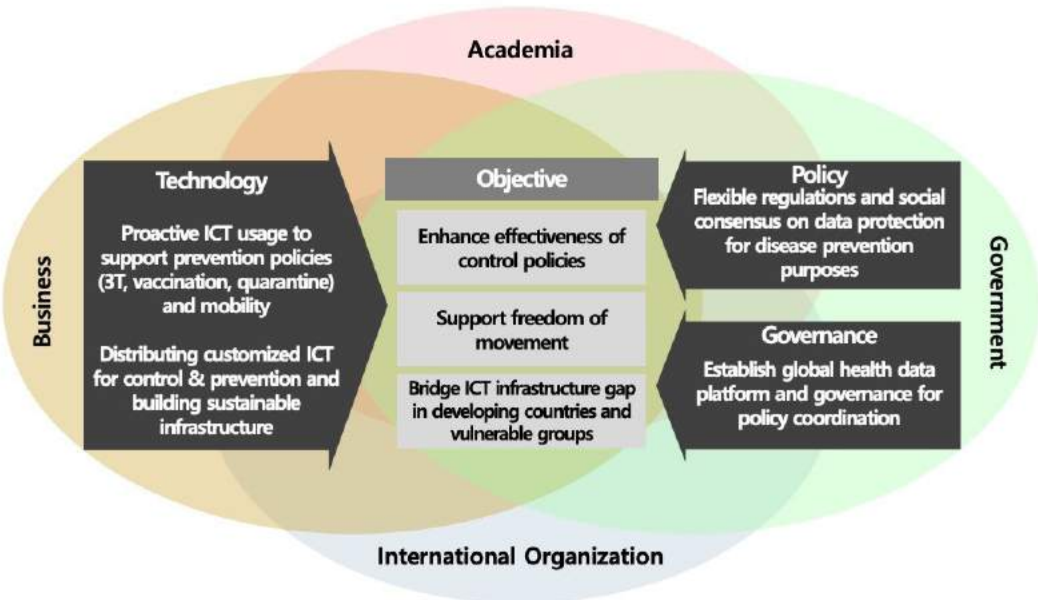
Technologies such as AI and Blockchain were deployed throughout the development and distribution stages of COVID-19 vaccines and treatment. Moderna used AI and cloud services to drastically reduce the time and money spent on new drug research, succeeding in developing the mRNA vaccine a year after the outbreak of COVID-19. Nokia contributed by providing its cloud resources for 5G software R&D to the World Community Grid, an initiative that supports humanitarian research to solve dilemmas faced by mankind. In addition, the cold chains for COVID-19 vaccines, requiring storage at ultra-low temperatures, were managed by smart barcodes.

Key insights and considerations for future epidemic responses

The examples above demonstrate how ICT plays a crucial role in pandemic preparedness and the ability to respond rapidly. ICT contributed to disease containment by boosting the efficiency of the 3Ts and to the sustainability of response measures by helping to maintain essential services which minimized public fatigue. Good governance* of COVID-19 response measures may contribute to the overall efficiency of the ICT-based public pandemic response system (UNDP, 2021e; UN Department of Economic and Social Affairs, 2020). A lack of access to ICT and other social infrastructures made it difficult for the LMICs and vulnerable groups who suffered the most to recover from the shocks of the pandemic. Based on these lessons, we can suggest four considerations. First, timely ICT-based responses require up-to-date and accurate data, and the development as well as deployment of strategies and tools for data collection. The use and management of data need to be guided by appropriate policy and regulatory frameworks that guarantee personal privacy and data security. Second, investment should be made to expand the role of ICT in public health, particularly in the context of a crisis. Third, we need to bridge the ICT infrastructure gap between countries to help the disadvantaged. Fourth, a global public-private governance for data sharing and policy coordination should be built. All of these should be founded on the specific context of individual societies and communities, and take into consideration people's level of access to, and capacity to use, ICTs (including the public as well as those involved in any public health response).

* Good governance has eight major characteristics. It is participatory, consensus-oriented, accountable, transparent, responsive, effective, efficient, equitable and inclusive and follows the rule of law (UN Economic and Social Commission for Asia and the Pacific, n.d.).

Considerations for future epidemic responses



Source: Working Group on Epidemic Management

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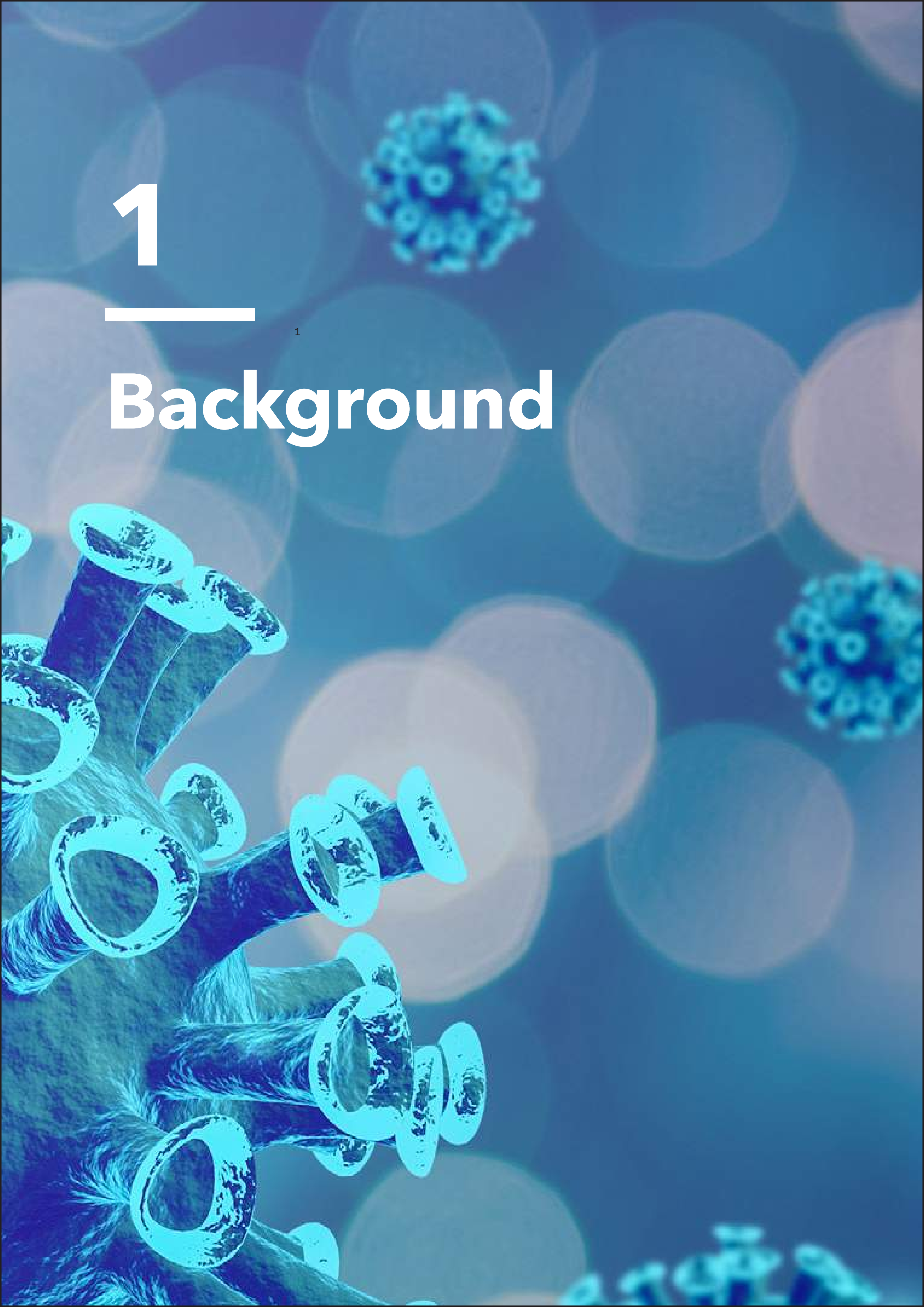
Background



1 Background

1.1 Overview of COVID-19

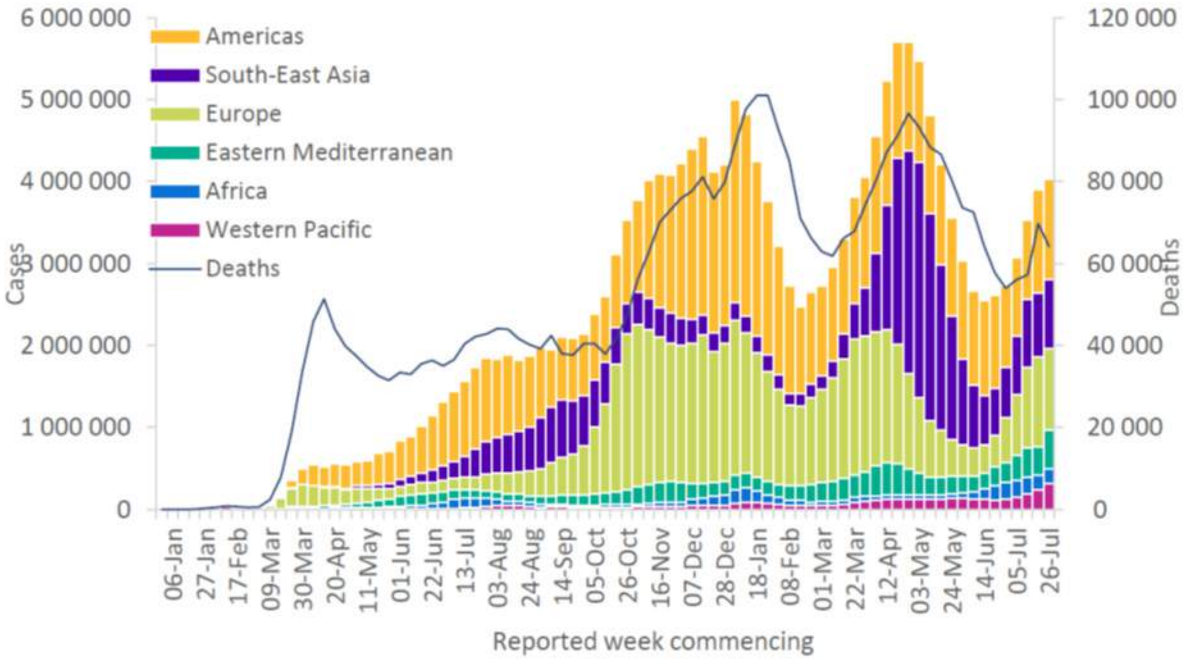
COVID-19 is an infectious disease that was discovered in 2019, and is caused by the pathogen SARS CoV-2 virus. Its symptoms include fever, dry coughs, respiratory illness, and pneumonia. The disease was first identified in Wuhan, China, followed by outbreaks around the world. With no treatments or vaccines at hand, 120,000 people were infected in 110 countries worldwide within a two-month period. The WHO officially declared COVID-19 to be a Public Health Emergency of International Concern on 30 January 2020, and a pandemic on 11 March.

Initially, the only way to fight the new pandemic was to contain the spread of the virus through non-pharmaceutical interventions (NPIs). Countries closed their borders and implemented travel restrictions. Strict lockdowns had to be put in place, including closing schools, banning public meetings, imposing quarantines and self-isolation, cancelling events, limiting the size of gatherings, and implementing home working, online schooling, and social distancing. Although the transmission of COVID-19 varies between countries, the curve was temporarily flattened from June to August as a result of strong measures taken by each government. However, the relaxation of social distancing measures following the first outbreak led to increased mixing among people, and governments were slow in imposing another lockdown owing to resistance by those in financial distress. This led to a second large outbreak in September and October. Lockdowns were imposed once again across Europe, curtailing COVID-19 cases for most countries. This resulted in continued conflict between political and economic demands, as stringent disease control measures led to bigger short-term economic losses.

New COVID-19 variants have been emerging globally. Variants of the virus that may pose a threat to global public health are classified by the WHO as variants of interest (VOIs) or variants of concern (VOCs). VOIs have genetic variations that affect transmissibility, disease severity, immune escape, and diagnostic or therapeutic escape. They are a rising threat to global public health, having instigated significant regional transmissions or clusters, leading to an increase in incidences over time or other specific epidemiological impacts. As of September 2021, the Lambda and Mu variants have been designated as VOIs. VOCs meet the definition of VOIs while bringing about additional detrimental changes that could increase the transmissibility or severity of COVID-19 epidemiology and cause further virulence or alter the clinical disease presentation. They may also undermine the effectiveness of public health or social measures and the efficacy of available diagnostics, vaccines, and treatment. VOCs impose an extreme burden on the medical system. The variants currently designated as VOCs are the Alpha, Beta, Gamma, and Delta variants (WHO, 2021a). The Alpha variant was discovered in the UK, the Beta variant in South Africa, the Gamma variant in Brazil, and Delta in India. They are highly contagious and thus prone to spread more easily and rapidly. In particular, the Delta variant caused another upturn in infection rates despite relatively high vaccination rates in many countries.

Pharmaceutical and biotech companies worldwide rushed to develop treatments and vaccines, with support from governments, including eased regulations and funding. Consequently, the R&D process was greatly reduced and the UK was the first to start the vaccination process in December 2020, approximately one year after the first outbreak, marking the beginning of the worldwide distribution of vaccines.

Figure 1: COVID-19 cases reported weekly (3 August 2021)



Source : WHO (2021b)

As of 3 August 2021, the cumulative number of COVID-19 cases globally has reached over 197 million (see Figure 1) with 4.2 million deaths (WHO, 2021b).

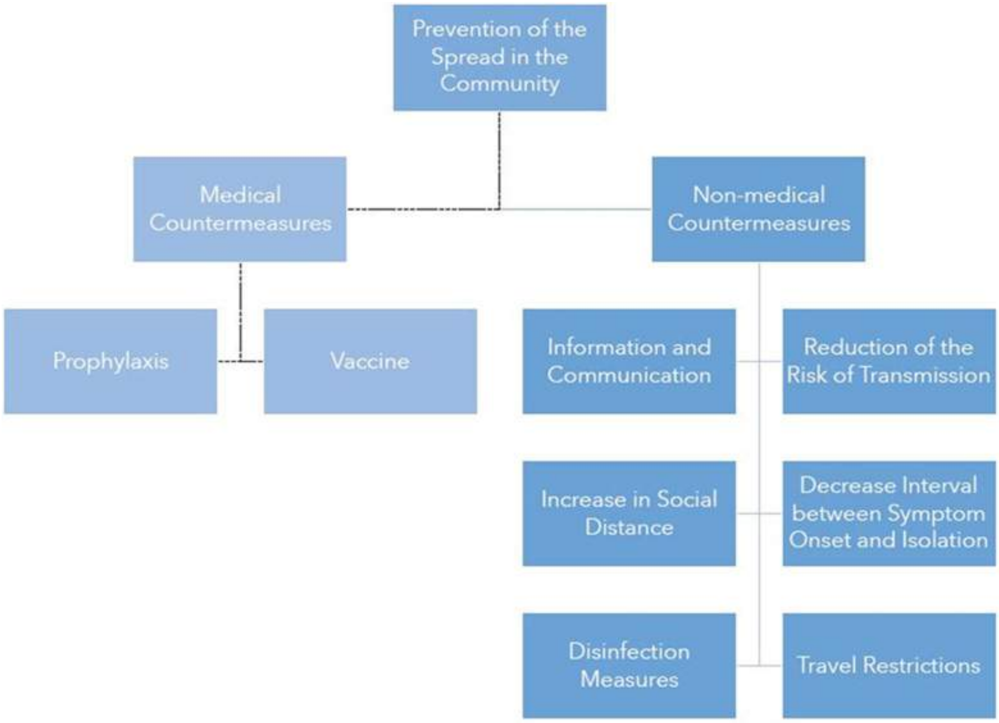
1.2 Strategies for Responding to New Infectious Diseases: PI and NPI

Strategies to contain the spread of new infectious diseases such as COVID-19 can be categorized into pharmaceutical and non-pharmaceutical interventions. The development of vaccines and treatment fall into the pharmaceutical intervention (PI) category, while non-pharmaceutical interventions (NPIs) are public health measures designed to control the spread of infectious diseases without the use of drugs (see Figure 2 and 3). New viruses can be quick to spread among people as there is little or no immunity to them. In this case, NPI offers viable solution for containing the infectious disease in the absence of a vaccine or treatment. It includes individual sanitation recommendations (wearing a mask and washing hands), travel restrictions (border control), social distancing policies (closing schools/theatres/restaurants, banning social gatherings), tracing and isolating confirmed cases and their contacts, and informing the public about the disease. The goal of NPIs is to control the inflow, outbreak, and peak size of epidemics so as to prevent the burden on the health system from exceeding its capacity (Liu et al., 2021). NPIs are considered as one of the best ways to prevent infections in the absence of a vaccine (CDC, 2020b). In particular, epidemics such as COVID-19 with a high basic reproduction rate may require the implementation of NPIs to ensure that the healthcare demands remain within the system's capacity (Ferguson et al., 2020). The response to COVID-19 also followed these procedures, consistently implementing non-pharmaceutical measures such as masks and social distancing while at the same time developing vaccines and treatment.

1.3 ICT's Contribution to the Infectious Disease Response

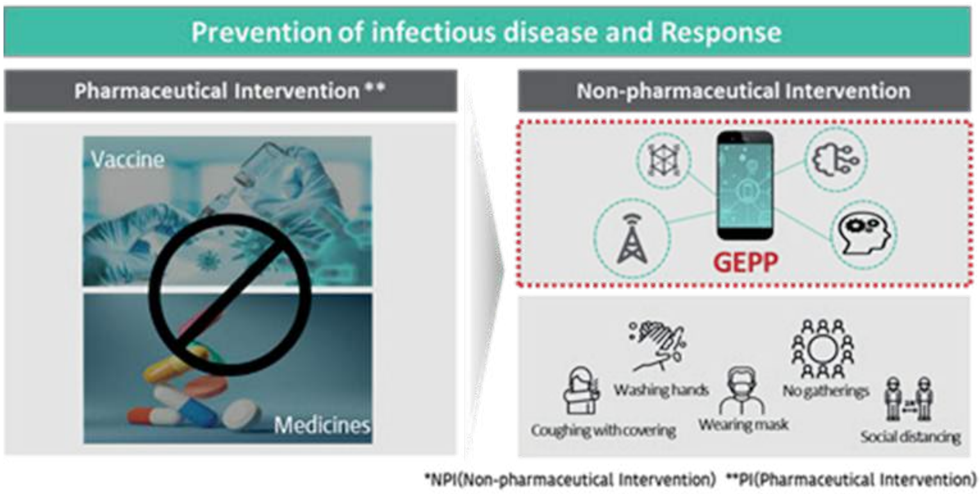
ICTs are technologies and equipment that handle (e.g. access, create, collect, store, transmit, receive, and disseminate) information and communication (ITU, 2013). Any usage of ICT should be anchored in the needs, realities,

Figure 2: Public health response policies for pandemics including COVID-19



Source : OECD (2020a)

Figure 3: PI vs NPI



Source : KT (2020a)

and aspirations of individuals, including driving a whole-of-society approach to digital transformation (UNDP, 2020d). Digital technology, if deployed thoughtfully and inclusively, can significantly contribute to the effectiveness of pandemic response strategies. The potential use of ICT has been harnessed through technological developments including low-power computing, machine learning, and natural language processing, as well as the availability of billions of connected mobile devices and large volumes of online datasets. ICT solutions that boost the entire response process include epidemiological surveillance and analysis of medical images using artificial intelligence and machine learning; survey applications and websites for reporting symptoms; data extraction and visualization; quick case detection using connected devices; sensors including wearables for checking symptoms; telemedicine; mobile phone tracking and route analysis; chatbots; and public communication.

1.4 Framework for Response to Future Pandemics

COVID-19 manifested the inefficiency of the existing health and social systems in dealing with new pandemic crises, demonstrating the systematic vulnerability of international cooperation and global supply chains, which had been the basis of globalization. However, lessons learned from successful response to COVID-19 illustrate how the system should be revamped to better cope with future pandemics. These lessons are reiterated in reports published by prominent international organizations and think tanks. The reports also specify the need for a framework to effectively prepare for and respond to potential pandemics.

This section looks at the key contents and messages of ten reports by international agencies and research institutions on disease response, including COVID-19, to draw out considerations for an epidemic response framework.

The Global Preparedness Monitoring Board (GPMB), co-convened by the WHO and the World Bank to evaluate our preparedness for global health risks, predicts in its annual report *A world at risk* published in September 2019 of "a very real threat of a rapidly moving, highly lethal pandemic of a respiratory pathogen killing 50 to 80 million people and wiping out nearly 5% of the world's economy" (GPMB, 2019).

One year later, in its report *A world in disorder*, it offers a grim evaluation of the global response to the pandemic with five lessons: that political leaders who act decisively based on science and evidence can make a difference; that not just governments but also individuals can implement crucial protection measures; that the pandemic has a devastating impact not only on health but on our society and economy as well, requiring preparedness in education, society, and the economy to become "pandemic proof"; that the existing pandemic response system is not predictive; and that investing in global health security can lead to large returns (GPMB, 2020).

Dennis J. Snower, nonresident senior fellow at the Brookings Institution and senior professor of macroeconomics and sustainability at the Hertie School in Berlin, mentions in his report *Awakening in the post-pandemic world* three lessons to be learned. First, the price paid for the pandemic was greater than it could have been, owing to our negligence in the face of many warnings for years. Second, the priority placed on each country's national interests aggravated the problem as worldwide cooperation was critical to end the pandemic. Third, the economic crisis arising from the pandemic had to be dealt with differently than previous crises. Snower suggests investing in global public health capacity and the diversification of global supply chains as insurance against future pandemics (Snower, 2020).

The OECD's initiative New Approaches to Economic Challenges (NAEC), in its report *A systemic resilience approach to dealing with Covid-19 and future shocks*, released in April 2020, claims that excessive emphasis on economic efficiency intensified the shock of COVID-19, and that the pandemic exposed the vulnerability of existing systems. The report also points out that cultural factors such as trust in institutions, inclination to follow their advice and instructions, and a sense of community, can greatly impact disaster recovery (OECD NAEC, 2020).

The Broadband Commission for Sustainable Development pointed out the growing risk of epidemics in its *Preventing the spread of epidemics using ICT* report published in September 2018. It examined the role of ICT as a game changer to resist such risks, introduced responses that used mobile and big data analytics technology, and stressed the importance of a global data sharing and monitoring system for epidemics (Broadband Commission for Sustainable Development, 2018a).

The OECD's report *Beyond containment: Health systems' responses to COVID-19 in the OECD* (April, 2020) presents four measures for going beyond containment of the virus, emphasizing that operational, financial, and R&D measures are essential for effective patient care and reducing the burden on the health system. The report first points out that universal access to diagnostics and treatment should be guaranteed, considering how infectious diseases do not discriminate between rich and poor, and that it should facilitate affordability as well as universal coverage. Also, as securing the 3S's (staff, supplies and space) has become a priority for countries due to increased demand for medical care, the role of existing health workers should be expanded and a "reserve army" should be planned. To address the shortage of medical supplies, the health system's capacity should be expanded and streamlined by boosting international cooperation in providing medical equipment, monitoring the supply chain, and ensuring adequate capacity of hospital beds.

The OECD also points out that digital transformation can assist countries in detecting, preventing, responding to, and recovering from COVID-19, and that global health authorities should share coherent, comparable and timely data within and between countries. The report suggests that standardizing EHRs (electronic health records) and using medical insurance databases, big data and smartphone data, e.g. from social media, web searches, and satellite information, can contribute to the containment of the pandemic, but that there is also the possibility of privacy violations. So the OECD recommends that the use of digital data and tools for monitoring diseases and enhancing treatment should include a data governance framework for privacy protection. Moreover, it is mentioned that although telemedicine can minimize physical contact and help patients with mild symptoms, regulations and access to broadband may be barriers to its use. In addition to concentrated investments in diagnostics, vaccines and treatment, the report suggests the enforcement of policies in areas including the use of AI, the simplification of approval processes, and incentives for pre-emptive R&D to guard against future pandemics (OECD, 2020a).

The mission of the Independent Panel, which was established by the WHO Director-General under the World Health Assembly resolution 73.1 (WHO, 2020d), is to provide an evidence-based path from past and present lessons for international institutions, to effectively respond to health crises. The panel's co-chairs are the Rt Hon. Helen Clark, former Prime Minister of New Zealand, and Her Excellency Ellen Johnson Sirleaf, former President of Liberia. The Independent Panel has a total of 13 members with a mix of skills and expertise in infectious disease, global and national health policy and financing, outbreaks and emergencies, economics, youth advocacy, and the well-being of women and girls. They also share knowledge of the international system, including the workings of the WHO, and experience from similar international processes (The Independent Panel, 2021a). Starting in September 2020, the panel was engaged in a neutral, independent, and comprehensive review which was published in the Main Report of the 74th World Health Assembly, entitled "COVID-19: Make it the last pandemic" (The Independent Panel, 2021b). The report provides actions to contain COVID-19 and recommendations on how to prevent future diseases from becoming yet another destructive pandemic (The Independent Panel, 2021c).

These recommendations are as follows (see Figure 4). First, leadership in preparing for and responding to global health crises should be elevated to the highest level to ensure justifiable, accountable, and multi-sectoral actions. This entails support from the UN General Assembly's resolution, the establishment of a Global Health Threats Council led by heads of state and government, and the adoption of a Pandemic Framework Convention. It also requires agreement on a political declaration by heads of state and government at an international meeting for the transition of existing disease response and preparedness measures to those outlined in the report, with the assistance of the UN General Assembly.

Second, the WHO's independence, authority, and financing should be emphasized. In particular, the panel suggests strengthening the financial independence of the WHO, the authority and independence of the Director-General, and the governance of the Executive Board by establishing a Standing Committee for Emergencies. The panel also stresses the WHO's oversight of norms, policies, and technical guidance, and its leadership, convening authority, and coordinating role for emergency response operations during pandemics. It also advises the WHO country offices to provide adequate resources to meet each government's technical needs in terms of pandemic preparedness and response.

Third, investments should be made to fully ensure operational capacity at the national, regional, and global levels. This includes new standards and goals for the WHO in terms of pandemic preparedness and response capacity, national preparedness plans based on the WHO's goals and benchmarks by all governments within six months, the official introduction of a universal and periodic peer review of countries' preparedness, and the inclusion of periodic evaluations in the IMF's "Article IV consultations" (IMF, n.d.).

Fourth, an international system for surveillance, ratification, and alert should be newly established. Specifically, the WHO should create a new global system for surveillance based on complete transparency and the latest digital tools. The WHO should also be given authority by the World Health Assembly to immediately release information on potential pandemics without the prior consent of governments and to investigate potential pathogens in all countries. Also, any PHEIC (Public Health Emergency of International Concern) declared by the WHO Director-General should be based on justifiable and prophylactic principles.

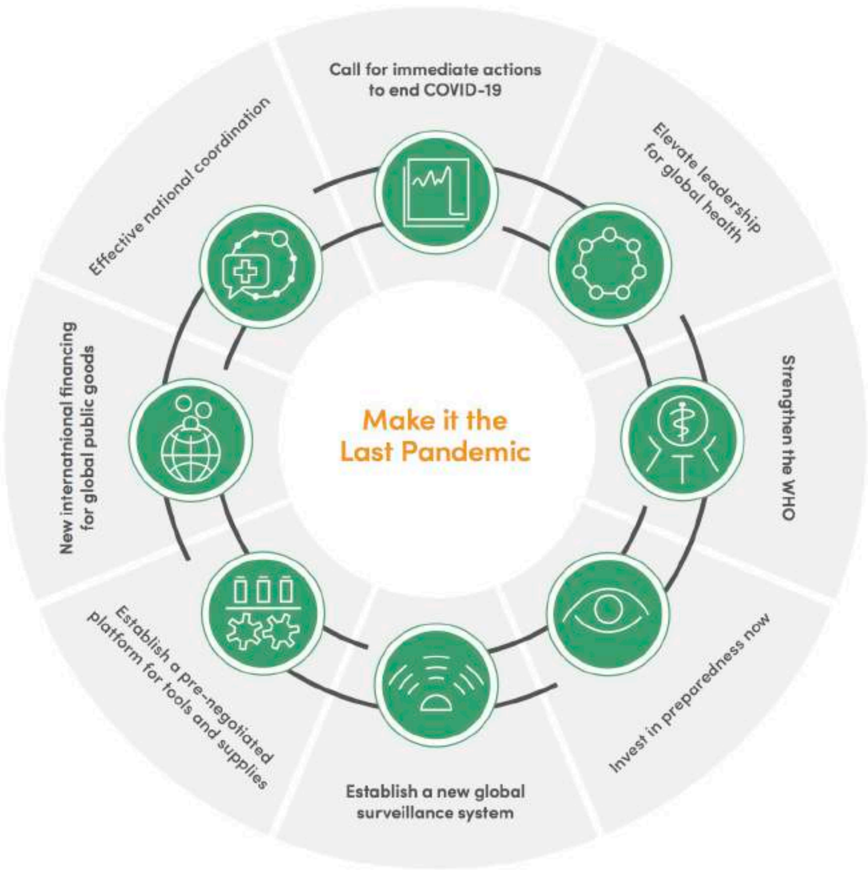
Fifth, a pre-negotiated platform should be established for tools and supplies. The ACT-A (Access to COVID-19 Tools Accelerator) should be transformed into a global end-to-end platform for vaccines, diagnostics, treatment, and essential supplies, and all agreements wherein public funds have been spent for its R&D should include arrangements for technology transfer and voluntary licensing. Fiscal and regional capacities for the manufacture, regulation, and procurement of tools should also be enhanced to ensure equal and effective access to vaccines, diagnostics, treatment, essential supplies, and clinical trials. Sixth, new financial resources should be secured for global public goods related to pandemic response and preparedness. This entails the creation of a financial institution dedicated exclusively to global pandemics to ensure reliable financing.

The final recommendation is to promote the highest level of coordination among countries. State and affiliated health institutions should take multidisciplinary and multisectoral approaches and engage with the private sector and civil society. Evidence-based decisions should be made based on the input of all social sectors, and national pandemic coordinators should be appointed by heads of state and held accountable at the highest levels of government. The report also envisages that active simulations could be run annually in all sectors. Lastly, it suggests promoting community engagement in pandemic preparedness and response, increasing thresholds for health and social investments for a resilient health and social protection system, and investing in risk communication policies and strategies to ensure timeliness, transparency, and accountability, while also catering for excluded groups.

The report Improving pandemic preparedness and management (November 2020), developed by the group of chief scientific advisors of the EC's European Group on Ethics in Science and New Technologies (EGE), presents the following proposals for better preparedness against future pandemics (Dykstra et al., 2020).

First, to prevent and pre-empt, pathogen reservoirs should be monitored, responded to, and predicted; multifaceted efforts should be supported to investigate and reduce the risk of pandemics, including early detection; complementary approaches should be taken to

Figure 4: The seven recommendations by the Independent Panel



Source : The Independent Panel (2021c)

develop responses and accelerate research on infectious agents with the potential to develop into an epidemic or pandemic. Additionally, multi-disciplinary analyses of prevention, preparedness, response, and impact including the social aspects and consequences of health crises, should be strengthened.

Second, a standing advisory body should be established to deal with health risks and crises to enhance cooperation between Member States and international institutions. A joint early response mechanism needs to be generated to contain the pandemic, including comprehensive, evidence-based, and rapidly shared monitoring measures and a strategy toolbox for testing, tracing and isolating (TTI). Medical countermeasures should be devised and implemented for pandemics and other health threats, resilience to pandemics and other public health crises should be enhanced, and countermeasures to respond to social damage should be researched, developed, and evaluated.

Third, Member States should be encouraged to offer healthcare for all in order to strengthen the system for better preparedness and management. All EU citizens should have robust and fair access to key products and services. Member States must be encouraged to strengthen their public health infrastructure, and false information should be monitored for an effective risk-communication system.

Fourth, basic rights and civil liberties should be protected following the highest standard, and social rights, including social security benefits for workers with an irregular or insecure employment status, should be guaranteed even during pandemics. Lastly, we should confront non-sustainable ways of living that contribute to epidemics and pandemics, dealing with the relationship between health crises and environmental degradation.

The UN Secretary-General's Roadmap for Digital Cooperation report noted that crucial challenges for digital technology were left unaddressed, despite its immense benefits in mounting an effective COVID-19 response and sustained communication. This included the development of vaccines and treatment, supply of essential goods and medical equipment through e-commerce platforms, and support of economic and learning activities through virtual meeting platforms. The report pointed out that although sharing accurate data and information is essential for an effective response, some important agendas for the future also include: containing the propagation of disinformation by those misusing social media; responding to cyberattacks on the WHO, hospitals, and pharmaceutical research institutions; and striking a balance between the use of technology to suppress the spread of the virus and the protection of individual privacy and fundamental rights. In addition, not everyone benefits from digital technology, and there is a greater risk of unemployment and suspension of education among vulnerable groups who lack proper access to the technology, not to mention unequal access among countries (UN, 2020a). As an example, the personal Internet usage rate in advanced countries had risen to 87 per cent as of 2019, whereas the rate remained at 19 per cent for the world's poorest countries (ITU, 2020e). The Internet use in the least developed countries (LDCs) was estimated at 25 per cent at the end of 2020 (ITU, 2021a). The UN emphasized the need to bridge such gaps as quickly as possible (UN, 2020a).

The Broadband Commission for Sustainable Development came up with actions for quicker and better pandemic recovery. These actions are based on three pillars: first, "resilient connectivity" refers to the maintenance and expansion of flexible, stable and safe infrastructures that can support all people; second, "affordable access" involves greater availability of and access to services and devices that guarantee the continuity of business and public life; and third, the safe use of online services for informed and educated societies supports security for everyone, especially children and vulnerable groups.

To this end, the Broadband Commission proposed the following agendas to be taken up by four sectors: industries, academia and NGOs, government agencies, and international agencies such as the UN. The proposed agendas for industries include secure connectivity, free text messaging, zero-rating for access to health, educational content and government information services, and digital tools to ensure children's safety online. Agendas for government agencies include a temporary lifting of regulations that restrict network capacity; funding for affordable access to health, education, and humanitarian and emergency services; and guidance for children's online safety, data protection, and cybersecurity measures. Agendas for international agencies include global technical support and cooperation, the transfer of expert knowledge, funding for digital connectivity initiatives in individual countries, and the promotion of innovative partnerships between agencies and the private sector. For academia and NGOs, priorities include support for innovation and knowledge leadership, health and emergency services, and teleworker training and digital-skills learning programmes. The Broadband Commission for Sustainable Development (2020b) also emphasized cooperation between these four sectors.

To summarize the proposals made within the reports mentioned in this section, the following factors should be considered when establishing a framework for infectious diseases. First, we need a monitoring system based on international cooperation, with a framework allowing flexible scalability of the health system while ensuring universal access.

Second, the health and socio-economic systems should become more resilient to effectively respond to similar crises in the future. A resilient supply chain, including a reserve of critical medical supplies such as personal protective equipment, is also required. Moreover, pre-emptive investments in medicine and medical supplies, including vaccines and treatments, should be made to guarantee fair access for all.

Third, we should build a robust public communication system to suppress disinformation and promote the adoption of control measures while respecting international standards on freedom of expression, as advocated in the Broadband Commission's 2020 report *Balancing act: Countering digital disinformation while respecting freedom of expression*. Fourth, policy intervention is needed in order to reduce inequality in health, education, and finance. Fifth, the proactive use of digital technology will be a crucial part of the successful implementation of these countermeasures, alongside other important missions such as securing safe digital technology and access for all. Last, international coordination on pandemic preparedness and response should be reinforced, as the related tools are becoming global public goods.

2

Global Response Strategies and their Effectiveness

2 Global Response Strategies and their Effectiveness

2.1 COVID-19 Response Strategies of Countries in North America, Europe/ Asia/ Africa and Their Impact

COVID-19 struck countries irrespective of region or economic level. However, they displayed a huge difference in their prevention and control measures, and the outcomes and socio-economic ramifications of these. This section observes the transmission pattern of COVID-19 in selected countries and their response strategies including governance and legislation as well as pandemic control and economic shock mitigation policies, examining the lessons learned from each country's response in terms of establishing effective approaches for future epidemics.

This report looked into 14 countries as comparative examples representing a variety of regions and different levels of economic standing (using the IMF categorization: Mexico, the United States of America, Germany, Spain, the United Kingdom, China, India, Japan, Republic of Korea, Malaysia, Kenya, Liberia, and Mauritius, see Table 1).

Table 1: List of countries for case analysis

Country	Region	Economic Standing	GDP per capita (USD, 2020)	Population (mil., 2020)
Mexico	Latin America	Emerging and developing	8,347	129
United States of America	N. America	Advanced	63,415	330
Germany	Europe	Advanced	45,732	83
Spain	Europe	Advanced	27,132	47
Sweden	Europe	Advanced	51,796	10
United Kingdom	Europe	Advanced	40,406	67
China	E. Asia	Emerging and developing	10,483	1,404
India	S. Asia	Emerging and developing	1,965	1,379
Japan	E. Asia	Advanced	40,146	126
Korea (Rep. of)	E. Asia	Advanced	31,496	52
Malaysia	S.E. Asia	Emerging and developing	10,269	33
Kenya	Africa	Emerging and developing	2,039	49
Liberia	Africa	Emerging and developing	646	5
Mauritius	Africa	Emerging and developing	8,993	1

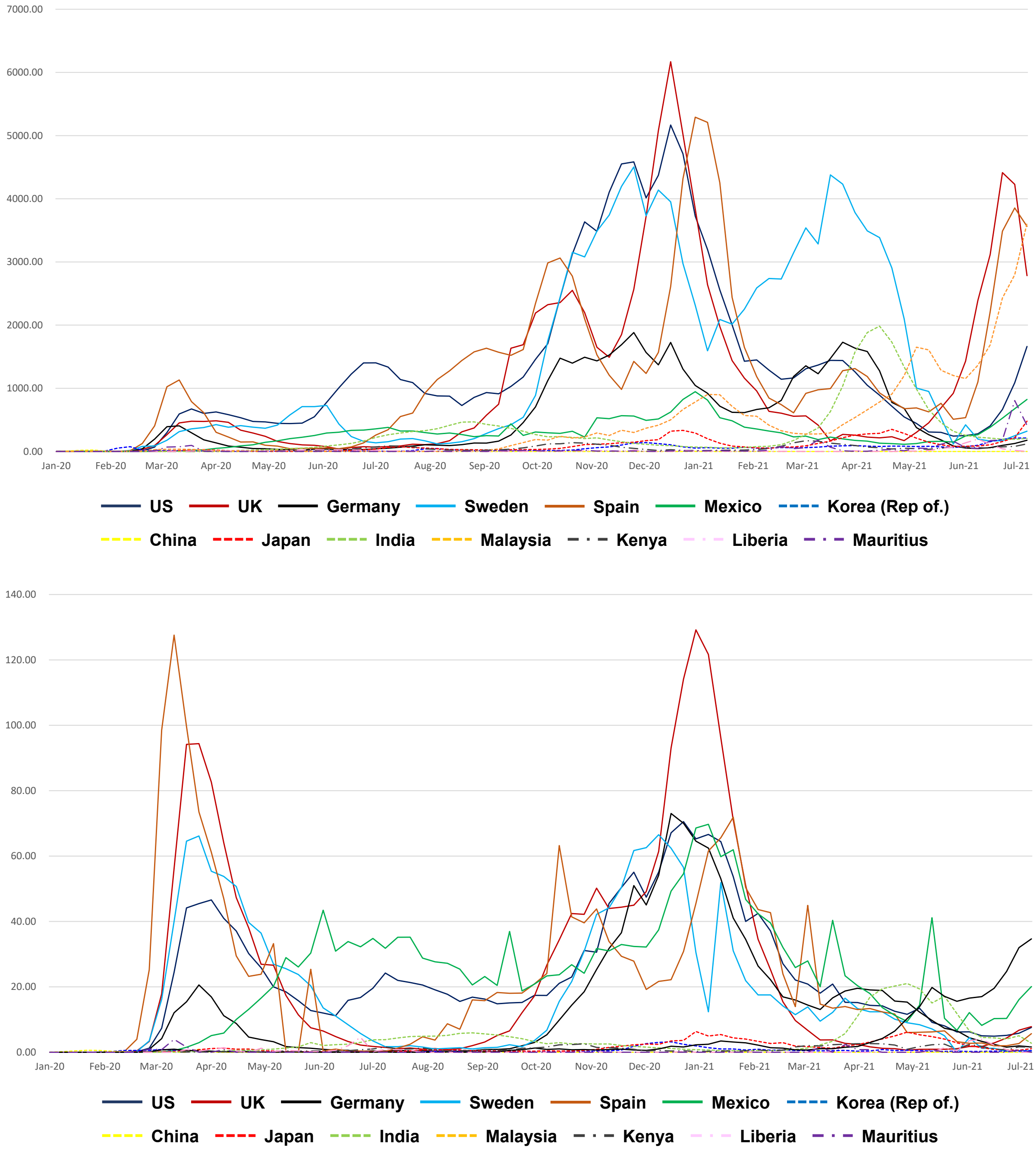
Source : adapted from IMF (2021b)

2.1.1 Comparison of COVID-19 responses by country

COVID-19 cases and deaths

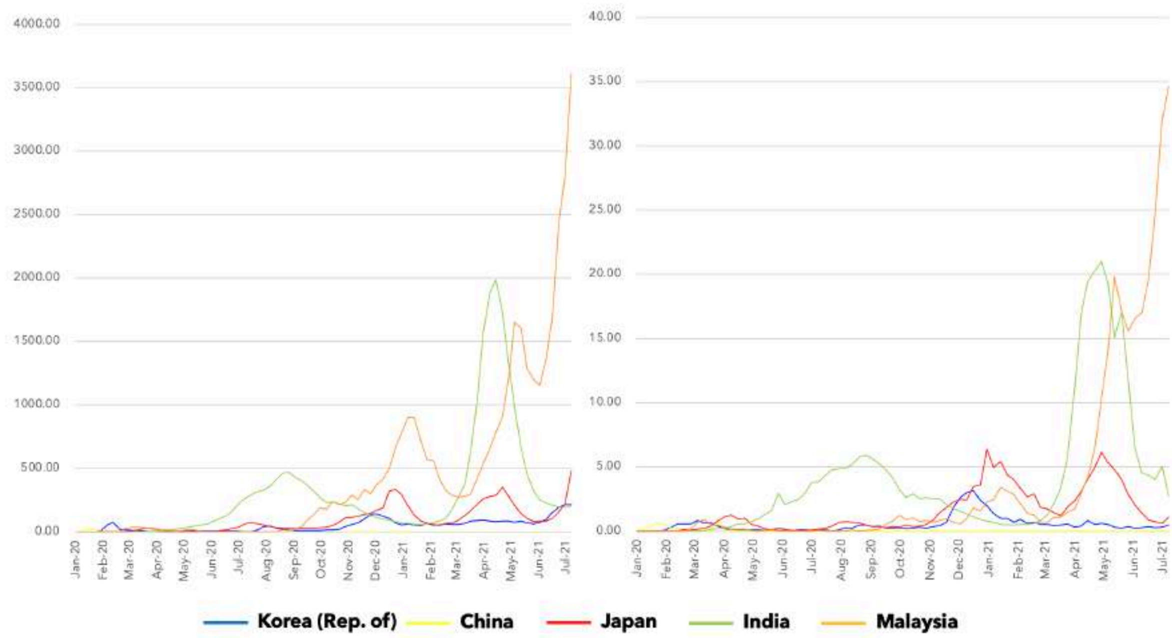
The curve of confirmed cases was mostly flattened globally after the first mass outbreak from January to Aprilof 2020 and the second wave of infections broke out between September of 2020 and February of 2021. The distribution of confirmed cases and deaths demonstrates the large disparity in the spread of COVID-19 between countries in the European and American regions and those in the Asian and African regions (see Figure 5). However, it should be noted that the availability of testing equipment, as well as mechanisms for reporting cases, hospitalizations and deaths,

Figure 5: Weekly COVID-19 cases (top) and deaths (bottom) per million people



Source : adapted from Our world in data (2021)

Figure 6: Weekly cases (left) and deaths (right) in Asia per million people



Source : adapted from Our world in data (2021)

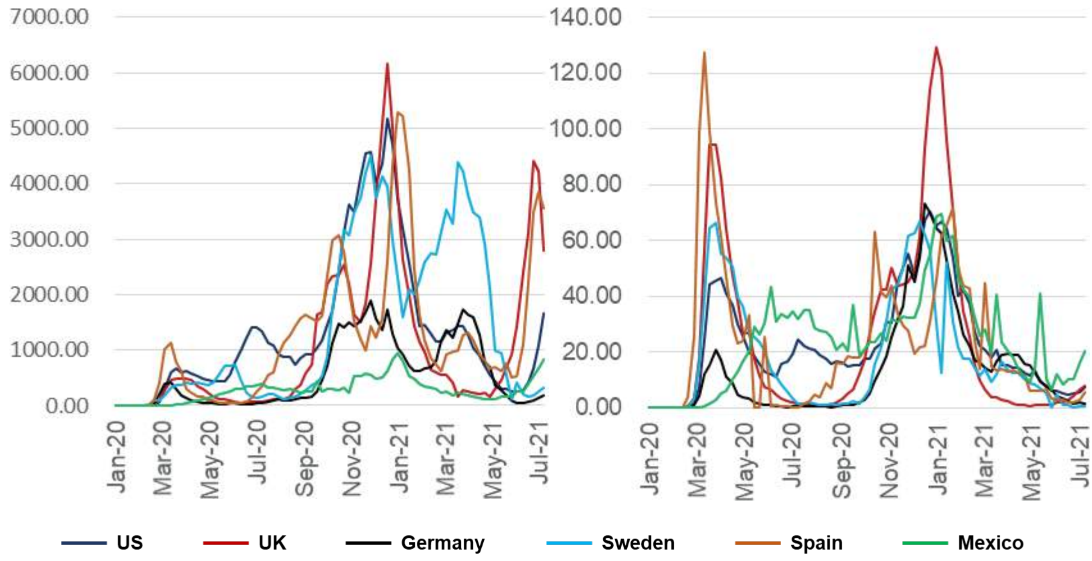
also varied greatly between these countries and so drawing conclusions from such comparisons is challenging.

Following the first identification of COVID-19 in China, Asian countries experienced the first mass outbreak, with large clusters in the Republic of Korea, followed by Malaysia and then Japan (see Figure 6). The number of cases and deaths rose sharply in India in May of 2020 when the lockdown was lifted. Although there was a momentary lull in the infection rate, the number of confirmed cases and deaths skyrocketed in the fall of 2020 in the Republic of Korea, Japan, and Malaysia. In March 2021, India recorded the highest number of cases worldwide as infections increased dramatically, to over 400,000. There was also an upward curve for Japan and Malaysia, which had both seen their case numbers largely flattened for the previous month. Meanwhile, China contained the proliferation of cases starting in early 2020 through strong control measures.

In Europe and America, countries that implemented lockdowns early on, such as Germany and the United Kingdom, managed to control the infection rate until mid-2020, but the number of cases hardly fell in Sweden or the United States where there were no national movement restrictions (see Figure 7). All analysed countries experienced a sharp increase in cases and deaths from around September 2020. The number of cases was higher for the second mass outbreak in all of the European countries with the exception of Germany. This might be due to the fact that Germany already had the necessary medical capacity prior to the outbreak, whereas other countries had to increase their existing capacities following the first wave of infections. The number of cases also fell after January 2021 in the United States and the United Kigdom owing to high vaccination rates. Although Mexico's number of confirmed cases is relatively low, the number of deaths is on par with that of the United States and developed countries in Europe.

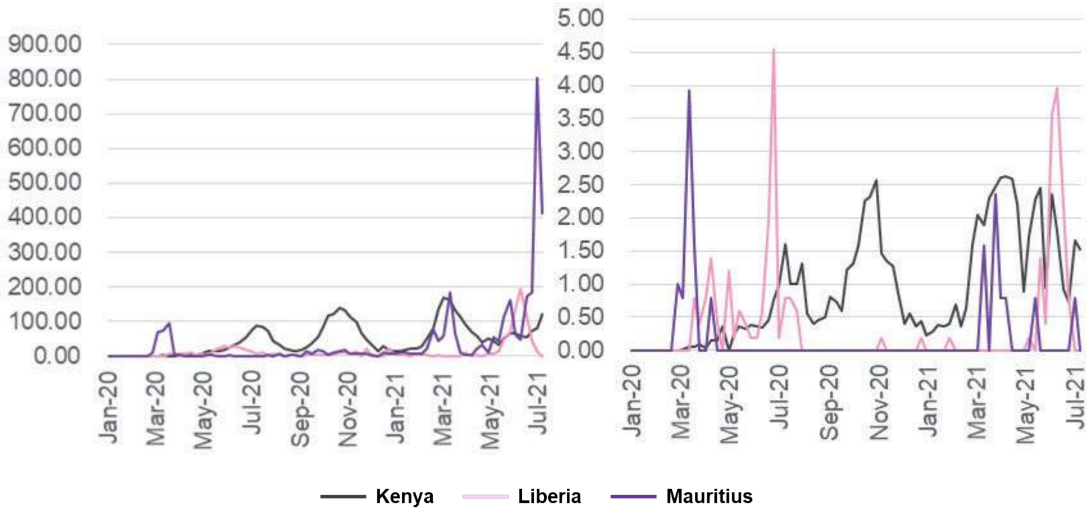
Among the surveyed African countries, the highest numbers of cases and deaths were reported in Kenya (see Figure 8).

Figure 7: Weekly cases (left) and deaths (right) in Europe and America per million people



Source : adapted from Our world in data (2021)

Figure 8: Weekly cases (left) and deaths (right) in Africa per million people



Source : adapted from Our world in data (2021)

COVID-19 governance

The governance of measures to respond to COVID-19 was shaped by existing political and administrative systems (see Table 2). However, efficient containment measures were determined more by the effective coordination of communication than the countries' governance structures. In terms of key pieces of legislation related to COVID-19 control, most Asian and African countries were able to engage in early responses based on the enforceable laws already in place, owing to previous experiences with epidemics such as SARS and Ebola. Countries in Europe and America also belatedly enacted response legislation (see Table 3) but it became clear that the conflict between effective disease control and the restriction of basic individual rights requires further discussion.

Table 2: Main response agencies and governance characteristics by country

Country	Response Agency	Governance Structure	Characteristics
Mexico	COFEPRIS (Federal Committee for Protection from Sanitary Risks)	Centralized	Publishes and implements mandatory nationwide guidelines
United States of America	CDC (Centers for Disease Control and Prevention)	Decentralized	Dispersed authority/role between federal/state/regional governments, conflict between levels
Germany	RKI (Robert Koch Institut)	Decentralized	Dispersed authority/role between federal/state governments, mediation through "Corona Cabinet"
Spain	National Health System / Interterritorial Health Council	Decentralized	Royal decrees – regional governments and autonomous cities are responsible for decisions in their territories and decide the level of application for measures stated in the legislation according to each situation.
Sweden	PHA (Public Health Agency of Sweden)	Decentralized	Dispersed authority/role between central/regional/local governments, maximum autonomy guaranteed
United Kingdom	DHSC (Department of Health and Social Care)	Centralized	Minister of Health charged with full authority to oversee COVID-19 policies
China	COVID-19 LSG (Leading Small Group)	Centralized	Top-down communication from Central Communist Party for overall control measures
India	MoHFW (Ministry of Health and Family Welfare)	Centralized	Central government takes the lead in providing response guidelines, despite the federal system
Japan	Novel Coronavirus Response Headquarters	Centralized	Prime Minister directs the agency and oversees disease prevention measures
Korea (Rep. of)	KDCA (Korea Disease Control and Prevention Agency)	Centralized	In charge of control measures, with support from the Prime Minister's Office and Ministry of Health and Welfare
Malaysia	NSC (National Security Council)	Centralized	Considers COVID-19 to be a risk to national security; the Prime Minister heads the agency to oversee response measures
Kenya	MoH (Ministry of Health)	Centralized	In charge of policy-making and execution, enactment of lower statutes, and information provision
Liberia	MoHSW (Ministry of Health and Social Welfare)	Centralized	In charge of policy-making and execution, and enactment of legislation
Mauritius	High-Level Committee on COVID-19	Centralized	Headed by the Prime Minister and MoHW. In charge of legislation and orders related to disease prevention and control

Source: National health authorities

Table 3: Key legislation related to COVID-19 by country

Country	COVID-19 legislation	Enactment period	Key content
Mexico	Sanitary Emergency (*Emergencia Sanitaria*)	Mar-20	Request for social distancing, self-isolation, and suspension of work in non-essential sectors
United States of America	Individual states' regulations on emergency public health response	March~April 2020	Stay-at-home orders and mask wearing but disparities between states in the degree of restriction and penalties
Germany	Law to protect the citizens in the event of an epidemic situation of national concern	Mar-20	Right to secure health supplies during epidemics granted to government, support for COVID-19 testing, mandatory social distancing, support for hospitals and households
Spain	Royal Decrees 463, 21, and 926	March 2020 (463); June 2020 (21); and October 2020 (926)	Measures to protect citizen's health and security; coordinated actions between the national and regional governments and autonomous cities; and risk prevention measures, monitoring and reinforcement of health and service assistance in each territory
Sweden	Infectious Diseases Act 2004	Existing law	Legal measures for state and local governments to deal with infectious diseases
	Government Bill for a temporary Act to prevent the spread of COVID-19	Jan-21	Authority to adopt disease control measures (restricted gatherings and penalties) that are legally binding
United Kingdom	Coronavirus Act 2020	Mar-20	Reinforcement of health personnel and lessened workload, restricted social gatherings (closed educational facilities, prohibition of gatherings and postponement of events), and quarantine of suspected cases
China	Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases	Existing law	Control of transportation and passengers in epidemics and quarantine of suspected cases, basis for regional or border lockdowns
India	Epidemic Diseases Act 1897	Existing law	Measures for central government including distribution of guidelines for infectious disease containment
	National Disaster Management Law 2005	Existing law	Basis for ordering and relaxing lockdowns
Japan	Special Measures Act to Counter New Types of Influenza	Existing law (last revised in March 2020)	Basis for emergency declarations allowing stay-at-home orders and business shutdowns, under revision owing to the lack of regulation for compensation and penalties
Korea (Rep. of)	Infectious Disease Control and Prevention Act	Existing law (last revised in March 2021)	Basis for disease response measures such as epidemiological surveys, active sharing of related information, and penalty regulations for violation
Malaysia	Prevention and Control of Infectious Diseases Act 1988	Existing law	Notification and quarantine of confirmed or suspected cases, regional control during infectious disease outbreak, granting of confiscation rights
	The Regulation of Measures within Infected Local Areas 2020	Mar-20	Minister of Health granted right to prohibit activities and restrict movement within infected areas
Kenya	Public Health Rules 2020	Apr-20	Regulations for reporting, searching, shutdowns, and quarantine, rules for penalties (fines and imprisonment)
Liberia	National Health Emergency	March and April 2020 (revised)	Mandatory mask-wearing, social distancing, measures for using key facilities, fines and imprisonment upon violation
Mauritius	Quarantine Act 2020	May-20	Prime Minister granted authority over infectious diseases, regulations for mandatory quarantine and reporting upon arrival from overseas
	Quarantine Regulations 2020	Jun-20	Fine or imprisonment for violating quarantine and travel restriction orders

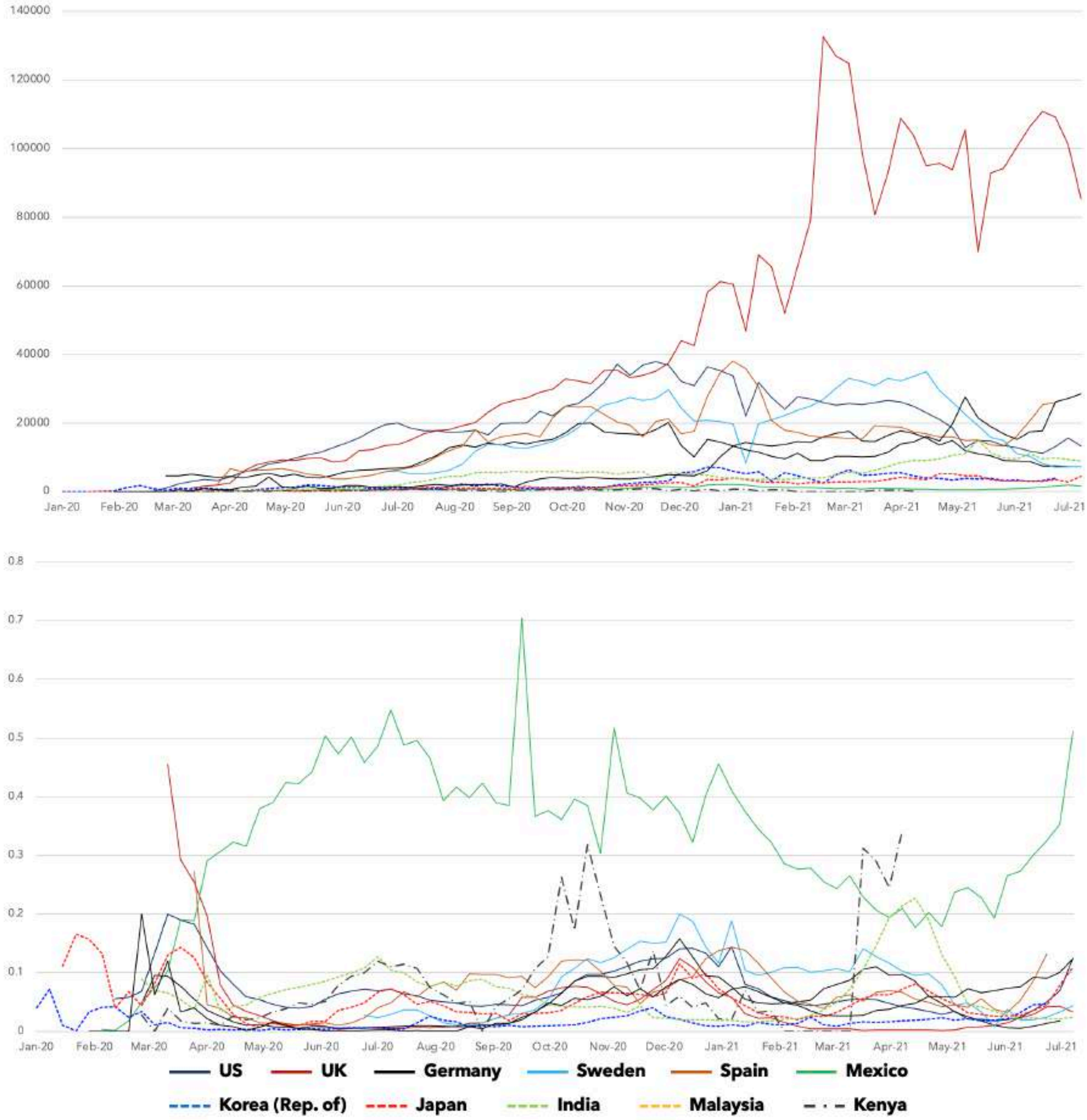
Source: National health authorities

3T (test, trace and treat) policy and use of digital technologies

The disease control policies of the surveyed countries may be examined from a 3T (test-trace-treat) perspective as well. The number of tests appeared to increase overall with the rise in cases, but the growth stagnated in countries in Europe and North America such as the United States and the United Kingdom in March 2020 despite extremely high positivity rates (see Figure 9). The exception was Germany. In Asia, Japan's testing rate was also relatively low despite its high positivity rates. India's positivity rate skyrocketed in April 2021, owing to its rapid increase in confirmed cases. Kenya was the only country among those analysed in Africa to have a verifiable positivity rate, and this rate was relatively high (Our world in data, 2021).

Meanwhile, Republic of Korea and Mauritius managed to greatly enhance their testing capacities through ICT. The Republic of Korea

Figure 9: Weekly tests per million people (top) and positivity rate (bottom)



Source : adapted from Our world in data (2021)

Government requires those entering two weeks of isolation to download the Self-Quarantine Safety Protection App to report their status twice a day to the health authorities and receive immediate testing in case of symptoms. The authorities may also monitor remotely whether quarantine rules are being observed. These functions facilitate the screening and treatment procedures, ultimately reducing the medical and administrative workload. The Mauritian Government introduced the OpenELIS (Open Electronic Laboratory Information System), which is supported by the UNDP, to increase their reporting. The system boosted the testing capacity of the Central Health Laboratory by e.g. offering batch processing of bio-samples and easy-to-print barcodes.

ICT was most actively used for tracing activities (see Table 4). The Republic of Korea and Chinese governments introduced a digital tracing system in the early stages of COVID-19 between January and April 2020, allowing contact tracing by using mobile phone records, without anyone having to download an app. Some countries opted for tracing methods through apps using Bluetooth information, rather than mobile phone records. However, as the downloading of these apps in most of the countries being explored in this analysis was voluntary, the effect of digital tracing was limited. Japan and Germany managed to contain cases in the early stages without digital tracing by relying on manual epidemiological investigations. But they struggled during the second wave as the number of cases rose above their survey capacity levels.

Meanwhile, Republic of Korea and China were able to overcome several crises through their optimal use of digital tracing, overall showing good performance in their control of the disease. Digital tracing proved to be a difficult task for some LMICs in Africa and Asia due to the low penetration rate of mobiles and smartphones. Digital tracing was not adopted in Liberia where mobile phone and Internet penetration rates stood at 47 and 15 per cent respectively as of 2020 (GSMA Intelligence, 2021). India – with only 35 per cent of its population owning a smart device – had difficulty in distributing the digital tracing app *Aarogya Setu* (Sanskrit for 'the bridge to liberation from disease'), despite mandatory policies (CNN, 2020). This calls attention to the need for approaches that best fit each context and the local availability of ICT infrastructure and devices.

Privacy protection legislation affected the disparities between countries with respect to digital tracing. Countries such as Republic of Korea and China were able to use various data since the statutory ability to relax regulations on the use of personal information for public interest purposes, such as the prevention of infectious diseases, was in place prior to COVID-19. On the other hand, the lack of appropriate legislation for data protection in some countries is leading to concerns over privacy infringement.

As for treatment, the importance of the medical infrastructure was proven through Germany's low number of deaths per million, which is probably due to having a substantially larger number of hospital beds per 1,000 people than other developed countries (see Table 5). Meanwhile, ICT contributed to relieving the burden on countries' medical facilities in several cases. The classification of patients based on big data from health insurance companies in Republic of Korea helped to screen people and separate out the treatment of serious cases. In the United States , the deregulation of telemedicine served to lessen the need for on-site medical treatment.

UN's Joint Statement on Data Protection and Privacy in the COVID-19 Response

In November 2020, the United Nations system organizations adopted the Joint Statement on Data Protection and Privacy in the COVID-19 Response, stating that any data collection, use and processing by UN System Organizations in the context of the COVID-19 pandemic should be rooted in human rights and implemented with due regard to applicable international law, data protection and privacy principles, including the UN Personal Data Protection and Privacy Principles.

The Joint Statement pledges the UN system organizations to the following minimum standards:

- Be lawful, limited in scope and time, and necessary and proportionate to specified and legitimate purposes in response to the COVID-19 pandemic;
- Ensure appropriate confidentiality, security, time-bound retention and proper destruction or deletion of data in accordance with the aforementioned purposes;
- Ensure that any data exchange adheres to applicable international law, data protection and privacy principles, and is evaluated based on proper due diligence and risk assessments;
- Be subject to any applicable mechanisms and procedures to ensure that measures taken with regard to data use are justified by and in accordance with the aforementioned principles and purposes, and cease as soon as the need for such measures is no longer present; and
- Be transparent in order to build trust in the deployment of current and future efforts alike.

Source : UN (2020d)

Social distancing policy

All countries introduced social distancing measures (e.g. border restrictions, the shutdown of public facilities, and curbs on gatherings) but there were differences in when they were introduced. Lockdown policies were mostly executed during the early stages in China and countries in Europe, in order to ease the burden on the medical system. India, Malaysia, and the African countries in this study adopted such measures in advance to prevent the spread of the virus. The lockdowns were more effective during the first mass outbreak than the following two, possibly due to public fatigue. In addition, ICT-based services (e.g. online education, e-commerce, and virtual meetings) helped to mitigate the socio-economic impact and raise public receptiveness to the restrictions. However, social distancing policies had a limited effect in LMICs where, among many factors, weak ICT infrastructures made their application difficult or impossible.

Table 4: Use of digital tracing by country

Country	Contact tracing data	Release period	No. of downloads/ distribution rate	Data protection measures
Mexico	N/A	-	-	-
United States of America	Bluetooth data (based on Google-Apple Framework)	Varies by state	Varies by state	Encrypted, distributed architecture
Germany	Bluetooth (based on Google-Apple Framework)	Jun-20	25.8 million/ 32% ('25 February 2021)	Encrypted, distributed architecture
Sweden	N/A	-	-	-
Spain	Bluetooth (based on Google-Apple Framework)	June/July 2020	Due to anonymity and privacy, download information is not available	UE privacy standards / interoperable model
United Kingdom	Bluetooth (based on Google-Apple Framework)	Jun-20 (terminated after release), October 2020 (second release)	20.9 million/ 32% ('23 December 2020)	Encrypted, distributed architecture
China	Phone records, GPS information, transaction information	Apr-20	All mobile phone users	Non-identifying processing, for authorized purposes only
India	Bluetooth, GPS information	Apr-20	172.6 million/ 13% ('30 March 2021)	Encrypted, personal information discarded after 180 days
Japan	Bluetooth (based on Google-Apple Framework)	Jun-20	25.18 million/ 20% ('12 February 2021)	Encrypted, distributed architecture
Korea (Rep. of)	Phone records, credit card information, visitor entry logs	Mar-20	All mobile phone users	Non-identifying processing, discarded upon termination of COVID-19
Malaysia	Bluetooth, visitor entry logs	May-20	24.5 million./ 74% ('4 December 2020)	For authorized purposes only, personal information discarded after one month
Kenya	GPS information, visitor entry logs	Mar-20	All mobile phone users	Unknown
Liberia	N/A	-	-	-
Mauritius	N/A	-	-	-

Source: National health authorities

Vaccination strategy

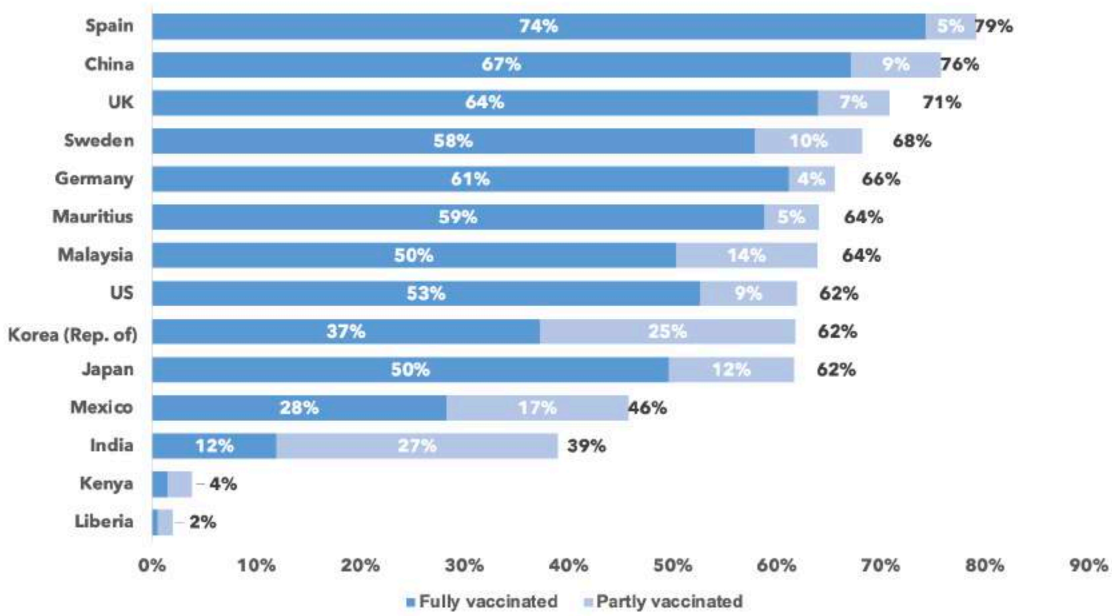
Vaccination rates (see Figure 10) are highest in countries in Europe and America, with Mexico lagging behind somewhat. The rates for Asian countries are generally lower than for Europe. African countries have the lowest rates, with Mauritius relatively higher owing to

Table 5: No. of hospital beds, COVID-19 deaths and fatality rates per 1,000 by country (as of 31 July 2021)

Country	Hospital beds/1,000	No. of deaths/million	Cumulative fatality rates (deaths/cases)
Mexico	1.0(2018)	1,868	8.46%
United States of America	2.9(2017)	1,829	1.73%
Germany	8.0(2017)	1,094	2.54%
Spain	2.4(2019)	1,809	1.87%
Sweden	2.1(2018)	1,434	1.33%
United Kingdom	2.5(2017)	1,914	2.21%
China	4.3(2017)	3	4.69%
India	0.5(2017)	307	1.34%
Japan	13.0(2019)	120	1.64%
Korea (Rep. of)	12.4(2019)	41	1.05%
Malaysia	1.9(2017)	279	0.81%
Kenya	1.4(2010)	73	1.93%
Liberia	0.8(2010)	29	2.72%
Mauritius	3.4(2011)	15	0.49%

Source: Hospital beds/1,000 adapted from the WHO, No. of deaths/million and cumulative fatality rates data adapted from Our world in data (2021)

Figure 10: National vaccination rates (30 July 2021 - 8 September 2021)



Source : adapted from Our world in data (2021)

the importance that its government and society place on international exchange, to support its pivotal tourism sector. The fact that African countries fell behind in the vaccine race is a key factor in their low rates (World Bank, 2021c).

Fiscal and monetary policies

Fiscal policies in response to COVID-19 were composed of unemployment benefits, enhanced healthcare capacities, measures to revitalize the post-lockdown economy, and relief measures for SMEs and microbusinesses who were hit the hardest by social distancing (see Table 6). These support measures included tax reductions, liquidity assistance, and subsidies. Some governments reduced rental fees and extended loan repayments. Central banks also lowered their interest rates and executed expansionary monetary policies

Table 6: Key fiscal policies in response to COVID-19 by country

Country	Name and announcement date of key fiscal policies	Contents	Amount (USD bil.) (Supplementary expenditure/ liquidity)	Share of GDP (Supplementary expenditure/ liquidity)
Mexico	*Crédito a la Palabra* (Credit to the Word) Program (April 2020)	Low interest credit loan for individuals, SMEs and microbusinesses; extension of tax deadline	14-Jul	0.7/1.3
United States of America	CARES Act (March 2020)	Vaccine distribution, medical support, relief for unemployed, microbusinesses, and SMEs	3,503/510	16.7/2.4
	America Rescue Plan (March 2021)			
Germany	Supplementary Budget Bill 2020 and Economic Stabilization Fund Bill (March 2020)	Enhancement of healthcare capacity, vaccine R&D	418/1054	11/27.8
	Stimulus Package (June 2020)			
Sweden	Announcement of revised 2020 budget (April 2020)	Tax reductions, support for rental fee discount, support for unemployed and SMEs	22.3/28.3	4.2/5.3
	Additional measures to relieve employment, corporate, and economic shocks (April 2020)			
Spain	SPA (February 2020)	Extraordinary liquidity mechanisms, financial facility with 0% interest for autonomous communities	52/284	14.4/20
	Suspension of fiscal rules for 2020/2021 for economic and social reconstruction	EUR 10,000 million for each autonomous community from the EUR 12, 439 million of the REACT-UE Fund for health (enforcement and vaccines), education, and enterprise support		
United Kingdom	Business Interruption Loan Scheme (March 2020)	Tax reductions, lockdown compensation, relief for unemployed, microbusinesses, and SMEs,	441/437	16.3/16.1
	Self-employment Income Support Scheme (March 2020)			
	Coronavirus Job Retention Scheme (March 2020)			
China	Special funding for companies participating in disease prevention (February 2020)	Disease prevention support, expansion of unemployment insurance, support for affected companies, tax reduction, increased joint investment	711/193	4.7/1.3
India	Economic Support Policy (March 2020)	Support for farmers and labourers, support for medical expenses, food provision, tax reduction, extension of loan repayments	81/134	3.1/5.1
Japan	Emergency Economic Package Against COVID-1 9 (January-April 2020)	Disease prevention support, business and employment safety, market stimulus	782/1428	15.6/28.4
Korea (Rep. of)	1st, 2nd, 3rd, and 4th Supplementary Budget (March, April, July and September 2020)	Disease prevention support, financial and employment safety, stimulus package	56/166	3.4/10.2
Malaysia	1st, 2nd, 3rd, 4th, and 5th Economic Recovery Package (February, March, April, June and September 2020)	Tax and utility bill relief, SME support, market stimulus	15.2/11.9	4.4/3.5
Kenya	Stimulus Plan (March 2020)	Tax rate reduction, cash assistance for vulnerable groups, support for medical institutions	2.4/-	2.4/-
Liberia	Stimulus Plan (April 2020)	Food support for vulnerable groups, free electricity and water supply, financial support for microbusiness owners	0.1/-	2.1/-
Mauritius	Tax reduction scheme (June 2020)	Dual tax reduction for employers to promote telework	1.1/3.8	10.0/33.6

Source : IMF (2021a)

such as quantitative easing. The scale of fiscal policies was larger in developed countries with higher credit ratings and bigger losses from COVID-19. On the other hand, some LMICs experienced even greater economic shocks despite their success in containing the spread of COVID-19 through lockdown measures.

A key obstacle for LMICs trying to implement fiscal policies is the absence of identification methods such as driver's licences, credit cards, passports, and social security numbers. One billion people worldwide do not have any formal proof of identity, and 80 per cent of them live in sub-Saharan Africa and other less developed areas (*Economist*, 2020). The Indian Government introduced the digital ID system Aadhaar to address this, which covers 98 per cent of Indians at the time of writing. Aadhaar has supported India's fiscal policies by enabling USD1.5 billion of subsidies to be sent to 300 million bank accounts during the pandemic and also by detecting fraudulent claims by patients, doctors, and hospitals (*FT*, 2020).

Public approval of disease control policies

As for the level of public approval of disease control policies, opinion polls indicate that most countries displayed better compliance to prevention rules in the early stages (Ipsos MORI, 2020; YNA, 2020; *Washington Post*, 2021b). The approval level fell starting in September 2020 owing to heightened fatigue, leading to protests and litigation against policies such as restrictions on movement and gatherings. Some countries experienced a groundswell of public protests by people whose livelihoods were threatened by social distancing. In India, thousands of migrant workers who had lost their jobs because of the extended lockdowns took to the streets in various parts of Mumbai (Reuters, 2020c). Demonstrations continue to take place in Kenya by those claiming that their rights to live are being undermined by the oppressive control measures (AA, 2020; ABCnews, 2020b; *Guardian*, 2020c). On the other hand, the public's approval of policies was positively impacted by consistent and transparent information-sharing by the government. The Republic of Korean Government diligently communicated information about COVID-19 incidences, in an effort to avoid the situation it faced during the 2015 MERS outbreak when it was criticized for not disclosing the names of hospitals with confirmed cases (Moneytoday, 2015). Information was also sent out via its emergency disaster messaging system. According to a survey by the Presidential Committee on the 4th Industrial Revolution, over 90 per cent of those surveyed in the Republic of Korea agreed with such protocols (YNA, 2020).

Economic and social impact

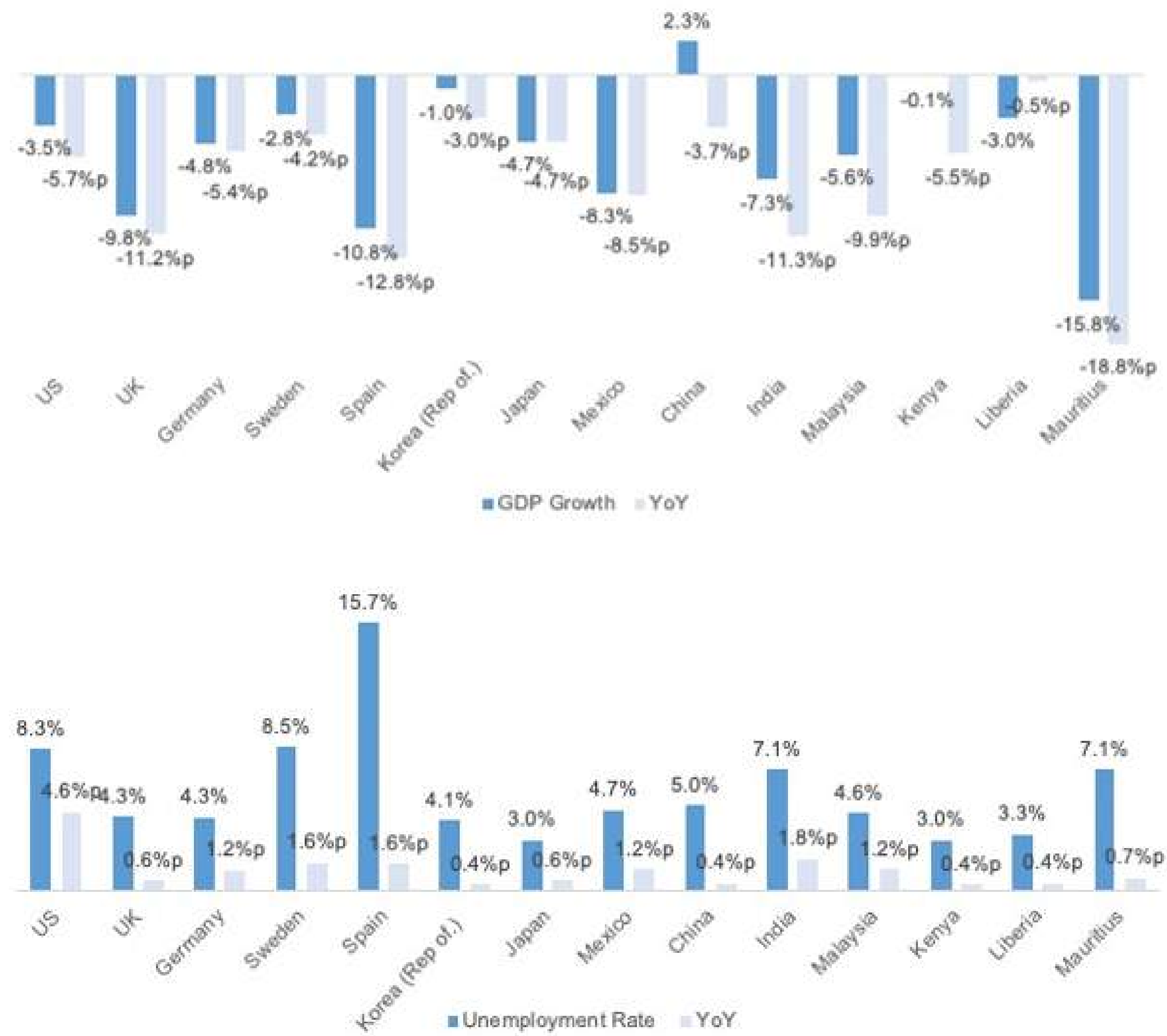
Most countries that were analysed recorded negative growth, with greater economic shocks for countries that were hit harder by COVID-19. The downturn was concentrated in Q2 of 2020 for most countries, with the exception of China, in line with the implementation of lockdowns.. Meanwhile, the world's unemployment rate increased by 1 per cent from 5.37 to 6.47 per cent due to COVID-19 (see Figure 11).

The pandemic incurred not just economic but also social costs. The most significant issue is the increased inequality between classes and countries. Vulnerable groups suffered the most from lockdowns and social distancing measures, as low-skilled informal workers are mostly in industries where telework is unavailable. The suspension of public services is also more devastating for vulnerable groups.

Similarly, women and girls have been particularly badly affected. The 'quarantine paradox' (Mittal & Singh, 2020) has seen lockdown policies designed to improve public safety leading to increases in gender-based violence. In addition, women's access to health services has declined (Chattu et al., 2021). According to a study by the National Bureau of Economic Research, the negative impact on gender equality is likely to be greater from COVID-19 than previous economic crises (Alon et al., 2020). The reasons include more women being employed in sectors that are not "telecommutable", and school closures forcing mothers – including single mothers as

Figure 11: 2020 GDP growth rate (top) and unemployment rate (bottom), YoY from 2019

2020 GDP growth (top) and unemployment rate (bottom), year on year (YoY)



Source : Growth rates from IMF (2021b), unemployment rates from ILO (2021a)

well as those from dual-income families who were already burdened with more housework than their spouses – to leave their jobs. ICTs can play an important role in tackling and mitigating these impacts, from digital solutions supporting gender-based violence survivors (UNICEF, 2020b) to ensuring women have access to essential public services (UNDP, n.d.). This important function of ICT in empowering women and girls has been a long-standing focus of the Broadband Commission for Sustainable Development (2018b).

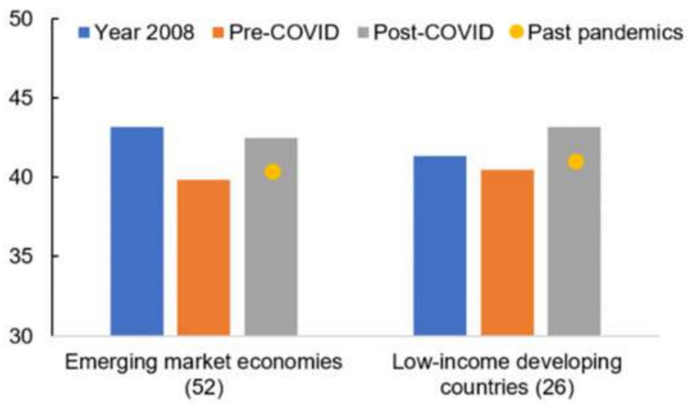
LMICs with a higher share of vulnerable groups are even more susceptible to such shocks (IMF & World Bank, 2020). According to researchers at the World Bank, the number of people in extreme poverty increased by 97 million worldwide due to COVID-19, with most of the damage inflicted on developing countries in South Asia and sub-Saharan Africa. This figure may reach 155 million in 2021 (World Bank, 2021a).

Furthermore, the income gap – which had been decreasing since the 2008 financial crisis – could be aggravated as the ratio of telecommutable jobs is greater for high-income groups (Brussevich et al., 2020). Taking into account the proportion of those able to work from home for all income levels, a study by the IMF (2020) suggests that the Gini coefficient[1] for emerging and low-income developing countries will rise to 42.7, which is comparable to the Gini coefficient during the global financial crisis (see Figure 12). The impact on income inequality is expected to be greater for low-income developing countries (IMF, 2020).

Social distancing and lockdowns also had adverse effects on education. The UNDP measures the HDI (Human Development Index) every year, which accounts for not only the national income but also indices such as average life expectancy and level of education. The closure of schools led to a drastic drop in global HDI for 2020 – the largest decline since the index was first measured in 1990 (see Figure 13). This offsets progress from over the previous six years.

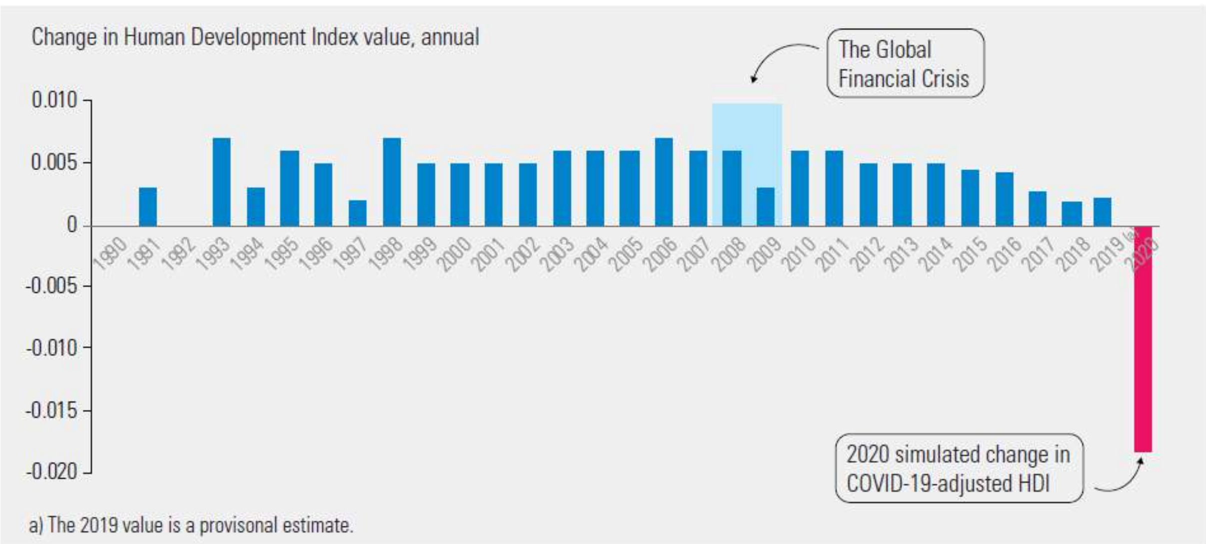
This impact on the education sector is expected to be even greater in low-HDI countries. According to the UNDP, the global educational loss measured in short-term effective out-of-school rates for primary education is estimated to increase by 50.1 per cent to 59.6 per cent in 2nd quarter of 2020 (see Figure 14). This out-of-school rate will only go up by 18.6 per cent to reach 20 per cent for high-HDI countries, but increase to 85.9 per cent for low-HDI countries, indicating that 59.4 per cent of their students will be deprived of primary education due to COVID-19.

Figure 12: Gini coefficients during the global financial crisis, pre-Covid, and post-Covid



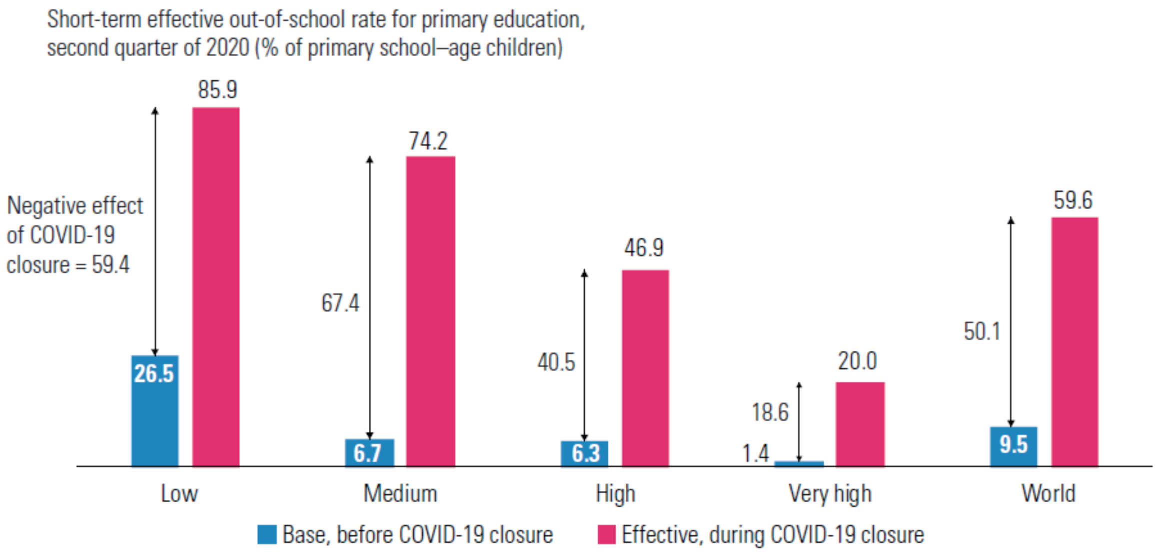
Source : IMF (2020)

Figure 13: Sharp decline in HDI due to COVID-19



Source : UNDP (2020a)

Figure 14: Changes in out-of-school rate for primary education by HDI group

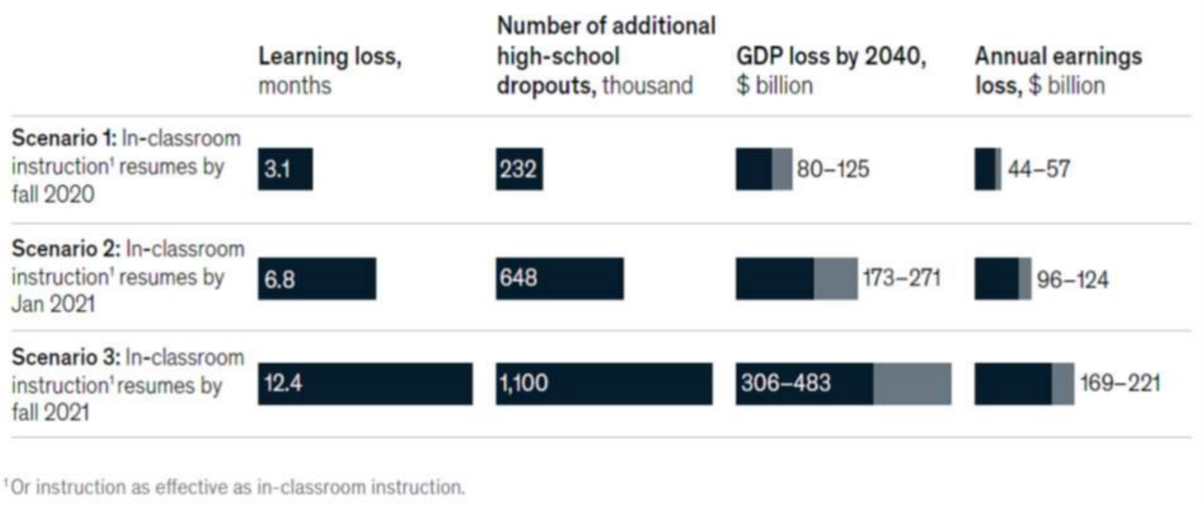


Source : UNDP (2020a)

This difference lies mostly in the environmental conditions for online education. Households with Internet access only amount to 15 per cent in low-HDI countries, which is a stark contrast to the rate of 84.1 per cent for their high-HDI counterparts. Computer access rates are even lower at 9.7 per cent. Nonetheless, the UNDP projects that more equitable Internet access will significantly counterbalance the drop in HDI incurred from educational loss. The UNDP also points out that activities which impact HDI beyond education (e.g., working, shopping, staying healthy, reporting domestic violence, and interacting socially) are becoming more dependent on online resources and applications. This implies that there is a higher likelihood for disadvantaged groups lacking Internet access to fall further behind. With this in mind, the UNDP emphasizes the importance of public policies to expand the accessibility of technologies (UNDP, 2020a).

In its report *COVID-19 and student learning in the United States: The hurt could last a lifetime*, McKinsey (2020) gives projections on the long-term damage to K-12 students in the United States from school closures as well as the incurred economic loss. Students are divided into four archetypes: the first group is those who received remote learning along with sufficient instructions; the second group are those who got insufficient instructions; the third group received no instructions at all; and the last group represents those who dropped out of school. There are also three epidemiological scenarios: virus containment, virus resurgence and pandemic escalation. According to the report, under the second scenario, students who were given sufficient instructions experienced a learning loss of 3~4 months, with students who had received insufficient instructions experiencing a loss of 7~11 months, and students getting no instructions a loss of 12~14 months. This learning loss was estimated to be greater for low-income, Black, and Hispanic students. Students from low-income families have less chance of being in an environment that is conducive to learning, i.e. one with minimum distractions and access to their own devices and parental academic supervision. Consequently, whereas the average learning loss was 7 months on average under the second scenario (resurgence), it is expected to be 10.3 months for Black students, 9.2 months for Hispanic students, and over a year for low-income students, with the existing achievement gaps increasing by 15~20 per

Figure 15: The educational losses caused by COVID-19 could hurt long-term GDP growth



Source : adapted from McKinsey (2020)

cent. School closures are also likely to lead to greater high-school dropout rates.

This learning loss translates into economic shocks (see Figure 15), with K-12 students expected to lose lifetime earnings of USD61,000~82,000 on average. The GDP loss in 2040, which is when the current K-12 students would be in the workforce, is projected to be USD173~271 billion, accounting for 0.8~1.3 per cent of the overall GDP.

To avoid such damage from learning losses, the report suggests extended Summer Schools, quality online education and relevant teacher training, immediate response measures for remote and in-class learning, and above all, increased investment in the school system to protect vulnerable students (McKinsey, 2020).

The pandemic has also increased the risk of hunger and malnutrition. The UNDP's analysis suggests that by 2030 an additional 12.8 million people could suffer from malnutrition due to COVID-19, with the number of malnourished children in particular increasing by 1.6 million (UNDP, 2021a).

Choices made now could alter this dire scenario, and changing course becomes harder as time passes with serious challenges left unaddressed. The UNDP has identified an ambitious – but feasible – set of targeted investments in governance, social protection, green economy and digitalization. Through this 'SDG Push', 100 million people in low- and medium-income countries could be lifted out of poverty by 2030 (UNDP, 2021a).

Sub-conclusion

Reviewing national response policies and outcomes demonstrates the importance of early detection and containment, which necessitate pre-emptive measures to build an ICT-based response system.

To begin with, there was greater need for early detection and containment since COVID-19 could be asymptomatic and there was a high possibility of community infection by the time the outbreak could be identified. Indeed, the damage was greater for countries in Europe and America whose responses were delayed compared to Asian or African countries who were prepared based on previous pandemic experiences.

Moreover, the COVID-19 crisis demonstrates the need to strengthen the ICT-based epidemic-response system for the swift and efficient containment of diseases in real time (or close to real time). Using ICT for digital tracing and other responses is important for two main reasons. First, ICT allows us to manage large-scale outbreaks by enhancing the efficiency of control measures (e.g. 3Ts and social distancing). Second, ICT can alleviate public fatigue by enabling disease control under less rigid social distancing measures. Studies suggest that NPIs such as mandatory masks, isolation, travel restrictions, and school closures, along with strong lockdown measures, contributed significantly toward curbing COVID-19 in the first and second quarters of 2020 (Bo et al., 2021; Liu et al., 2021). However, if these are introduced after an epidemic has already occurred, the response may be untimely and the existing legislations, not to mention the technology, could become obstacles to their implementation.

The importance of prior preparation for infectious diseases, aggressive disease containment in the early stages, and the ICT-based 3Ts, can be seen in how they were adopted by Republic of Korea who faired relatively better in their response to COVID-19 without resorting to lockdowns. But ICT-based response solutions may not readily be implemented among vulnerable groups or LMICs that do not have the necessary ICT infrastructure. The pandemic revealed how such disparate levels of access could further aggravate inequality. To meet these challenges, ICT solutions that work in places with relatively poor infrastructures should be developed and deployed, along with efforts to secure the relevant infrastructure based on the three pillars of the Agenda for Action proposed by the Broadband Commission for Sustainable Development – resilient connectivity, affordable access, and safe use of online services. This should be accompanied by ICT training and support for medical personnel and other public healthcare workers.

The COVID-19 response strategies of each individual country are examined in more detail below.

2.1.2 Mexico's response strategy

COVID-19 situation and reaction of the government

Mexico experienced its first three COVID-19 cases on 28 February 2020. The number of cases and deaths rose sharply owing to group infections from the second half of 2020, with over 10,000 infections per day for quite some time after December (see Figure 16). The cumulative infection rate was 2.2 per cent as of 31 July 2021.

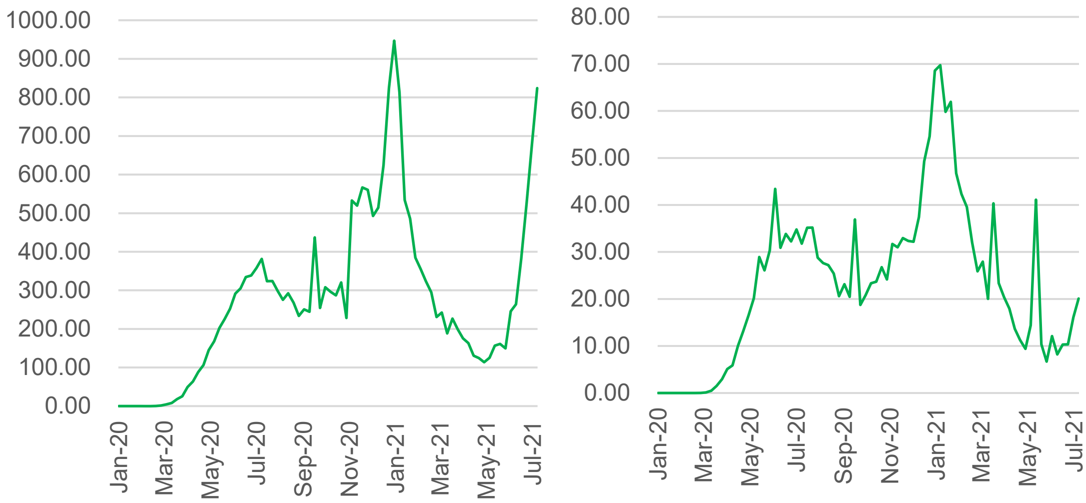
The Mexican Government announced a Phase I (Fase 1) pandemic alert, which targeted only people coming into the country, when the first three cases were identified. Phase II began on 24 March when regional infections spread, and this was ultimately elevated to Phase III on 21 April. On 30 March, the federal government declared an emergency health crisis (Emergencia Sanitaria), imposing essential lockdowns. A monitoring system was announced on 14 May 2020 to monitor the COVID-19 situation in each region. A budget was submitted on 8 September 2020 centred on social programmes and public investment. On 29 March 2021 the Secretaría de Salud (Ministry of Health and Assistance, MoHA) revised the statistics for the total number of COVID-19 deaths from 182,301 to 294,287.

COVID-19 governance

The government departments in charge of the COVID-19 response are the MoHA and the General Health Council (Consejo de Salubridad General), which is an agency directly under the President's Office. Measures announced by the General Health Council are applied nationwide. Care for COVID-19 patients is administered by the National Institute of Respiratory Diseases (Instituto Nacional de Enfermedades Respiratorias), which is the highest governing body, and medical institutions under the MoHA.

In terms of legislation, the function, role, and authority of the MoHA and related institutions are determined according to the General

Figure 16: Weekly COVID-19 cases (left) and deaths (right) in Mexico (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

Health Law (Ley General de Salud). Under Article 4, jurisdiction is given to the President of the Republic, the MoHA, the General Health Council, and health agencies of the federative entities, who may together enact and execute lower statutes for implementing social distancing, travel restrictions, and business shutdowns. Accordingly, the President ordered a prohibition of gatherings on 24 March 2020 and the MoHA proclaimed a health emergency on 30 March (Gobierno de Mexico, 2020). Local governments may also release necessary policies. For example, Mayor Claudia Sheinbaum of Mexico City released plans to diverge from federal policies by increasing mass testing to reach 100,000 tests per month and reinforce contact tracing.

3T policy

From the 3T perspective, Mexico chose a mitigation approach to prevent the collapse of its medical system. As such, it minimized testing from the early stages of the pandemic to only focus on patients with symptoms (essentially confirmed cases).

The Mexican Government did not conduct contact tracing. It made and distributed the COVID-19 MX app, which provides related information and self-diagnosis, but downloads were voluntary and the app did not include route-tracing functions (Law Library of Congress, 2020). Meanwhile, the mitigation of disease control policies from June 2020 to counter economic shrinkage led to increased cases (Globe and Mail, 2020).

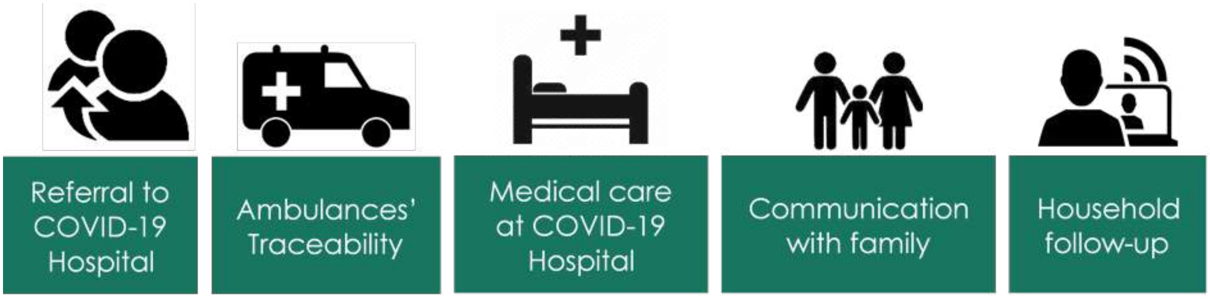
According to the WHO, Mexico ranks 119th out of 181 countries in the number of hospital beds per 10,000 (15 beds). This is a small number compared to other Latin American countries. There is also a shortage of doctors and nurses. The Mexican health authorities reported having 120,240 hospital beds as of February 2020, but their availability was quickly being exhausted due to increased cases. By January 2021, 89 per cent of hospital beds and 84 per cent of beds with ventilators in Mexico City were in use (Reuters, 2021d). There were concerns that the medical system might collapse as the number of confirmed cases rapidly increased (see Figure 17). Even in the most conservative scenario, there was expected to be a shortage of hospital beds in almost all regions (Parr, 2020).

The Carlos Slim Foundation set up a temporary COVID-19 unit with 625 beds in Latin America's largest convention centre in partnership with the Government of Mexico City, to support the entire response process including patient referral, admission, treatment, clinical

Figure 17: Comparison of medical infrastructure in Mexico versus other North/Latin American countries (No. of hospital beds, doctors, and nurses in 2015)

Source : Parr (2020)

Figure 18: Patient response process for the temporary COVID-19 Unit



Source : Carlos Slim Foundation (2021)

monitoring, discharge, and household follow-up (see Figure 18). The goal of the partnership was to reduce the pressure on the health system and contain community transmission through timely care. Patients were referred from 48 triage centres, including in Mexico City and its surrounding areas as well as federal, state, and private hospitals.

The COVID360 Digital Health Platform has been utilized in the unit's response process. Referrals are monitored in real time, ambulance routes are traced, and patient conditions are assessed on a standardized risk scale. Families may check on how the patients are doing on a daily basis through the platform, and follow-up responses are provided for up to 90 days once a patient is discharged. A mobile robot was also introduced to support collaboration between physicians (see Figure 19).

Social distancing policy

The federal government declared a health emergency (Emergencia Sanitaria) and called for social distancing, quarantine, and the closure of non-essential businesses. These measures were on a par with lockdowns as they called for suspension of activities for two months, with the exception of medical services, public order, and key industries, and included campaigns to "Stay Home" (Quedate en Casa) and "Wear Masks" (Usa Cubrebocas).

On 14 May, the Mexican Government adopted a traffic-light method allowing individuals and businesses to check whether they should shut down or resume their operations (see Table 7). Each region is coloured in green, yellow, orange, or red (see Figure 20), and this is updated every two weeks. The federal government simultaneously released strategies and basic guidelines through its Gazette for the reopening of the social, educational, and economic sectors. The main points

Figure 19: Mobile robot operated in the temporary COVID-19 Unit

Source : Carlos Slim Foundation (2021)

Table 7: Mexico's COVID-19 monitoring system: Meaning of traffic lights

Colour	Level of restriction	Contents
Red	Ultra-High-Risk Level	Operation of essential businesses only, suspension of activities
Orange	High-Risk Level	Operation of essential businesses only, shortened operation for non-essential businesses, 25% of public facilities in operation
Yellow	Intermediate Level	Operation of all businesses, public facilities allowed for open spaces only
Green	Normal Activities Level	No restriction of activities, schools allowed to open

Source : Gobierno de Mexico (2021)

Figure 20: Mexico's COVID-19 monitoring system: traffic light indicators (26 April ~ 9 May 2021)

Source : Gobierno de México (2021)

included progressive reopening in three phases (normalization of regions without cases, establishment of sanitary protocols, and resumption of businesses by sector). Businesses reopened starting from June 2020, which was followed by a sharp increase in confirmed cases and deaths (Gobierno de Mexico, 2021).

Vaccination strategy

The MoHA has disclosed a five-stage COVID-19 vaccination plan for late 2020 to early 2022. Its aim is to vaccinate 75 per cent of its population over the age of 16 by the end of 2021. The MoHA approved the emergency use of vaccines from Pfizer, Sputnik, AstraZeneca, Cansino, and Sinovac, adjusting the purchase volumes from early January 2021. Vaccinations began in Mexico City and other metropolitan areas, prioritizing medical professionals, high-risk patients, and people aged 60 or over, who received their shots by April of 2021. Then vaccines were administered to people over the age of 50. Mexico City administered its vaccines by alphabetical order of people's names (KOTRA, 2021). As of 8 September, 59.61 million people were vaccinated in Mexico, which is 46 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

The government announced various stimulus measures when the lockdown policies shook the economy. It supported 2.1 million loans for individuals and microbusinesses and 3 million low-interest loans worth 25,000 pesos (USD1,200) with a repayment period of three years for small business owners. The wages of government officials were cut back to finance credit loans, social welfare programmes, and other infrastructure projects, and the deadline for tax filing was also postponed. Local governments were also engaged in support measures, including tax exemptions for companies and cash assistance for individuals.

The central bank and the Secretariat of Finance and Public Credit sought to minimize economic shocks and stabilize financial indices through lower interest rates (announced on 20 March and 21 April 2020). They announced plans for the financial market on 21 April 21 2020 worth 750 billion pesos (roughly USD37 billion) to facilitate credit and promote liquidity.

Public approval of disease control policies

The disease prevention policies were voluntary rather than mandatory, for fear that travel restrictions would undermine people's livelihoods and lead to public resistance, as 60 per cent of Mexico's workers need to travel for their jobs every day. The government therefore focused on restricting facilities such as stores, schools, and churches, rather than the movement of individuals, and relied on providing information and carrying out campaigns to promote voluntary mask-wearing and self-quarantine (Washington Post, 2021a).

Socio-economic impact of COVID-19 in Mexico

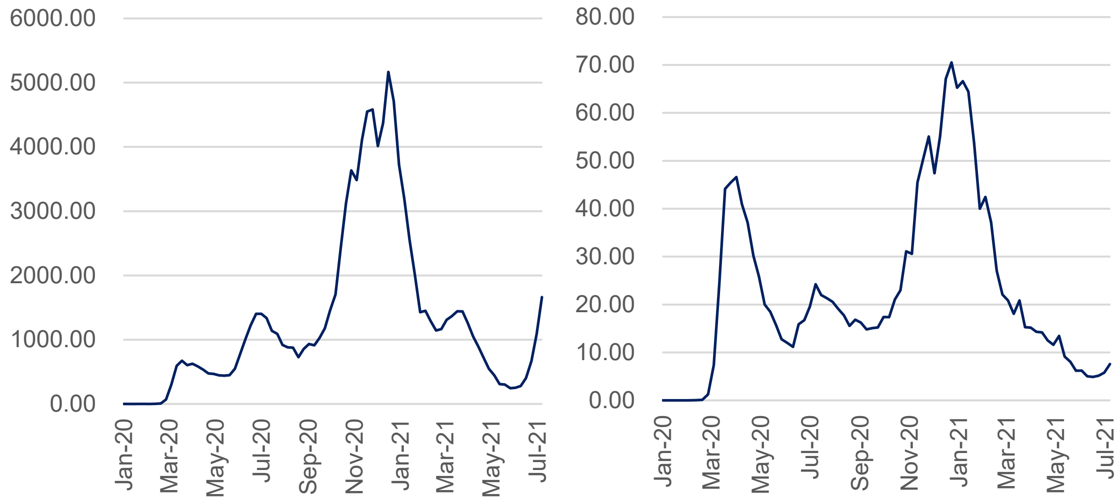
Mexico's GDP for Q1 of 2020 was 2.2 per cent lower than the previous year (-1.2 per cent compared to the previous quarter), reflecting the impact of the travel restrictions that started in March (OECD, 2020c). Q2 saw an 18.7 per cent drop compared to the previous year (a 17.1 per cent quarterly fall). This was the biggest drop for Mexico since the Great Depression in 1930 (Washington Post, 2021a). The GDP for Q3 showed a quarterly rise of 12 per cent, thanks to the mitigation policies and emphasis on economic recovery, although the growth rate was still -8.8 per cent compared to the previous year (Mexico News Daily, 2020b). The GDP for Q4 rose 3.3 per cent compared to its previous quarter, but in light of the previous falls, the year-on-year decrease was inevitable (Reuters, 2021e).

2.1.3 United States's response strategy

COVID-19 situation and reaction of the government

The first case of COVID-19 in the US was recorded on 20 January 2020, and by 8 November 2020 the number of cases had surpassed 10 million. There was a surge of outbreaks in March 2020 following the first confirmed case in January, a slight decrease from April to July, and another sharp increase from November with over 200,000 daily cases by January 2021. Although cases were substantially reduced through early large-scale vaccinations, infection rates started climbing once again in June 2021 owing to relaxed social distancing measures, a slowdown in vaccination rates, and the emergence of the Delta variant (see Figure 21). The cumulative

Figure 21: Weekly COVID-19 cases (left) and deaths (right) in the United States (Jan 2020~Jul 2021, per million people)



Source : adapted from Our world in data (2021)

infection rate was 10.5 per cent on 31 July 2021.

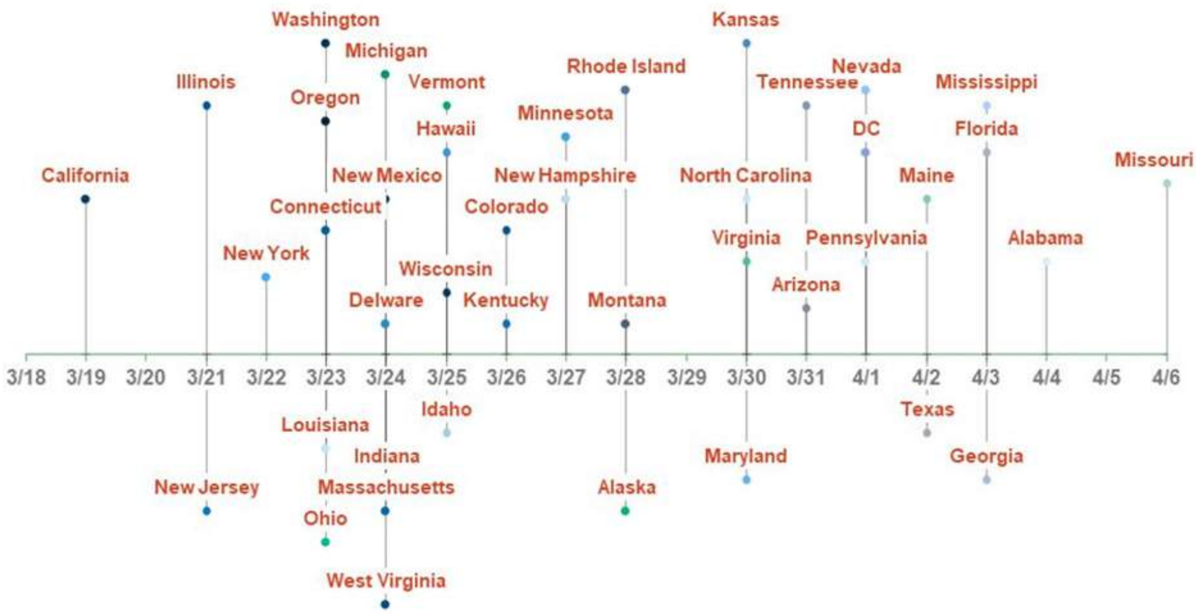
The main events impacting the pandemic's spread and the United States government's response are as follows. The government established a Coronavirus Task Force to monitor the situation nine days after the first domestic outbreak. The Task Force's leader, Vice President Pence, banned travel from countries affected by the disease in February 2020. The government signed bills and issued administrative orders to address medical supply shortages and stimulate the economy. They drew up emergency supplementary budgets, and on 6 March 2020, a bill was passed in Congress to provide USD8.3 billion. Other laws related to COVID-19 include the Families First Coronavirus Response Act (FFCRA), signed into law on 18 March, and the Coronavirus Aid, Relief and Economic Security Act (CARES Act) on 27 March. On 2 April 2020, the Centers for Medicare and Medicaid Services (CMS) and the Centers for Disease Control and Prevention (CDC) issued the Long-Term Care Facility Guidance. The United States announced its withdrawal from the WHO on 6 July 2020 and issued an executive order on the domestic production of medical supplies one month later. On 8 August, President Trump signed executive orders to extend COVID-19 economic relief. The death toll from COVID-19 exceeded 200,000 by 22 September 2020. The Food and Drug Administration (FDA) issued the first emergency use authorization (EUA) for COVID-19 vaccines on 10 December 2020, and vaccinations started on 14 December.

Upon taking office on 20 January 2021, President Biden passed an executive order on protecting the federal workforce and requiring mask-wearing, and on the suspension of entry from countries with cases of virus variants. Two days later, his administration announced its COVID-19 policy priorities. The number of US deaths from the pandemic surpassed 500,000 on 22 February 2021. The number of administered vaccine shots in the country reached 100 million on 12 March. On 4 May 2021, President Biden set the goal of vaccinating 70 per cent of adult Americans with at least one shot by 4 July.

COVID-19 governance

The Congress and federal, state, and local governments have been devising, implementing and amending the necessary laws to combat COVID-19 since early 2020. The United States's policy governance for COVID-19 is decentralized. The policies are issued by federal, state, and local governments through legislation in Congress, separated

Figure 22: Stay-at-home orders in key United States states



Source : KFF (2020)

from fiscal policies. The federal government deals mostly with economic policies such as stimulus funding, whereas state governments oversee the containment policies and technical response (Bergquist et al., 2020). Congress has mostly passed bills alongside the federal government to provide budgets for these containment and economic recovery purposes. State governments provided response measures for emergency public health situations. As shown in Figure 22, orders on mobility restrictions are given by the state governor (KFF, 2020).

Local governments at the county level may administer emergency measures on specific issues such as granting COVID-19-related authority to the local police and introducing regulations on behaviour such as mask-wearing.

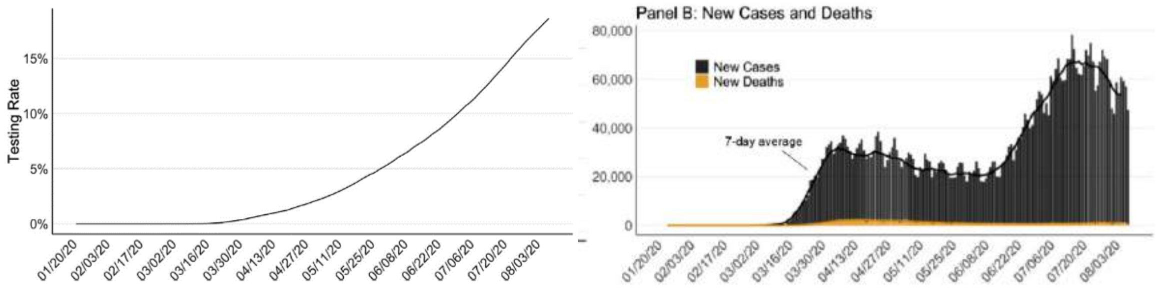
The execution of COVID-19 policies is also split between the local and federal levels. In the early phases of the pandemic, the federal government only issued travel restrictions and warnings, whereas on 16 March 2020, all states declared either general or public health emergencies.

The United States 's policies on COVID-19 were redirected with the inauguration of President Biden in January 2021, and have been included in the "Biden-Harris plan to beat COVID-19". Through this plan, the government proposes seven key changes including free testing, mask mandates, increased production of personal protective equipment (PPE), evidence-based guidance, vaccine and treatment plans, the protection of at-risk groups, and a system to deal with new pandemics (White House, 2020).

3T policy

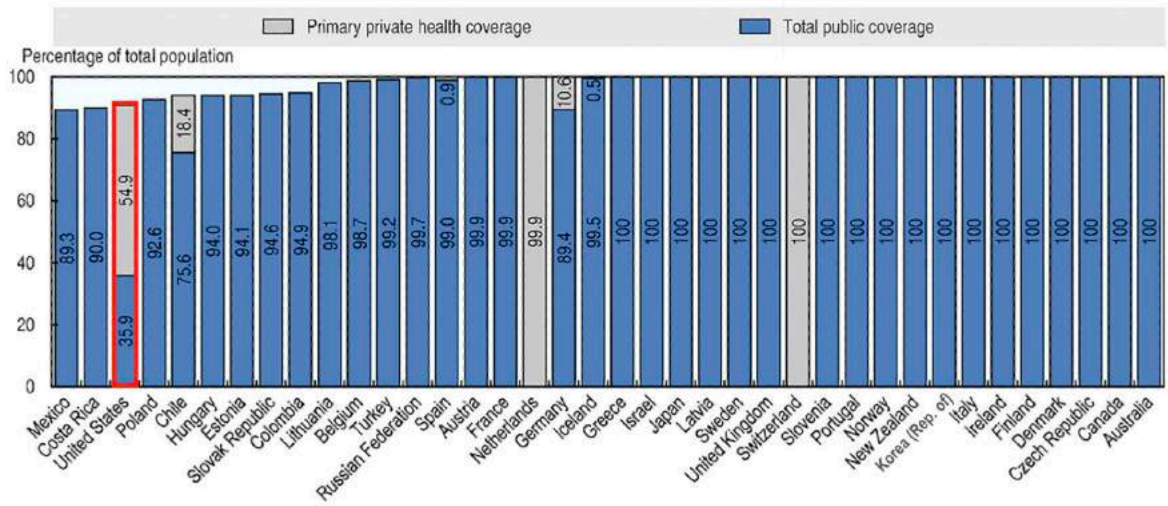
Studying the United States 's COVID-19 response from a 3T perspective, the United States struggled to set up a nationwide testing system for two reasons. First, the CDC did not follow its own protocol for creating test kits, leading to the mass production of defective kits, according to the FDA. Second, the administrative process for authorizing the widespread development and manufacturing of test kits was time-consuming. The United States did not establish a proper nationwide testing system until April 2020. The number of confirmed cases and deaths rose sharply as more tests were administered, as seen in Figure 23 (Wallach, 2020; Bergquist et al., 2020).

Figure 23: Daily testing rates (left) and number of confirmed cases and deaths (right) in the early stages in the United States (20 Jan to 8 Mar 2020)



Source : Bergquist et al. (2020)

Figure 24: Health service coverage for the United States population compared to other OECD countries (2018 standards)



Source : OECD (2020a)

There was no official app for tracking, although apps developed by universities such as Stanford (Covid Watch) and MIT (Safe Paths) were being used to do this. The deployment of apps was decided at the state level, with some states developing a tracking app with companies such as Google and Apple. For example, the State of California performed contact tracing for confirmed cases through the "California Connected" programme (California State Government, 2020).

Public health insurance coverage in the United States is lower in relation to other OECD countries and it has the third highest proportion of people without any coverage (see Figure 24), even when taking into account private insurance (OECD, 2020a). According to the Kaiser Family Foundation(KFF), only 61 per cent of Americans are enrolled in insurance plans, including employer insurance that does not offer full coverage of COVID-19 treatment. The United States is therefore enforcing policies to increase access to diagnostics and treatment for all.

Vaccination strategy

The United States government initiated the Operation Warp Speed (OWS) programme, with the goal of developing COVID-19 vaccines by the end of 2020. The program was created to reduce the R&D period, which usually takes from a year to 18 months, through direct support for tests and by compressing the time for evaluation and authorization. The government provided billions of dollars to companies such as Moderna, Johnson & Johnson, and AstraZeneca through the programme.

OWS also supported the roll-out process. The government first promoted credibility in vaccines by providing accurate information through continuous cooperation with local governments and stakeholders, followed by a phased allocation methodology for their immediate distribution upon approval. Secondly, the programme guaranteed the safety of the vaccination process by introducing the secure online Vaccine Tracking System (VTrckS) (U.S. HHS, 2020; CDC, 2020a).

The United States signed deals to receive 700 million doses by July 2021, which is enough to vaccinate roughly 400 million people. These 700 million come from different manufacturers, with Johnson & Johnson projected to supply 100 million doses by late June, Pfizer 300 million by mid-July, and Moderna 300 million by late July. The initial plan was to secure 20 million doses from Johnson & Johnson by March 2021, along with 100 million from Moderna and 120 million from Pfizer, and then by May receive an additional 100 million each from Moderna and Pfizer. The doses received as of 27 April 2021 amounted to 315.4 million, with 12 million coming from Johnson & Johnson, 104 million from Moderna, 123 million from Pfizer, and 76.4 million from other manufacturers. As of 8 September, more than 208 million people were vaccinated in the United States, which is 62 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

As for fiscal policies, shortly after the declaration of a national emergency in March 2020, a coronavirus relief bill covering testing costs and paid leave was passed by the House of Representatives. On 27 March, the CARES Act was passed to provide relief to central and local governments, businesses, individuals, and hospitals and healthcare facilities. In addition to the loans for businesses and direct payments to individuals under CARES, on 8 August, President Trump signed an executive order extending income tax and student loan repayment moratoriums. President Biden followed with a proposal for a USD1.9 trillion stimulus package, including cheques of USD1,400 for Americans and measures to raise unemployment benefits and increase paid leaves. This package passed the House and Senate in February.

Public approval of disease control policies

The American people's approval of COVID-19 policies was affected by the confusion stemming from unaligned policies and disinformation. First, the federal and state governments voiced different opinions about containment measures, which led to uncertainty about communication around COVID-19 (Bergquist et al., 2020). Second, conspiracy theories and the spread of disinformation also played a role in lowering trust in the government's control policies.

Socio-economic impact of COVID-19 in the United States

The United States economy also suffered due to lockdowns and other stringent measures. GDP had a negative growth rate (-5 per cent) in Q1, which includes the month of March when COVID-19 became a pandemic. GDP fell further by 32.9 per cent in Q2 – a drop three times bigger than that of the 1958 recession. Greater economic shocks led to demands to ease state policies on containment. Due to the strong will of the federal government to fight for economic recovery, GDP rose by 31.4 per cent in Q3, and by another 4 per cent in Q4 (Bureau of Economic Analysis, n.d.).

2.1.4 Germany's response strategy

COVID-19 situation and reaction of the government

Germany had its first case of COVID-19 on 27 January 2020 and the total number of confirmed cases surpassed one million by 26 November. The number of cases skyrocketed between March and April 2020 and fell from late April only to soar once again starting in September. Cases gradually decreased in 2021 due to large-scale vaccinations (see Figure 25). The cumulative infection rate was 4.3 per cent as of 31 July 2021.

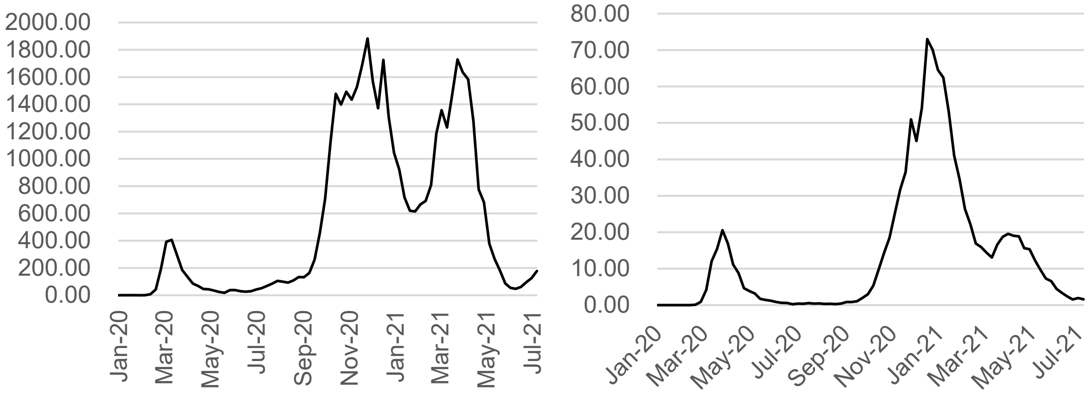
Key government responses include the following. On 4 March, the government decided to ban exports of medical protective equipment. Ten days after the first COVID-19 death occurred on 9 March, the government advised a ban on overseas travel. An official lockdown was put in place on 22 March. The COVID-19 alert was elevated to the highest level on 26 March. Lockdown measures were revised downwards in three stages from 15 April to 6 May. The Corona-Warn-App was launched on June 19 to track COVID-19 cases. A fine of at least EUR50 was introduced on 27 August for failure to wear masks. On 21 September, the federal government announced a new test strategy and quarantine rules in view of the cold season. They reintroduced a partial lockdown on 2 November, and vaccinations started on 27 December.

The lockdown was still in place as of March 2021. The German Government and state governors agreed on a five-step reopening plan on 3 March for businesses and leisure facilities, and the partial lockdown was extended on 24 March. On 21 June, the RKI announced that approximately half of the German population had received at least one dose of a vaccine.

COVID-19 governance

Germany's COVID-19 governance is centred on the Ministry of Health and the Ministry of Interior, Building and Community, according to its Pandemic Preparedness Plans. Scientific advice is provided by the RKI (Robert Koch Institut, which is responsible for disease control and prevention), the BfArM (Bundesinstitut für Arzneimittel und Medizinprodukte, German Federal Institute for Drugs and Medical Devices), and PEI (Paul Ehrlich Institute). Under the federal system, local governments take responsibility and authority over public health under the coordination of the federal government. The Federal Joint Committee, composed of the Chancellor and the 16 state governors, responds to national preventive measures, and policies for COVID-19 are announced by both the federal and state governments. The federal government

Figure 25: Weekly COVID-19 cases (left) and deaths (right) in Germany (Jan 2020~Jul 2021, per million people)



Source : adapted from Our world in data (2021)

also organized the executive bodies into a COVID-19 Cabinet, to deal with the rising number of cases. Members of the Cabinet convene every Thursday, and meetings are also held with state governors to discuss areas of cooperation (Health System Response Monitor, 2021).

The RKI under the BMG (Bundesministerium für Gesundheit, Federal Ministry of Health) oversees crisis management related to infectious diseases. The RKI issues reports on risk assessment, strategy development, response plans, and daily surveillance, as well as technical guidelines; acts as the channel for communication with public health authorities within and outside Germany; and manages the prevention, control and investigation of infectious diseases (Robert Koch Institut, 2021a).

The Federal Office for Civil Protection and Disaster Relief (Das Bundesamt für Bevölkerungsschutz und Katastrophenhilfe, hereinafter BBK) enforces mandatory disaster alerts during pandemics and provides detailed guidelines and information through various channels including smartphone apps.

Key pieces of legislation related to COVID-19 include The Act on the Protection of the Population in the Event of an Epidemic Situation of National Importance, which was amended three times in March, May, and November 2020. The first amendment granted authority to the government to ensure the supply of medicine, medical appliances, and goods during the pandemic. The RKI was also granted more authority and the Minister of Health was given the right to issue compulsory licences for patents. For the second amendment, COVID-19 testing fees were included in public medical insurance coverage, testing capacities in care facilities and hospitals were enhanced, a duty to report to health authorities was introduced, care incentives (Pflegepramie) up to EUR1,000 were distributed to workers in care facilities, and the short-time working allowance (Kurzarbeitergeld) was increased. The third amendment of the law laid out preventive measures such as lockdowns and social distancing, targeted help for hospitals, and legal grounds for supporting high-risk groups and working parents.

3T policy

Germany's testing, tracing and treatment system is as follows. For tests, although the first diagnostic method for COVID-19 was developed by a German research team in January 2020, the government failed to acquire the necessary testing capacity due to inaccurate predictions and it was only in April that Germany was able to adequately respond to the sudden rise of cases (Welt, 2020). Germany extended its testing to include those without symptoms in March 2020. However, it revised its National Testing Strategy once again on 15 October to concentrate testing on those with noticeable symptoms of COVID-19 (Robert Koch Institut, 2021b).

For tracing, the government initially relied on manual contact tracers and started developing an app that used Bluetooth data to track close contacts in early March 2020. The app was delayed due to personal information issues and the government was forced to switch to a decentralized development approach, with the Corona-Warn-App finally being released in June. This app sends out a warning to those in close proximity to a confirmed case who has reported it on the app and includes the following features: it does not detect the user's location; the developer discloses the source code of the app in advance, allowing the private sector to complement and inspect the app; data is automatically deleted after two weeks; and data is stored locally on the user's smartphone, protecting personal information through an encryption method that is undecipherable even by the owner of the smartphone. According to the RKI, the usage rate is rather low at 25.8 million downloads as of 25 February 2021, which is a drawback as its effectiveness depends on the number of downloads and reports.

Germany is one of the top countries in terms of medical services, and public health care is available to 88 per cent (83 million) of the population. It has more hospitals per capita than any other EU Member State. According to an OECD report, the proportion of ICU hospital beds is also the highest in Europe at 34 per 100,000 people. (OECD, 2020a) This advanced medical infrastructure contributed to lower COVID-19 fatality rates. But the number of infections, including severe cases, jumped in the winter of 2020, leading to a shortage of hospital beds. The RKI statistics show that daily deaths from COVID-19 reached a record high of 962 on 22 December, and the number of critically ill COVID-19 patients under intensive care reached 5,216, placing Germany at risk due to a shortage of hospital beds and medical staff. This was despite the country's Parliament having approved the COVID-19 Hospital Relief Act on 25 March 2020 to relieve the cost burden on hospitals of treating COVID-19 patients.

Social distancing policy

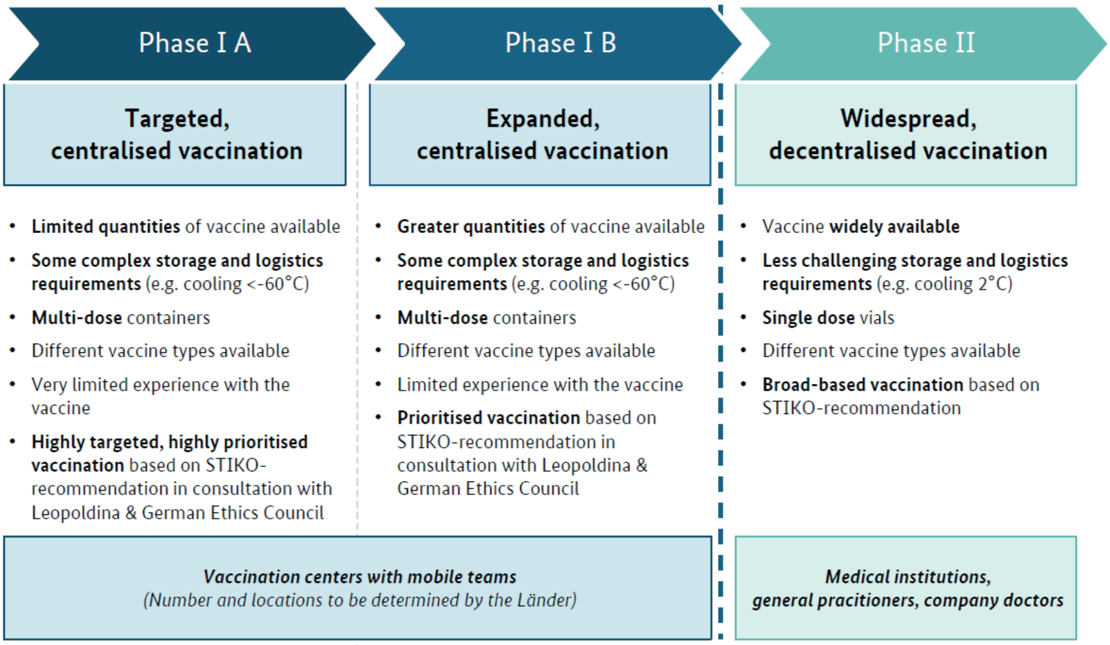
The federal and state governments devised codes of conduct for social distancing in March 2020. These codes allowed only minimum contact with other people, apart from those in the same household, and banned public gatherings of more than two people. Breaking the rules carried a maximum fine of EUR25,000, with severe breaches resulting in up to two years of imprisonment.

Vaccination strategy

Germany's vaccination strategy consists of targeted vaccinations for vulnerable groups at vaccination centres during Phase I, when there was greater difficulty in securing, storing, and transporting vaccines. In Phase II, when vaccines became more readily available, they were to be administered through medical institutions (see Figure 26). Phase I was divided into A and B according to the supply of vaccines (Bundesminister für Gesundheit, 2020).

Pfizer's COVID-19 vaccines were developed by its German partner BioNTech, and the German Government entered a USD445 million agreement with BioNTech in September 2020 to accelerate vaccine development by boosting domestic manufacturing and development capacities.

Figure 26: Germany's Vaccination Strategy



Source : Bundesminister für Gesundheit (2020)

The EU supervises the purchase and distribution of vaccines for its Member States, taking into consideration the disadvantages that some could be faced with due to insufficient purchasing power. As of March 2021, the EU had signed contracts for a total of 1.835 billion doses, with 500 million from Pfizer, 310 million from Moderna, 300 million from AstraZeneca, 300 million from Sanofi, 225 million from CureVac, and 200 million from Johnson & Johnson. Of these, 300 million doses were for Germany. As of 5 May, 35.713 million doses had been distributed by the EU. Meanwhile, there was controversy over Germany signing a separate supply contract with Pfizer for 30 million doses in September 2020. In addition, Germany entered into contracts with CureVac on 31 August 2020 for 20 million doses, and with Russia's Gamaleya Research Institute for 2.5 million in April 2021. By 8 September 2021, 55.04 million people had been vaccinated in Germany, which is 66 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

Although the German Government had strictly abided by a balanced-finance rule (Schwarze Null), it was temporarily put on hold because of the massive pressure on households and businesses. Germany's support plan of March 2020 is composed of a supplementary budget worth EUR156 billion and an Economic Stabilization Fund (WSF) of EUR600 billion, amounting to EUR800 billion in total. The EUR156 billion supplementary budget, provided through the issuance of government bonds, was for both medical support (EUR55 billion) and bolstering small businesses (EUR50 billion). The EUR600 billion in the WSF was mostly to be spent on businesses, equity investment, and supporting credit guarantees and loans.

Public approval of disease control policies

According to Germany's Kantar survey institute, over two-thirds of Germans were satisfied overall with the government's control of COVID-19 in September 2020 (dpa international, 2020). But despite the generally positive public response to the containment policies, there was resistance in the form of lockdown protests across several cities in May, August, November, and December of 2020.

The protesters demanded the complete removal of the control measures. The decision by some state governors to abolish social distancing and mask-wearing policies led to social confusion. Indeed, there was heated debate over how much the government's control measures could limit the basic human rights protected by the constitution, and lawsuits were filed against the government for allegedly violating these rights (DW, 2020b).

Socio-economic impact of COVID-19 in Germany

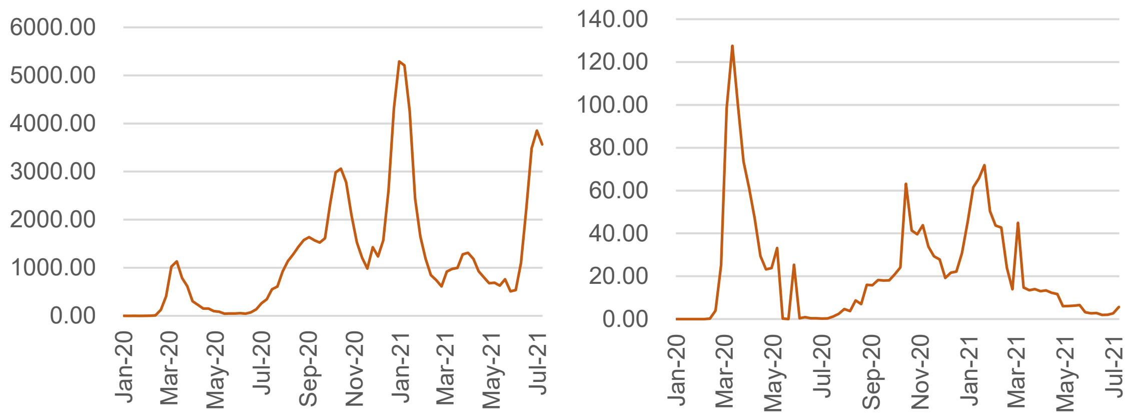
The GDP fell 1.8 per cent in Q1 of 2020 compared to the previous quarter, which is a smaller decrease than that of Germany's neighbouring countries. However, in Q2, the GDP contracted by 10 per cent compared to Q1, which was the largest quarterly drop since 1970. The growth rate rebounded to 9 per cent in Q3 but slowed down again in Q4, rising by just 0.7 per cent, most likely due to the new wave of COVID-19 infections and ensuing lockdown measures (Statistisches Bundesamt, 2021).

2.1.5 Spain´s response strategy

COVID-19 situation and reaction of the government

After the WHO categorized COVID-19 as a pandemic on 11 March 2020, the Spanish Government adopted immediate and effective measures. By Royal Decree 463/2020, it declared the state of emergency on 14 March. This situation lasted until 21 June 2020, followed by several phases. On 28 April 2020, the so-called "new normal" began, with the adoption of urgent measures for prevention, containment and coordination between the

Figure 27: Weekly COVID-19 cases (left) and deaths (right) in Spain (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

national and regional governments. This situation continued until the Royal Decree 926/2020 was approved on 25 October, declaring an emergency throughout the territory to contain the virus. This remained in force until 9 May 2021. The cumulative infection rate was 9.7 per cent as of 31 July 2021 (see Figure 27).

COVID-19 governance

The Spanish and EU authorities undertook a decisive response from the first moment to mitigate the different impacts of the pandemic, thus preventing a highly disruptive economic and social scenario. One of the most important was the decision to reinforce the National Health System (NHS). The central government transferred significant resources to the regional governments in order to finance the necessary strengthening of public health care and education. To curtail the transmission of the virus, sanitary authorities, keep constant tracing of the epidemiological situation and establish timely adapted control measures.

Spain's NHS is configured as a coordinated set of health services from the Central Government Administration and the 17 regional governments who are entrusted with carrying out its functions due to the political decentralization. The NHS is financed by public resources and provides universal coverage that is free at the point of use. Specifically, its structure is as follows:

- The central government is responsible for basic health principles and coordination, foreign health affairs, and policy on medicines;
- The regional governments are responsible for health planning, public health, and healthcare services management;
- The local councils are responsible for health, hygiene, and cooperation in the management of public services.

During the crisis, the local and regional governments, continued to maintain their responsibilities while adopting the new measures.

Royal Decree 21/2020 sets out the basic hygiene and prevention measures for the crisis. In addition, the Interterritorial Council of the National Health System together with the regional governments and other ministries approved a document called the Coordinated Response Actions, which gathers indicators from the Early Response Plan in a Pandemic Control Scenario of COVID-19. This Plan establishes the preparedness and response capabilities to respond to an increase in COVID-19 transmission. Regional governments must have contingency plans in place to reinforce their healthcare capacities (primary and hospital) so that they can respond to any scenario of increased transmission of the virus in their local context.

Royal Decree 463/2020 declaring the state of emergency is the main regulation for the health crisis. The government delegated competences to e.g. the Defence Minister; Interior Minister; Transport, Mobility and Urban Agenda Minister; and Health Minister. In addition, each regional government and autonomous city was able to have its own disease control legislation. The government also activated the Situation Committee (Law 36/15), and requested the cooperation of citizens in order to prevent obstructions to the work of the officers in the exercise of their duties.

Royal Decree 8/2020 assured the continuity of public services such as digital connectivity to keep the country online. This measure aimed to enable people to carry on with their lives, business activities, education, and access to health and social services with the least possible negative impact. Furthermore, the Secretariat of State for Telecommunications and Digital Infrastructures reinforced the ordinary supervision of activities to ensure that essential services were not disturbed. To sustain connectivity, the government undertook extraordinary regulatory measures, and signed a Cooperation Agreement with the telecommunication operators in order to guarantee digital service provision for people and businesses within the framework established by the health authorities.

3T policy

Spain's Ministry of Health established its own guidelines for coping with the pandemic called "Strategy for Early Detection, Surveillance and Monitoring of COVID-19". They cover three main areas: case detection, notification and management; the investigation and management of contacts; and screening studies. To control transmission, they indicate that the government needs to reinforce the primary care teams, guaranteeing the diagnosis and case management capacity at this level.

To facilitate the early detection, robust and timely information from the Epidemiological Surveillance Network (RENAVE) has been key. Statistics used for decision-making also include data on bed and ICU occupancy and vaccinations from the Spanish Laboratory-based Information System (SERLAB) and Vaccine Register (REGVACU). Since June 2020, RENAVE has included information derived from genomic sequencing. Specific data is also available in social and health care centres collected at the national level by the IMSERSO (Institute for Elder People and Social Services). The epidemiological situation and various COVID-19 strains oblige the health system to manage different scenarios and update its response on a regular basis.

The Health Institute Carlos III published the Strategy for Early Detection, Surveillance and Monitoring of COVID-19and the "Alerts, Preparedness, and Response Plans Presentation", and the Public Health Commission of the Interterritorial Council reviewed it. The latest version is from July 2021.

The National Government also developed a Bluetooth app called "Radar Covid" to help control the spread of the virus, by identifying possible close contacts.

Social distancing policy

Royal Decree 7/2020 expressed the need for the National Security System to foresee and activate health contingency plans and for the regional governments to guarantee the protection of individual and community health in Spain at all levels. The focus was to reinforce epidemiological control and surveillance, as well as home-based care for those patients for whom it was appropriate, whether they had COVID-19 or another condition, to reduce the need to go to health centres or hospitals, so that hospital care could be reserved for those who needed it.

Social distancing measures allowed the pandemic to be contained as much as possible. Royal Decree 21/2020 adopted urgent measures to contain, prevent and coordinate actions such as implementing social distancing and hygiene measures for public spaces and transport (maritime, trains, buses, air transport, etc.).

Additionally, on 15 March 2020, the Presidency together with the Health Minister launched the Campaign #EsteVirusLoParamosUnidos (We will stop this virus together) followed by recommendations and promotional videos, in order to marshall forces from across the country to battle COVID-19 and encourage social distancing measures. Royal Decree 8/2020 also recommended that enterprises shift to teleworking.

Vaccination strategy

The Interterritorial Council of the National Health System (CISNS)[2] developed the "Vaccination Strategy to Face COVID-19 in Spain". At the European level, the Commission and Member States have taken a common EU approach to securing supplies and facilitating the rollout of vaccines. Spain actively participates within the "EU Vaccines Strategy" where Advanced Purchase Agreements are negotiated with individual producers on behalf of Member States.

The vaccination strategy for Spain took into account the limited initial availability of vaccines and the continuing evolution of knowledge on key aspects of the disease. The fundamental pillars of the strategy are 1) COVID-19 epidemiology; 2) vaccine development; 3) prioritization of vaccination; 4) logistics, supplies and administration; 5) communication strategy; and 6) monitoring and evaluation of the vaccination. This is a living document, updated on a regular basis.

The population groups were prioritized for vaccination according to their risk of exposure, transmission and serious disease, as well as the socio-economic impact of the pandemic (see Figure 28). As of 8 September, 37.01 million people had been vaccinated in Spain, 79 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

The safety net deployed from the outset of the crisis, through a significant injection of public resources to sustain the productive networks, employment and household incomes, has mitigated the economic and social impact.

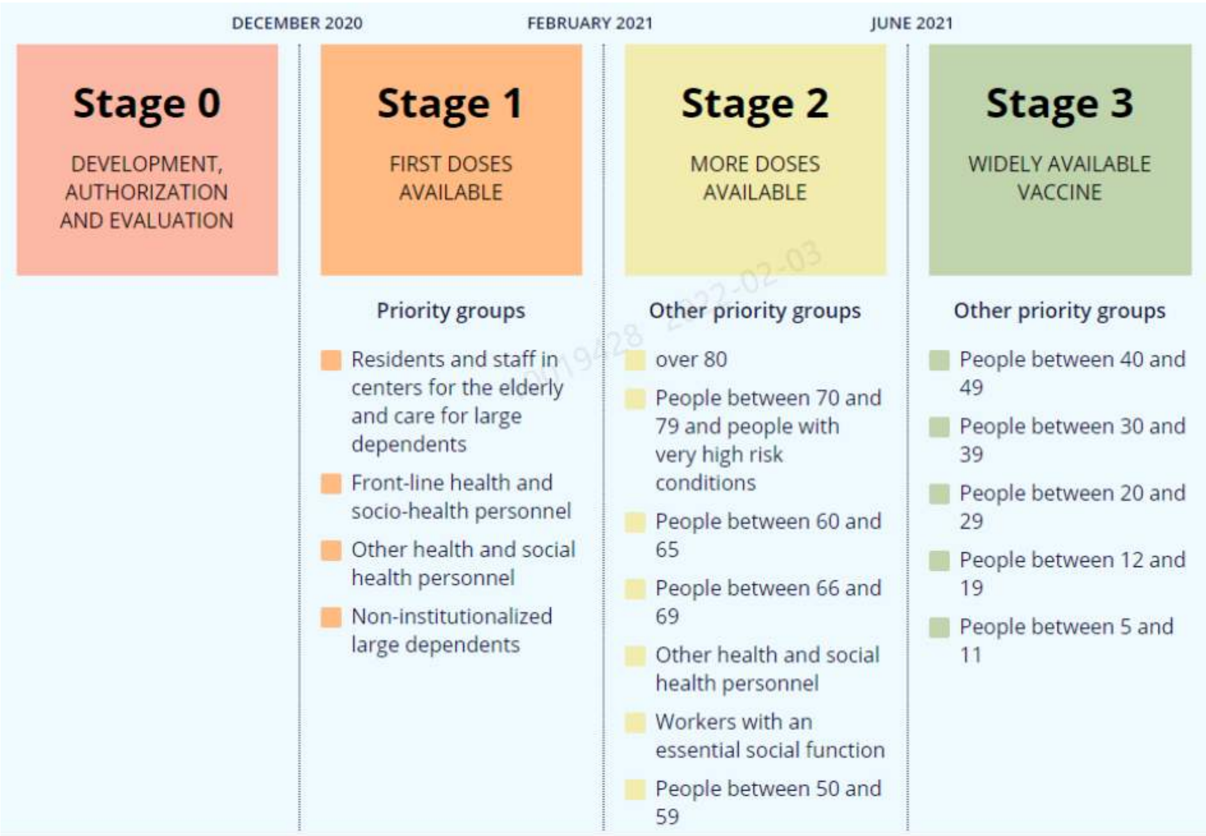
The packages of measures launched by the government prevented a GDP drop in Spain of over 25 per cent in 2020 and the destruction of more than 3 million jobs. Its investment through loans and guarantees, as well as direct aid, especially that channelled through short-term employment schemes (ERTEs) and benefits for self-employed workers, offered companies an alternative to redundancies, and preserved a considerable proportion of jobs and household income. The average unemployment rate remained at 15.5 per cent, much lower than in previous crises.

All of these measures were adopted and amended in line within the evolution of the pandemic and of the economy. The government launched sectoral plans, in addition to the general measures for companies. This aimed to help close the production gap in those areas most affected by restrictions on mobility and drops in demand, such as tourism, transport and the automotive industry, which account for a large proportion of GDP and have a substantial impact on the rest of the economy.

The response has progressively focused on the sectors and companies facing the greatest difficulties in returning to normal operation, and aimed at supporting business solvency. The main objective was to prevent a structural impact and ensure a sound foundation for the recovery in line with the recovery of activity in Europe and globally.

But response and support measures, which are essential for protecting activities, production and jobs in the short term, are not on their own sufficient to guarantee a return to pre-pandemic GDP levels, or to correct the significant imbalances, both new and inherited, and address the challenges of the future.

Figure 28: The population groups prioritized for vaccination



Source : Government of Spain (2021c)

All this showed the urgent need to launch an investment and reform plan, with a threefold objective: 1) to support the recovery from the health crisis in the short term, 2) to promote a process of structural transformation in the medium term, and 3) to lead in the long term to a more sustainable and resilient development from a financial, social, territorial and environmental point of view.

In this context, another answer to the crisis has come through the EU's Next Generation funding instruments, providing an opportunity to deploy the Recovery, Transformation and Resilience Plan and counter the impact of the pandemic on investment and economic activity. This will allow Spain to boost the recovery and modernize the Spanish economy, enabling a return to the path of progress and prosperity.

Public approval of disease control policies

Although the public had adjusted relatively well to lockdowns and other strict social distancing measures in the early stages of COVID-19, the prolonged measures led to fatigue and therefore opposition to their extension by the second half of the year (Reuters, 2020a). In July 2021, the Spanish Constitutional Court ruled the government's lockdown as unconstitutional (BBC, 2021a).

Characteristics of Spain's responses to COVID-19

In addition to the coordination of national and regional decision-making, Spain has also understood the struggle that the pandemic would cause in countries where inequalities were even more severe due to development conditions. At an early stage, the overview was that the crisis was going to have the worst effects on territories that are more vulnerable with higher levels of poverty. In communities suffering the worst forms of discrimination, health and social protection systems were largely unable to cope with the enormous challenge caused by this disease. The pandemic compounded the extant difficulties being experienced with other endemic health emergencies such as AIDS, malaria, tuberculosis and tropical diseases. In addition to exposing fragile health systems, it showed the shortage of health professionals.

Spain therefore found it more necessary than ever to reaffirm the importance of international cooperation and sustainable development through a strategy with three aims, in line with the priorities of the EU's global response to COVID-19 and the "Team Europe" approach:

1) Saving lives and strengthening public health systems;
2) Protecting and recovering rights and capacities; and
3) Preserving and transforming socio-economic systems, recovering the productive fabric and strengthening democratic governance.

Spain is fully committed to the multilateral approach for fighting the pandemic, collaboratively leading and promoting several initiatives, such us the recent donation of 22.5 million vaccines that the President announced to the UN Secretary General. Of this, 7.5 million will go to Latin America, contributing a total of 180 million euros to multilateral efforts.

As mentioned above, the European Commission recently approved, with the highest qualification, the Recovery, Transformation and Resilience Plan presented by Spain for 69.5 billion euros in direct transfers from the EU Next Generation funds. The leveraging of private investment will support a modernization and transformation of the production model with particular impact on these key sectors: mobility and connectivity; infrastructure aimed at energy sustainability; the development of renewable energy; the modernization of public administration and measures to strengthen human capital; the resilience of the job market; the modernization of industry; digitalization and the development of 5G; science, technology and innovation including AI, focused on the health system; education and digital skills; inclusion policies; employment and integration policies; cultural and sports industries; and the tax system.

Current estimations suggest that the full implementation of these reforms would entail, on average, an increase in GDP of approximately 2 percentage points per year during the implementation period, the creation of over 800,000 new jobs, and the cohesion by preventing rural depopulation throughout Spain. In addition, it is expected to reduce income inequality, cutting the difference from the EU average by two thirds and stimulating recovery in those territories most adversely affected by the pandemic. Finally, it is especially aimed at offsetting the foreseeable negative impact of the crisis on the two groups who have been most adversely affected: women and young people.

Socio-economic impact of COVID-19 in Spain

Spain's economy also suffered a lot from COVID-19. Spain's GDP fell by 5.4 per cent in Q1 2020 and 17.8 per cent in Q2, due to lockdown policies and the global economic recession. The economy had rebounded as its GDP grew by 17.1 per cent in Q3 but the rate dropped to 0.01 per cent in Q4 as the second wave of COVID-19 struck the European continent. This means that Spain's GDP contracted by 11 per cent in 2020, more than after the global financial crisis. It was the steepest drop since Spain's 1936-39 civil war. However, the Spanish Government expected a strong rebound in 2021 (FRED Economic Data, 2021; Reuters, 2021c) (The IMF projected that the real GDP growth rate of Spain in 2021 would be 5.8% - GDP Data from January 2022 World Economic Outlook Update)

2.1.6 Sweden's response strategy

COVID-19 situation and reaction of the government

Following its first outbreak on 31 January 2020, Sweden saw over 100,000 confirmed infections by 13 October, with the number of cases and deaths totalling 566,957 and 11,591 respectively by 31 January 2021. The number was trending downward from Q2 of 2021 due to the national vaccination effort (see Figure 29). The cumulative infection rate was 10.9 per cent on 31 July 2021.

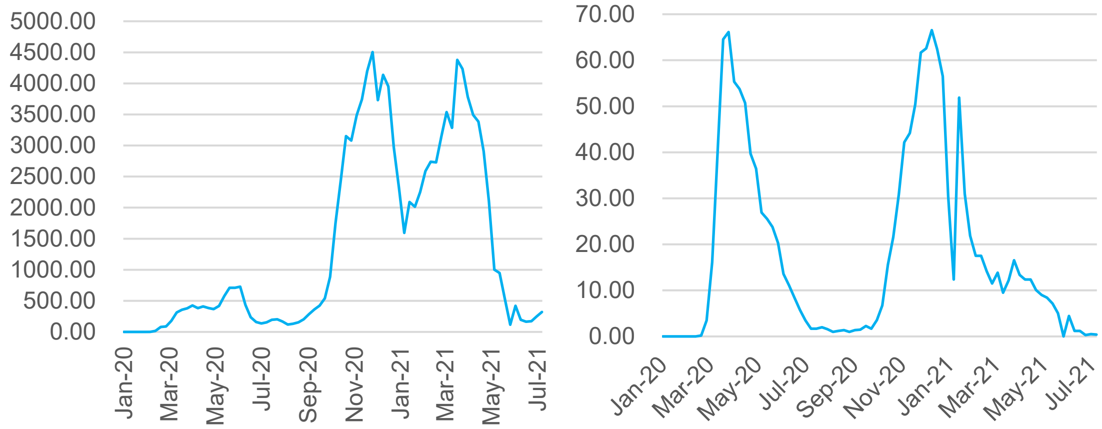
The following government responses were devised to curtail the spread of the pandemic. Public gatherings of more than 500 people were banned on 11 March, 40 days after the first coronavirus case was detected in Sweden. On 14 March 14, the Swedish Ministry for Foreign Affairs advised against non-essential overseas travel. Two days after the first death from COVID-19 on 17 March, the Riksdag (Swedish Parliament) voted in favour of laws to close schools. The government executed orders to process 100,000 weekly tests, eased travel restrictions within Sweden on 13 June, and set up the Independent Coronavirus Commission on 30 June. On 30 July, the government encouraged people to work from home for the remainder of the year and introduced national vaccine plans on 31 August. The first report of the Independent Coronavirus Commission was released on 15 December. Vaccinations began on 27 December. The Riksdag enacted the COVID-19 Act in January 2021 to temporarily increase its powers to enforce COVID-19 measures. By 11 February, over 80 per cent of residents in nursing homes had received at least one shot, which most likely influenced the drop in COVID-19 deaths according to health authorities.

COVID-19 governance

Sweden has a decentralized healthcare system, overseen by regional councils as well as local councils or municipal governments when necessary. The system is managed on three levels (see Figure 30). First, the central government oversees national policies and legislation including the governance of national agencies such as the Public Health Agency (PHA) and the National Board of Health and Welfare (NBHW) (Government of Sweden, 2021). Second, healthcare institutions are supervised by the 21 county councils. Third, roughly 290 municipal institutions are in place for elderly and disabled people.

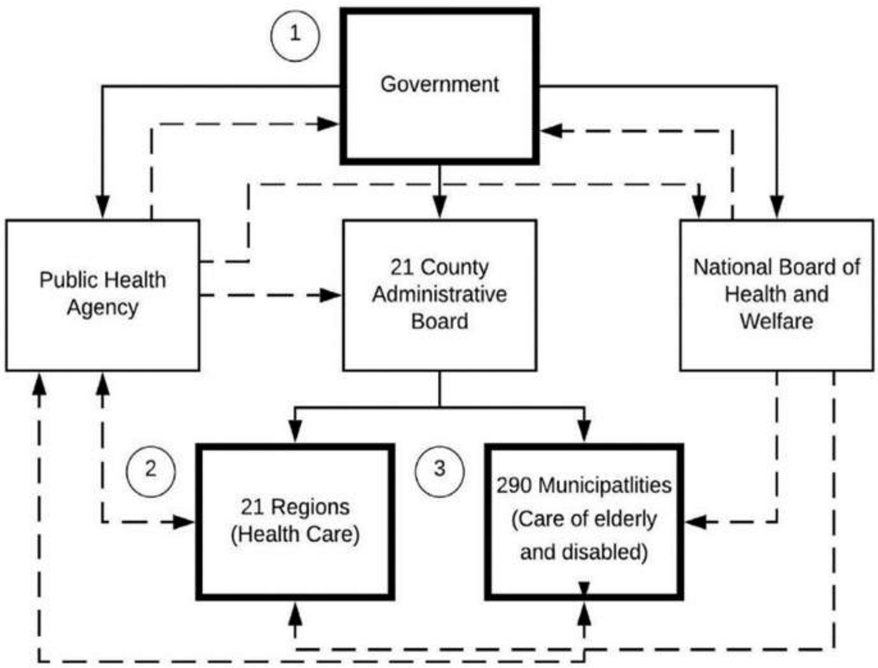
This decentralized healthcare system arises from the idea of local self-government enshrined in the Swedish Constitution, promoting the autonomous functioning of local organizations, and it is this very distributed

Figure 29: Weekly COVID-19 cases (left) and deaths (right) in Sweden (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

Figure 30: Sweden's healthcare governance: Three levels



Source : Kavaliunas et al. (2020)

responsibility that appears to have delayed early decision-making during the epidemic. National agencies such as the PHA may not exercise rights over regional councils, unless stipulated otherwise by regulations enforced by the legislature (Ludvigsson et al., 2020).

The PHA is in charge of national supervision over pandemics such as COVID-19, including developing regulations, recommendations and guidelines based on advice from expert groups. Its responsibilities include vaccination programmes, emergency preparedness for health risks, and securing stockpiles of infectious disease medications. It is also engaged in national efforts on antibiotic resistance, infection control, and healthcare-related infections. Ministers may express their opinions but do not hold rights to nullify the PHA's actions. As for the government, it may dismiss the PHA's guidelines but has traditionally abided by its decisions (Public Health Agency of Sweden, 2018).

Sweden introduced the Communicable Diseases Act 2004 (Smittskyddslagen) to respond to infectious diseases. Sweden did not introduce a lockdown like other European countries, owing to the "citizens' right to move freely within Sweden and to leave the country" stated in its 1974 Constitution. As such, Sweden's containment policies were voluntary, rather than compulsory (Ludvigsson et al., 2020). However, in January 2021, the Riksdag introduced the Government Bill for a Temporary Act to prevent the spread of COVID-19 (The COVID-19 Act), giving the government more executory power in enforcing mandatory measures on its people and more authority in adopting binding disinfection measures. It was effective from 10 January to 30 September 2021.

3T policy

Examining the Swedish response to COVID-19 in light of the 3Ts, the country was not active in the beginning in terms of testing due to its strategy being geared toward maintaining social functions through moderate measures rather than containing the disease (Ludvigsson et al., 2020). Sweden shifted its testing strategy on 13 March 2020 to protect those who were the most vulnerable and exposed to the coronavirus. Accordingly, priority was given to hospitalized patients and healthcare workers for the elderly. In early June 2020, the COVID-19 testing agreement was concluded, allowing individuals to make reservations for tests using a variety of web-based solutions (Kavaliunas et al., 2020).

Sweden carried out sampling and tracing for all suspected cases among travellers from infected countries until 12 March 2020 but stopped tracing as the disease started to spread locally. Sweden only used traditional methods for contact tracing through epidemiological investigators, as opposed to using a tracing app, which its government said is neither necessary nor efficient (Digwatch, 2020).

In terms of treating infections, its initial response mainly targeted the elderly who fell into high-risk groups, but proper treatment did not take place due to shortages in equipment and medicine (Ludvigsson et al., 2020). The number of hospitalized cases skyrocketed towards the end of March 2020, reaching a peak in late April to early May and making April the deadliest month for Sweden since 1993. The National Board of Health and Welfare (NBHW) was charged with coordinating intensive care beds on a national level, resulting in an increase in ICU capacity across the country to 600 beds – in comparison to 500 before the pandemic – even reaching 1,000 in peak periods.

Social distancing policy

On 10 January 2021, the government issued the "'limitations ordinance for COVID-19" under the Act, introducing legally binding regulations on gyms, sports centres, swimming pools, shops, and venues for private gatherings.

Vaccination strategy

The PHA divided people into four priority groups depending on their age, underlying conditions, occupation, and environment. Sweden adopted a centralized process with eight vaccination centres nationwide. Vaccination and information were made available through its public remote medical service Kry.

The government had acquired vaccines for approximately 24 million people, which amounts to 231.3 per cent of its population. Unlike Germany, Sweden only used the vaccines distributed by the EU and had received 4,309,035 doses as of 2 May 2021, with 65.9 per cent of the doses from Pfizer, 25.6 per cent from AstraZeneca, and 8.4 per cent from Moderna.

Sweden started vaccinations in late December 2020. As of 8 September, 6.93 million (68 per cent) of its people were vaccinated (Our world in data, 2021).

Economic countermeasures against COVID-19

Sweden's fiscal policies for COVID-19 included an amended budget being passed to provide tax relief on 19 March. On 27 March, the government also proposed loan guarantee programmes for SMEs. It announced an amended budget of 100 billion SEK on 15 April to limit the spread of the coronavirus and mitigate economic shocks. On 20 April, the government decided to cut rental costs in vulnerable sectors, providing partial aid to compensate for the reduction. On 30 April, additional measures were proposed to ease the burdens on employers and businesses.

Public approval of disease control policies

The public's opinions of the containment policies were relatively positive, with people showing high levels of trust in researchers and experts. A majority (60~80 per cent) also expressed trust in the PHA and other health authorities. In addition, Swedish people were comparatively compliant with the PHA's guidance on hand washing and social distancing. However, the country's failure to control COVID-19 weakened people's trust in institutions over time. By September 2020, only one out of three people said that the government was responding well to the pandemic, and in November, 82 per cent of respondents expressed concerns over how the health system was dealing with the pandemic (Bloomberg, 2020b).

Socio-economic impact of COVID-19 in Sweden

In terms of COVID-19's impact on the Swedish economy, policies that focused on mitigation rather than containment led Sweden to suffer the least in Q1 of 2020. It therefore experienced a slight increase in GDP (0.1 per cent). In Q2 however, GDP fell by 8.6 per cent despite the less stringent policies, due to social distancing, border control, and a global economic recession. The economy picked up again in Q3, with recovery in exports and manufacturing leading to a 4.3 per cent increase. The growth rate of Sweden's GDP was 0.5 per cent in Q4 (SCB, 2021).

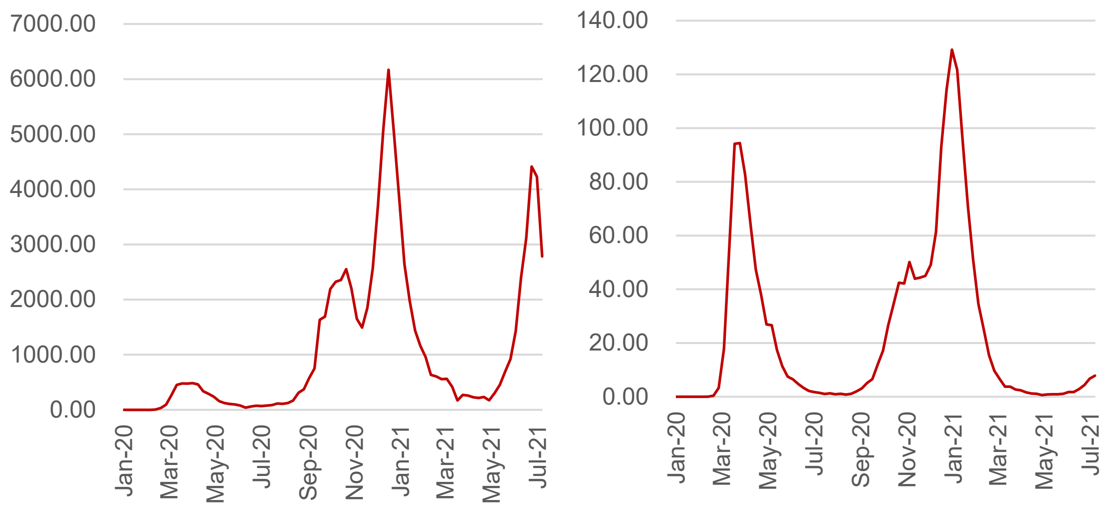
2.1.7 United Kingdom's response strategy

COVID-19 situation and reaction of the government

The United Kingdom's first case of COVID-19 was confirmed in January 2020 with the number of cases reaching over a million by October and 3,852,801 as of 31 January 2021. There was a rapid rise in March and April 2020, and then the curve flattened out in June and July only to soar once again in September to over 60,000 daily cases (see Figure 31). Large-scale vaccinations helped to reduce cases significantly in 2021, but the number grew once again from May 2021 due to the Delta variant. The cumulative infection rate was 8.7 per cent on 31 July 2021.

The key events impacting the pandemic's spread and the United Kingdom Government's response are as follows. The first death from COVID-19 occurred on 30 January 2020 and the government announced the "Coronavirus Action Plan" on 3 March. A ban on mass gatherings and postponement of local elections were announced on 13 March. On 23 March, Prime Minister Boris Johnson himself issued stay-at-home orders. By 13 April, the total number of COVID-19 deaths exceeded 20,000. On 10 May, the government announced "Our Plan to Rebuild: The United Kingdom Government's COVID-19 recovery strategy". By 23 May, the death toll had surpassed 50,000. On 23 June, the government gave up on its centralized development of a contact-tracing app – into which it had invested millions of pounds for over three months – announcing new plans for using the contact-tracing standards of Apple and Google. The government eased the restrictions on 4 July.

Figure 31: Weekly COVID-19 cases (left) and deaths (right) in the United Kingdom (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

On 12 October, a three-tier legal framework was introduced in England for local lockdowns.

On 2 December 2020, the United Kingdom became the first country to authorize COVID-19 vaccines, which were administered from 8 December. Stronger lockdown measures were announced for London and its suburbs to control the spread of the Alpha variant. On 4 January 2021, the PM declared a third national lockdown and announced further financial measures. By 7 January, the number of COVID-19 deaths exceeded 100,000. Over 15 million people had received at least one dose of a vaccine by 14 February. The PM announced the government's reopening plans on 22 February 2021, starting with schools in March and ultimately removing all restrictive measures by June. However, on 14 June the government decided to delay the full reopening due to concerns over the Delta variant.

COVID-19 governance

The United Kingdom's COVID-19 policies are supervised by the Department of Health and Social Care (DHSC). The Secretary of State for Health and Social Care takes full responsibility for all health-related disasters, with support from the Chief Medical Officer and the DHSC. The National Health Service (NHS) Commissioning Board mobilizes resources and communicates with NHS institutions to ensure that all institutions follow the same response strategy. Public Health England works closely with its counterparts in other regions to offer expert skills and knowledge. On 18 August 2020, the United Kingdom Government brought together Public Health England, NHS Test and Trace, and the Joint Biosecurity Centre to establish the National Institute for Health Protection (NIHP), in response to criticism over its failure to provide an early response to the pandemic.

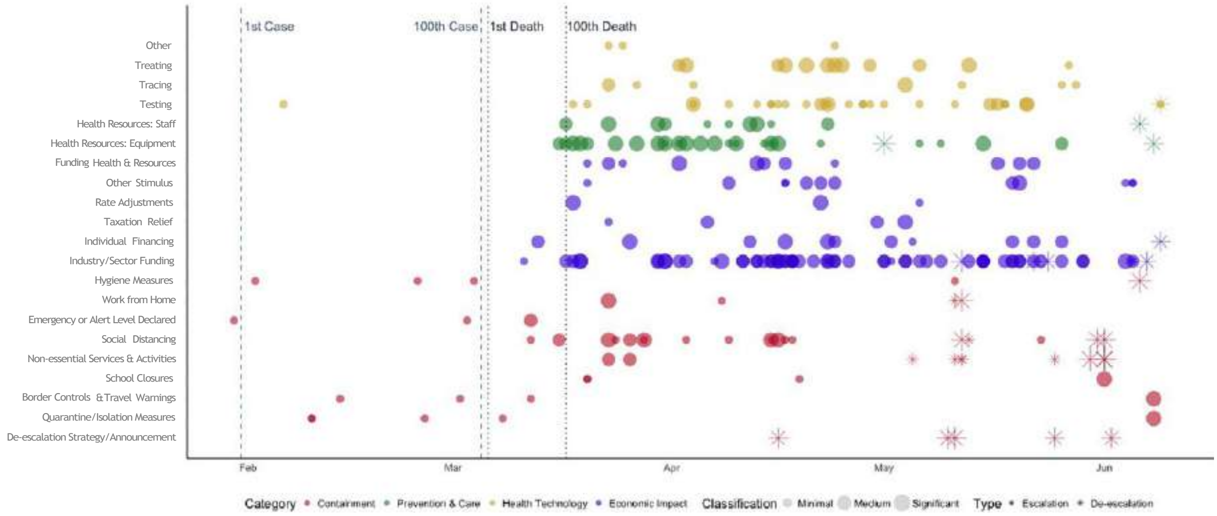
As for legislation, the central government introduced the Coronavirus Act 2020 (c.7) and the Public Health (Control of Disease) Act 1984 (c.22). Regulations for COVID-19 policies were enacted autonomously in the four regions of the United Kingdom (England, Wales, Scotland, and Northern Ireland).

3T policy

Observing the United Kingdom's response measures from the 3T (test-trace-treat) perspective, the government issued clinical guidelines and announced the development of diagnostic tests for the new disease on 22 January 2020 (GOV.UK, 2020a). However, despite the government's efforts, the testing rate eventually fell behind the transmission rate as the virus spread in earnest starting in mid-March. (*Guardian*, 2020a, 2020b). In early April, out of the 10,000 people getting tested daily, 4,000 were positive, indicating a high likelihood of further infections. The United Kingdom expanded its testing capacity such that the 35,000 daily tests available as of 16 April rose to more than 100,000 by late April.

Turning to contact tracing, the government used this during the initial stages but stopped when it implemented the "mitigation" phase on 12 March. Contact tracing was then resumed after the testing capacity was enhanced and Parliament affirmed its necessity. The United Kingdom launched the test, track and trace plan through the NHS contract-tracing app from 4 May, piloting it on the Isle of Wight. The government then introduced the NHS COVID-19 mobile app through which people could report symptoms, order tests, and check in to places using the QR code scanner, helping the NHS to track people at risk of infection. Instead of saving personal information or tracking the user's location, the app stored all records on the user's device so as not to infringe on privacy, according to the NHS. However, there was controversy as the Department of Health admitted to the app's breach of the EU's GDPR (General Data Protection Regulation) on 20 July 2020 (EURACTIV.com, 2020). As a result, the app was discontinued and a new one following Google and Apple's standards was launched. The new version was designed to detect nearby smartphones through Bluetooth, without using location data or sharing personal information.

Figure 32: Trend of COVID-19 responses by the United Kingdom Government (Q1~Q2 2020)



Source : Flynn et al. (2020)

In terms of treatment, the number of COVID-19 hospitalizations increased sharply from mid-March, reaching a peak between 7 and 12 April. The number of patients in critical care beds also rose rapidly during this period. For this reason, the United Kingdom's National Institute for Health and Care Excellence (NICE) distributed algorithms for the effective allocation of intensive care units.

Social distancing policy

Figure 32 shows the frequency and impact of United Kingdom Government policies from the outbreak of COVID-19 to June 2020. Its initial focus was on preventing and curtailing infections. After the 100th death, stricter measures were put in place for containment along with measures for economic stimulus and medical resource provision. The most significant restrictions were the closure of non-essential services on 16 March and the lockdown on 23 March (Flynn et al., 2020).

Vaccination strategy

In the United Kingdom, the Joint Committee on Vaccines and Immunisation (JCVI) makes recommendations on COVID-19 vaccines through expert and scientific analysis. The DHSC follows the recommendations to make policy decisions and support the budget, and the Medicines and Healthcare products Regulatory Agency (MHRA) supervises and takes responsibility for vaccine manufacturing and control, including the system for reporting side effects. Public Health England is in charge of the vaccination schedule, procurement, supply, and promotion, and the National Institute for Biological Standards and Control (NIBSC) is responsible for quality assessment and authorization (PHE, 2021). The DHSC planned to vaccinate priority groups, including elderly residents in care homes, health and social care workers, and those 70 years of age and older, by 15 February 2021. The next priority groups (people aged 50 and older, and people with underlying conditions) were scheduled to be vaccinated by the spring of 2021. The DHSC ultimately sought to offer vaccinations to the entire United Kingdom population with as few side effects as possible (DHSC, 2021).

The Oxford-AstraZeneca was designed at Oxford University and produced by the British-Swedish company AstraZeneca. The United Kingdom Government took the lead in procuring the finances for the vaccine, announcing its plan to devote GBP84 million to it in May 2020. According to Samuel (2021), public funding accounted for 97 per cent of

AstraZeneca's vaccine development, of which the United Kingdom Government was the largest contributor, providing GBP38.8 million. By March 2021, the government had signed up to receive 100 million doses from AstraZeneca, 60 million from Novavax, 60 million from Sanofi (France), 60 million from Valneva (France), 50 million from CureVac, 40 million from Pfizer, 30 million from Johnson & Johnson, and 17 million from Moderna. In addition, the government signed an additional contract for 60 million doses from Pfizer for its booster programme. This added up to 477 million doses secured by the United Kingdom, which is enough to cater for more than three times the country's population. As of 8 September, 48.32 million (71 per cent) of its people were vaccinated (Our world in data, 2021).

Economic countermeasures against COVID-19

The United Kingdom Government implemented various fiscal policies to lessen the economic shocks from the epidemic and the lockdown. They included tax relief for retail businesses and reductions in the VAT rate, loans for SMEs, paid sick leave, wage protection, and compensation policies.

Public approval of disease control policies

As for public approval, according to surveys conducted during the early phase of the pandemic in April 2020 and a later phase in November, people showed high levels of compliance with the restrictive policies. In April, when asked whether they had "socialized in person with friends or relatives who [they] don't live with", 86 per cent said no. About 87 per cent said they had not "traveled for leisure (e.g. driven somewhere to go for a walk)" (LSE BPP, 2020). In a survey of 1,037 Scottish adults conducted in November 2020, roughly half supported a national lockdown and agreed that there should be harsher consequences for rule-breaking. When asked whether they adhered to the rules, 95 per cent replied that they did so most of the time (Ipsos MORI, 2020).

On the other hand, protests against the government's policies broke out because of severe economic distress and psychological fatigue, which undermined trust in and motivation to follow government guidelines. People marched against mandatory measures and fines for not wearing masks on 19 July 2020 and again on 19 September, with anti-mask protesters arguing that the coronavirus was a conspiracy. Yet another protest occurred on 26 September 2020 over the closure of pubs and restaurants (BBC, 2020b).

Socio-economic impact of COVID-19 in the United Kingdom

The United Kingdom's economy was also hard-hit by the government's failure to respond promptly to COVID-19. In 2020, the GDP for Q1 fell 2.9 per cent compared to the previous quarter (Q4, 2019). The restrictions, including the national lockdown that started on 23 March, affected the decline in consumption, the service sector, and the construction sector. The GDP for Q2 then dropped 19 per cent from Q1, which was the biggest quarterly downturn since records began in 1955. But GDP increased by 16.1 per cent in Q3 due to the easing of lockdown measures. (Office for National Statistics, n.d.).

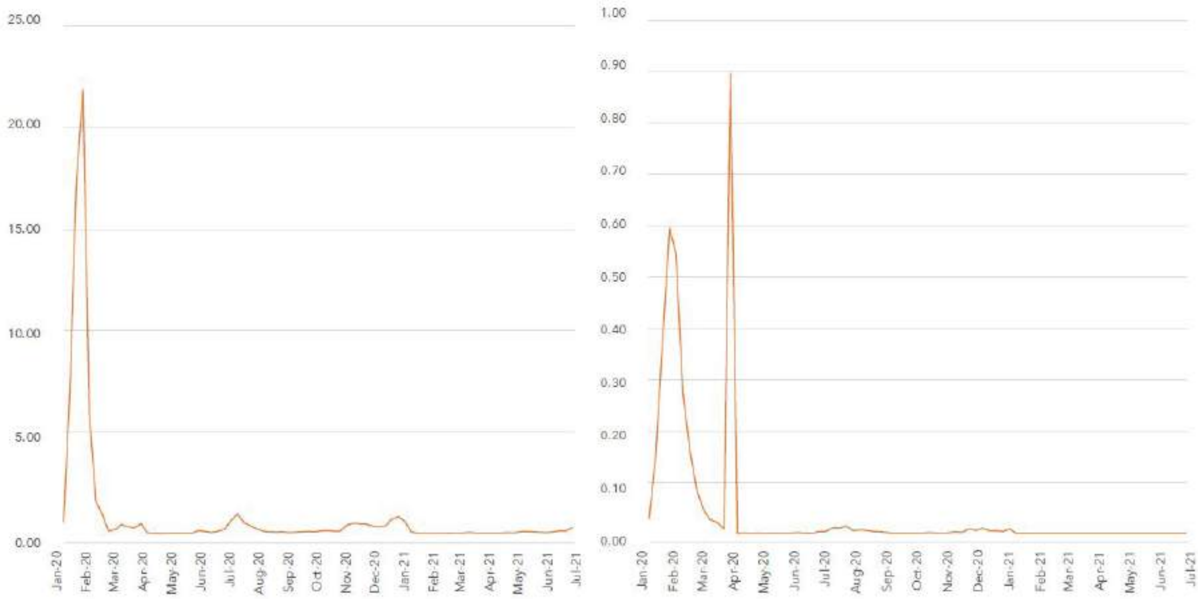
2.1.8 China's response strategy

COVID-19 situation and reaction of the government

Four cases of COVID-19 were detected in Wuhan, China on 29 December 2019 and the total number of patients had exceeded 100,000 by 31 January 2020. The number of cases continued to increase rapidly until early March of 2020, but fell from mid-March on (see Figure 33). The cumulative infection rate was 0.01 per cent on 31 July 2021.

In terms of the government response, on 21 January 2020, China classified COVID-19 as a Class B disease along with SARS and MERS but implemented response measures that matched Class A diseases, which are the strongest

Figure 33: Weekly COVID-19 cases (left) and deaths (right) in China (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

measures. Two days later on 23 January, the government imposed a lockdown on Wuhan, which was extended to eight regions near Wuhan on 24 January. On 26 January, the Leading Small Group on infectious diseases, headed by Premier Li Keqiang, decided to extend the Spring Festival holidays in key cities including Shanghai. On 7 February, a second range of lockdowns were imposed on 14 provinces, affecting 340 million people. As the infections subsided, a victory over the COVID-19 war was declared at the "Two Sessions" congress meeting in May. On 7 June 2020, the State Council Information Office released a white paper titled "Fighting COVID-19: China in Action". On 22 July, the emergency use of vaccines was adopted for clinical trials. On 8 September, President Xi Jinping declared the de facto end of the COVID-19 pandemic in China. However, new cases broke out in several regions within the country on 24 January 2021. Parts of Hebei were consequently put under lockdown. There continued to be sporadic clusters of infections and regional lockdowns in the first half of 2021 in Ruili, a city near the Myanmar border, and parts of the Guangdong Province. Authorities remained vigilant as the Delta variant, first identified at the Nanjing Lukou International Airport, spread nationwide.

COVID-19 governance

Strong control over disease prevention and social order are key components of the Chinese government's governance model in dealing with COVID-19. The central party has full authority and orchestrates the policies, distributing power to the lower governmental bodies. On 25 January 2020, General Secretary Xi Jinping established the COVID-19 Leading Small Group (LSG) under the Standing Committee of the Central Political Bureau of the Chinese Communist Party. The LSG, headed by Premier Li Keqiang, is committed to combatting the disease and gives orders on its prevention and control. Since the formation of the LSG, the headquarters for control policies switched from the National Health Commission to the State Council. The State Council dispatched training teams throughout China, becoming fully engaged in disease control and prevention in local areas, thereby facilitating training and supervision. It also adopted a top-down communication approach in addressing issues arising from the pandemic response.

The Chinese government classified COVID-19 as a Class A disease, laying the groundwork for various pieces of legislation. In a Class A disease outbreak, the following laws serve as the basis for the government to screen passengers, quarantine people likely to be infected, and in extreme cases, impose lockdowns on certain areas and/or close borders: Articles 39, 41, and 43 of the Prevention and Control of Infectious Diseases Law; Articles 6 and 12 of the Frontier Health and Quarantine Law; Article 7 of the Emergency Response Law; and Articles 4 and 38 of the Regulation on the Urgent Handling of Public Health Emergencies. The National Health Commission's first public notice of 2020 made it possible for Class A actions to be taken despite COVID-19 being categorized as a Class B disease.

3T policy

The Chinese government conducted screening, testing, and monitoring through epidemiological investigations as the key method to contain the spread of COVID-19 and provide timely treatment. The government's basic stance lies in providing "early detection, early reporting, early isolation and early treatment", and "testing all who need to be tested, hospitalizing all who need to be hospitalized, [and] isolating and treating all who need to be isolated and treated" (China Watch Institute et al., 2020).

The government sped up the test process by enhancing testing capacities, expanding the supply of test kits, and increasing the number of authorized testing facilities. This allowed for timely testing, and the daily testing capacity increased significantly from 300 in the early stages to over 50,000 by April. The government also conducted total inspections on the entire residential districts of confirmed cases.

China's epidemiological investigation team used big data technology and digital systems to trace close contacts. When the infection rate was at its highest, the government organized a team of 1,800 investigators to trace the transmission routes and close contacts of confirmed cases and introduced regional apps for effective route tracking. For example, residents of Beijing used the Beijing Health Kit app and residents of Wuhan used the Ehui Office app.

When lockdown measures were lifted, the citizens of Wuhan were required to install a "health code" on their smartphones, which acted as an e-pass required to enter and exit the region (see Figure 34). The app provides real-time information on the user's level of infection risk. The health status is shown in green, yellow, and red: green indicates good health, yellow indicates fever or close contact with a confirmed case, and red indicates that the user is a confirmed case. The status is displayed as a QR code and individuals may only leave their homes when their health code is green. First introduced in Hangzhou in the Zhejiang province on 11 February 2020, the health code system was commissioned by the local government and developed by Alibaba through its payment platform Alipay. It was eventually adopted nationwide as Alibaba's competitor Tencent also launched a similar app through WeChat (SCMP, 2020).

According to the Statistical Report on Internet Development in China released in September 2020, over 900 million Chinese citizens applied for the disease prevention code which was used over 40 billion times.

Telecommunication information is also used to track transmission routes. When the outbreak of COVID-19 began, the Ministry of Information Industry Technology built a national mobile data analysis platform. Based on this platform, mobile carriers (China Mobile, China Unicom and China Telecom) can provide the location tracking records of mobile users for the last 15 to 30 days.

Although personal details such as GPS and base station information are necessary to operate such digital tracking services, the Personal Data Security Regulation – the Chinese legislation for the protection of personal information – states that prior consent is unnecessary when the information is collected and used for public safety purposes. The Cyberspace Administration of China authorizes companies approved by the National Health Commission to collect relevant data without

Figure 34: Three health codes for Hangzhou citizens

Source : SCMP (2020)

consent in mechanisms to combat COVID-19 (Norton Rose Fulbright, 2021).

China struggled with the rapid increase of cases in the early stages of the pandemic and experienced high fatality rates. Having experienced the SARS outbreak in 2003, the Chinese government made large investments in public medical services, infrastructure, and hospitals, raising the level of healthcare resources in urban areas to the OECD level. Treatment was provided for free to prevent infected people from spreading the virus due to affordability issues. Patients were classified into four groups according to their symptoms to facilitate targeted responses. Initially, both mild and severe cases were treated in the same hospital, but mild cases were eventually moved elsewhere so that critical patients could be treated in designated hospitals with ExtraCorporeal Membrane Oxygenation (ECMO) and ventilators. In addition, exhibition halls and gymnasiums were turned into health facilities to make up for the shortage of hospital beds (Xu et al., 2020).

Social distancing policy

People were banned from leaving Wuhan – where the first cases were identified – until 8 April 2021 and a total inspection of the city's 4 million households was conducted by 80,000 government officials through visits, phone calls, and the Internet by Online Surveys. Through this process, confirmed or suspected cases were moved to hospitals or designated facilities to sever all possibilities of further infection. Lockdowns were imposed on areas with confirmed cases and the entire community had to undergo mandatory testing to avoid penalties.

Vaccination strategy

The Chinese government gave priority to high-risk groups, dividing the vaccination into two phases. Phase I consists of officials in high-risk areas, vessel and aircraft operators, and workers in fresh food markets, cold chain logistics, public transport, medical services, and the Chinese Center for Disease Control and Prevention (CCDC). Phase II consists of all other qualified people (Fuqiang Cui, 2021).

Chinese vaccines that were approved domestically include those from CanSino (which collaborated with the Institute of Biotechnology at the Chinese Academy of Military Medical Sciences), Sinopharm (a state enterprise with the Chinese government), and Sinovac. However, people's concerns over the efficacy and safety of domestic vaccines have hindered the targeted vaccination rates. As such, the Chinese government is adopting a carrot-and-stick approach, with some local governments giving out freebies[3] while some companies are mandated to have their employees vaccinated (DW, 2021b). The government has also been engaged in distributing its vaccines to neighbouring countries, Eastern Europe, and friendly developing nations.

According to Bloomberg's COVID-19 vaccine tracker, China has secured 300 million doses from non-domestic sources, in addition to its own, with 200 million from AstraZeneca and 100 million from Pfizer. However, the government has not disclosed material on the number of vaccines that they secured, making it difficult to validate these findings. China started vaccinations on 20 December 2020 and as of 5 May 2021, a total of 285 million doses were administered, which covers 10.2 per cent of its population. The Chinese government announced that the number of doses administered exceeded 1 billion in June.

Economic countermeasures against COVID-19

China introduced a huge stimulus package to move out of the economic depression caused by COVID-19. The package included measures to reduce the burdens on companies, give financial relief to SMEs, increase SOC (social overhead capital) investment, stimulate consumption, offer preferential employment for people in need, provide unemployment benefits, and boost domestic demand. The fiscal deficit rate was set at a record high (over 3.6 per cent) and a financial stimulus of 5.75 trillion yuan was introduced by issuing special treasury and local government bonds. The government also spent 2.5 trillion yuan in tax support and the reduction of corporate VAT, social insurance fees, electricity costs, and telecommunication fees.

Public approval of disease control policies

China relied on strong penalty regulations for their disease control and management, rather than voluntary engagement. A case in point is the notice released on 10 February 2020 entitled "Opinions on strict punishment of violations and crimes that hinder the prevention and control of COVID-19 in accordance with the law", stating that resistance against prevention measures, such as unauthorized withdrawal from quarantine and violence towards those executing official prevention duties, will be severely punished (National Health Commission of PRC, 2020).

Socio-economic impact of COVID-19 in China

China managed to control COVID-19 through its strong prevention policies, resulting in a GDP increase of 2.3 per cent compared to the previous year, making it almost the only major country to achieve economic growth in the year 2020. The GDP for Q1 of 2020 was approximately 20.6 trillion yuan, which was a 9.7 per cent fall from the previous quarter. However, the Chinese government carried out various reflation measures and financial policies to prevent an economic recession throughout the first two quarters, resulting in a V-shaped recovery as the GDP increased by 11.63 per cent in Q2, 3.0 per cent in Q3, and 2.6 per cent in Q4 (KOTRA, 2021b).

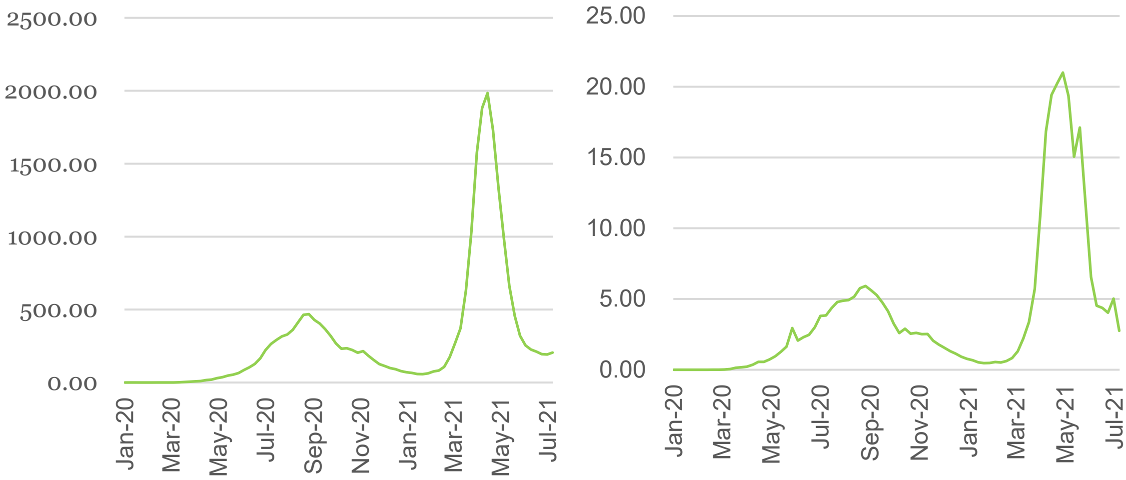
2.1.9 India's response strategy

COVID-19 situation and reaction of the government

The total number of confirmed cases in India reached over one million on 16 July 2020, six months after its first case on 30 January in the Thrissur district of Kerala (see Figure 35). The cumulative infection rate was 2.3 per cent as of 31 July 2021.

The main events related to the government's response are as follows. The government declared a national lockdown that same year

Figure 35: Weekly COVID-19 cases (left) and deaths (right) in India (Jan 2020~Jul 2021, per million people)



Source: Our world in data (2021)

from 25 March to 14 April. On 14 March, Prime Minister Modi extended the lockdown to 3 May and the Minister of Home Affairs announced the "National Directives" for COVID-19 management, including mandatory mask-wearing. Conditional easing of the lockdown was announced on 4 May. On 31 May, the lockdown was lifted and measures were taken to gradually remove the restrictions on economic activities. The total number of cases was 4.11 million by 7 September, making India the second most impacted country following the United States The rate gradually slowed and the number of daily confirmed cases had fallen to under 10,000 by 26 January 2021. However, cases soared once again between March and April.

COVID-19 governance

India is characterized as a centralized country despite its federalism, wherein the central government distributes its sovereignty to each state. Its COVID-19 response followed suit, with the central government establishing and sharing basic guidelines, and the state governments revising and carrying them out according to their interests.

The Ministry of Health and Family Welfare directed the COVID-19 response based on the Epidemic Diseases Act 1897. Article 2 of the Epidemic Diseases Act allows the central government to take necessary steps to prevent the spread of the epidemic. The government established various guidelines and standard operating procedures (SOPs), and introduced the "Epidemic Diseases (Amendment) Ordinance, 2020" on 22 April 2020 to punish acts of violence against doctors or healthcare personnel (Ministry of Home Affairs, 2020a).

Another important piece of legislation is the "National Disaster Management Law 2005". This is the legislation under which India declared COVID-19 as a national disaster early on and implemented a lockdown.

3T policy

Examining India's COVID-19 response strategy from a test, trace, and treat perspective, its government followed the Strategy of COVID-19 Testing designed on 9 March 2020 by the ICMR (Indian Council of Medical Research). In March 2020, when most cases were people who had been overseas, the ICMR limited testing to those with symptoms who had come into close contact with these travellers. But in September 2020, the ICMR announced a more proactive strategy that allowed anyone to be tested (ICMR, 2020a, 2020b).

Figure 36: India's Tracker App Aarogya Setu

Source : NPCI

For tracing, the government utilized the Aarogya Setu app, officially launched on 2 April 2020 (see Figure 36). Developed by the National Informatics Centre under the Ministry of Electronics and Information Technology, the app was downloaded 200 million times as of 17 August 2021. Users can self-evaluate their risk of COVID-19 and measure their interaction with others using Bluetooth technology, algorithms, and AI. The app detects nearby devices that also have the app and calculates the infection risk when the device belongs to someone with COVID-19. Aarogya Setu also records the user's location every 15 minutes through the GPS that is connected to the mobile device. The Indian Government claims that privacy protection is taken into account by encrypting the personal data collected through the app and storing it within the device until it should become necessary for medical purposes (Ministry of Electronics & IT, 2020).

However, the absence of a data protection act is deemed as a potential risk factor (Hindu, 2020). Meanwhile, although users were initially free to choose whether they wanted to install the app, its installation became mandatory for government officials (29 April) and private company employees (1 May), and this requirement is being extended to include people entering crowded areas. Failure to comply could result in fines or imprisonment (Human Rights Watch, 2020). The tracing activity is being boosted through such compulsory installation but the low penetration rate of smartphones within India is curbing the effectiveness of digital tracing. Only 35 per cent of Indians own a smart device and even if they all downloaded the app, tracing would still not be available for the remaining 800 million (CNN, 2020). Moreover, the number of downloads, at 200 million, is less than half the number of smartphone users, making it a mere 14 per cent of the entire population. State governments are also creating their own apps to respond to COVID-19 by providing key information and support for epidemiological surveys. The Delhi Corona App produced by the state of Delhi provides the number of available beds and hospitals, infection updates, and necessary information for dealing with COVID-19. The state government of West Bengal developed the Sandhane mobile app to support the work of epidemiological investigators in rural areas. Investigators submit data to the app about people with fevers or other related symptoms when making house visits, which serves as the basis for the state government to take additional action.

For treatment, India's weak medical infrastructure seems to add to the difficulty of responding to COVID-19. According to OECD statistics, the number of hospital beds per 1,000 people in India was 0.5 in 2017, which was the lowest of all surveyed countries, and the number of doctors per 1,000 people was also a mere 0.8. There was a near-collapse of the medical infrastructure in Mumbai in May 2020 (Indian Express, 2020b).

Social distancing policy

The Indian Government responded to COVID-19 through pre-emptive control measures such as a lockdown between March and May 2020. However, the government retreated from its control policies and concentrated on economic recovery as it lifted the lockdown in June 2020 (BBC, 2020c).

Vaccination strategy

The response strategy has been is to encourage the R&D, manufacturing, and efficient administration of vaccines within India, so that vulnerable groups may be protected by the national medical system. India's vaccination strategy is divided into three phases with first priority at Phase I being given to medical professionals and frontline workers (16 Jan 2021). Phase II started in March 2021 and is concentrated on protecting people over the age of 45, who make up more than 80 per cent of COVID-19 deaths. Finally, Phase III expands vaccination to include everyone, with liberalized pricing to incentivize manufacturers to increase production and to attract further vaccine developers (Ministry of Health and Family Welfare, 2021).

The Indian Government has spared no effort in enhancing vaccine development capacity. It convened regular meetings with vaccine manufacturers to conduct public-private research and tests. The government also boosted the production capacity by dispatching its officials to vaccine development sites to identify bottlenecks and provide customized support. India is the biggest producer of AstraZeneca vaccines and it also developed its own COVID-19 vaccines through Bharat Biotech, in collaboration with the ICMR and the National Institute of Virology (NIV).

India resorted to innovative ICT solutions such as eVIN (Electronic Vaccine Intelligence Network) and CoWIN (Covid Vaccine Intelligence Work) for their COVID-19 vaccine distribution and management. eVIN is implemented under the National Health Mission and Ministry of Health and Family Welfare, with the UNDP assisting in its design and deployment. The goal is to offer real-time information on vaccine stocks, flows, and storage temperatures for all the cold chain points in India. The system was used to guarantee the continuity of key immunization services and to protect children and pregnant women from preventable diseases. By combining state-of-the-art technology, IT infrastructure, and trained human resources, eVIN has allowed for stock monitoring across all 36 states and union territories of India, in 29,000 public health facilities (Government of India, 2020d; UNDP, 2021; Times of India, 2021). Over 50,000 cold-chain handlers were trained in digital record-keeping, and 23,900 electronic loggers automatically track the storage temperature. eVIN contributed to the generation of a big-data architecture that promotes data-based decision-making and consumption-based planning, which in turn reduces costs through optimum stock management. The vaccine availability in most health centres has increased to 99 per cent, reflecting the high adoption rate of the technology in regions where eVIN operates. Stockouts have been reduced by 80 per cent with the time taken to restock reduced by more than half.

The government's other IT solution is a cloud-based tool called CoWIN, for the planning, implementation, monitoring, and evaluation of COVID-19 vaccination across the country with technical support from UNDP. It is the mainstay of all data and information related to managing COVID-19 vaccine delivery in India.

CoWIN allows for the individualized registration of beneficiaries, booking of appointments, provision of immunization certificates, and communication with beneficiaries. Users may also link their vaccine certificate with their passport (India. Com, 2021; Mint, 2021).

Together, eVIN and CoWIN interface at last-mile immunization sites and provide an end-to-end solution for managing the vaccine supply chain and tracking consumption, wastage and coverage across the country. The system design allows for a large database across two platforms that can share with one another.

India has signed deals for the largest number of COVID-19 vaccines at 2.2 billion doses, with 1 billion from AstraZeneca, 1 billion from Novavax, and 950 million from Gamaleya (Russia), making a total of 3 billion doses, which exceeds the dosage required for its entire population. As of 8 September 2021, 543.46 million people were vaccinated in India, 39 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

The Indian Government implemented fiscal policies to minimize the economic shock from COVID-19, most of which were carried out in the first half of 2020. For the first set of support packages announced on 26 March 2020, the government set aside 1.7 trillion rupees (approximately USD23 billion), 0.8 per cent of the GDP, for food assistance, tax deferrals, and loan repayment extensions for low-income and vulnerable social groups, as well as an exemption from import tariffs for medical supplies. The second support package worth 20 trillion rupees was announced less than two months later on 12 May and mostly included measures for SMEs, including signature loans, lower pension payment rates, and tax deductions. The government also increased its health and welfare budget for 2021 by 137 per cent compared to the previous year, investing 350 billion rupees into the development of COVID-19 vaccines.

Aadhaar, India's digital ID system, contributed to the swift and efficient delivery of fiscal policies. National ID systems are unnecessary in developed countries as there exist many personal identification methods such as driver's licences, credit cards, and social security numbers. However, these methods are not readily available in developing countries and one trillion people worldwide lack a formal proof of identity, with more than 80 per cent them in sub-Saharan or underdeveloped Asian regions. In India, higher-income people are identifiable through passports and tax ID numbers but lower-income people do not have these, marginalizing them from access to core government services. Aadhaar grants everyone a digital ID through a 12-digit number as well as various biometrics such as facial images, fingerprints and demographic characteristics. Roughly 98 per cent of all qualified people are currently registered on the Aadhaar database. In response to COVID-19, Aadhaar was used to digitally remit USD1.5 billion in subsidies efficiently and cheaply to approximately 300 million bank accounts. It was also used to identify any fraudulent claims from patients, doctors, or hospitals, thereby mitigating the rise in pandemic-related expenses.

Moreover, Aadhaar is also used for the management and certification of the COVID-19 vaccination process and is being reviewed to incorporate facial recognition technologies (Economist, 2020; ITU, 2020a; FT, 2020). However, the requirement of a digital ID to access public services excludes from welfare distribution the millions of people who do not own a digital device; furthermore, the vast range of personal information collected through Aadhaar is raising concerns over data privacy (Reuters, 2020b).

Public approval of disease control policies

As for public engagement, there were somewhat strong levels of resistance against the government's stringent control policies, a substantial part of which is due to structural issues. First, many people lost their jobs and had a hard time maintaining their livelihoods because of the lockdown measures, which undermined the public's approval of the government's policies (Reuters, 2020c). The Diwali Festival, one of the biggest events in the national calendar, exacerbated the mass outbreak in winter (*Christian Science Monitor*, 2020).

Socio-economic impact of COVID-19 in India

The GDP growth rate for Q1 of 2020 was 3.0 per cent, a slight decrease from its previous quarter (3.3 per cent). Owing to the lockdown, the growth rate for Q2 was a record low -24.4 per cent. The rate picked up for Q3 as the lockdown was eased at -7.4 per cent and recovered to a positive growth in Q4 at 0.5 per cent (Ministry of Statistics and Programme Implementation, 2021).

2.1.10 Japan's response strategy

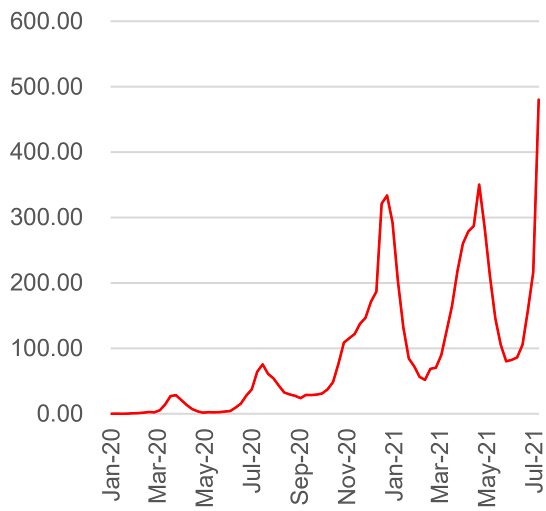
COVID-19 situation and reaction of the government

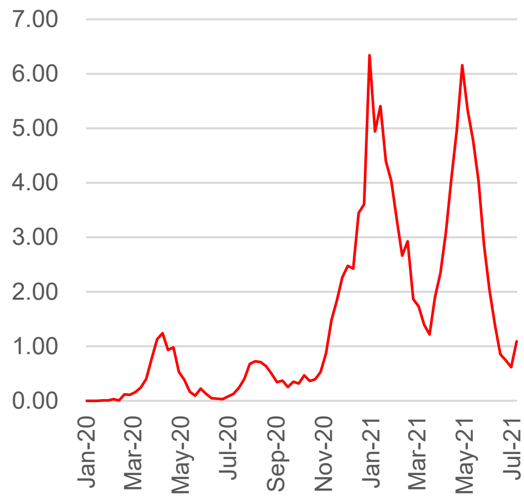
Japan's first COVID-19 infection occurred on 16 January 2020 in the Kanagawa Prefecture and the number of confirmed cases had reached 100,000 by 30 October. As of 31 January 2021, the total number was 235,811. The first mass outbreak was in March and April 2020 with approximately 700 cases every day, and the second outbreak in July and August saw the daily number peaking at 1,600. From November on, the number skyrocketed to reach almost 8,000 new cases daily. Cases decreased temporarily thereafter but in July 2021, the number soared once again mainly in the capital area during the Olympic Games in Tokyo (see Figure 37). The cumulative infection rate was 0.7 per cent as of 31 July 2021.

The government's response to the spread of COVID-19 has been as follows. On 25 February, it announced Basic Policies to respond against the new coronavirus. On 26 March, Prime Minister Abe established a response headquarters in accordance with the Special Measures Act on New Influenza (hereafter referred to as the Special Measures Act). On 7 April, he announced a one-month emergency for seven regions, namely the Greater Tokyo area, Kanagawa, Saitama, Chiba, Osaka, Hyogo, and Fukuoka, under the same Act. Nine days later, the government declared an extension of the emergency nationwide until 6 May.

The government followed with the "Go to Travel" campaign on 22 July. On 28 August, it announced new policies to secure a medical provision system, enhancing capacities to 200,000 daily tests, and procuring vaccines for

Figure 37: Weekly COVID-19 cases (left) and deaths (right) in Japan (Jan 2020~Jul 2021, per million people)





all Japanese people by the first half of 2021. The government decided to suspend the Go to Travel campaign in December, owing to the spread of the disease. The country's new leader, Prime Minister Suga, declared a state of emergency on 7 January 2021 in one province and three prefectures in the Greater Tokyo area until 7 February. On 13 January, he extended the period of emergency and the regions that it covered. On 3 February, revision bills for laws including the Special Measures Act were passed at the House of Councillors' general session.

COVID-19 vaccines were first authorized on 14 February and administered from 17 February. In April, cases surged and the number of cumulative deaths reached over 10,000. In May, the state of emergency was withdrawn in intervals by region as cases dropped. A state of emergency was declared again in the Greater Tokyo area on 17 July, as cases surged again.

COVID-19 governance

According to Article 15, Clause 1 of the Special Measures Act, the government decided to establish a Novel Coronavirus Response Headquarters on 30 January 2020, and it was officially introduced on 26 March.

The headquarters is directed by the Prime Minister, with ministers such as the Chief Cabinet Secretary of Japan and the Minister of Health, Labor and Welfare as deputy directors. They oversee the administrative affairs related to the Special Measures Act, which is carried out by local governments and public agencies and institutions. The director of the headquarters may also declare a state of emergency when there are profound risks to people's lives, health, and livelihoods, and the national economy. Action plans, guidelines for personnel, early response recommendations, and business advice for related departments were announced by the Novel Coronavirus Response Headquarters.

3T policy

Japan was relatively passive in its 3T strategy during the early phase of the pandemic. Its preventive policies were more focused on cluster management, which refers to the identification of infection sources and transmission groups based on individual cases while limiting the action of close contacts. PCR (polymerase chain reaction) tests were conducted for a limited number of people with respiratory symptoms, fevers exceeding 37.5 °C, and oxygen saturation levels under 93 per cent (Japanese Society for Infection Prevention and Control, 2020). The Ministry of Health, Labor and Welfare altered the standards in May 2020 to include close contacts of infected people, asymptomatic people with doctors' orders, and people with similar illnesses difficult to discern such as influenza (National Institute of Infectious Diseases, 2021).

Japan depended entirely on its workforce to carry out epidemiological investigations on confirmed cases in the early days of the pandemic but introduced an app called COCOA (COVID-19 Contact-Confirming Application) in June 2020 for digital contact tracing. The app uses Bluetooth signals to automatically save contact records in users' smartphones when they are within one metre of each other for more than 15 minutes. However, there are controversies over the COCOA app. To begin with, at least 60 per cent of the population needs to use contact tracing apps for it to contribute to controlling regional infection, whereas the number of downloads for COCOA was only 25.18 million as of 12 February 2021 – barely 20 per cent of the population. Moreover, its Android version had not been functioning properly since September 2020 (Nikkei, 2020).

In terms of treatment, Japan had favourable conditions for preparedness, with the highest number of hospital beds per population among all OECD countries as well as high medical standards. Nonetheless, the soaring number of intensive-care patients in the early stages of the pandemic led to concern that the medical system could collapse. The system got back on track as cases subsided, but hospital beds were still lacking in the third wave of mass outbreaks in November 2020. In February 2021, the Diet, Japan's legislature, revised the Infectious Disease Act to secure hospital beds for COVID-19 patients and advise doctors to accept patients, introducing measures to disclose the names of hospitals denying care to patients without proper reason.

Vaccination strategy

The Japanese public's confidence in vaccines is low because of scandals in the 1970s and 80s related to the MMR shot and other vaccinations. The government has therefore been extremely cautious in its authorization of vaccines (CNN, 2021). The public sentiment is not much different towards the COVID-19 jab, with only 18 per cent of respondents wanting to be vaccinated according to a February 2021 survey by the newspaper Yomiuri Shimbun. As such, the government has adopted a conservative approach, taking more than two months to review Pfizer's vaccine before approving it in February 2021. Those of Moderna and AstraZeneca were then approved on 21 May 2021. Seeking to reassure the public, the government has shared data on side effects and ensured that safety assessments are carried out even after authorization. The priority groups for vaccination are also limited to health care professionals, people 65 years of age and older, and workers at elderly care facilities. As of March 2021, Japan has secured a total of 314 million doses, with 144 million from Pfizer, 120 million from AstraZeneca, and 50 million from Moderna. This is equivalent to the dosage for 163.3 million people, which is 129.4 per cent of the entire population in Japan. As of 8 September, 77.75 million people were vaccinated in Japan, 62 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

According to a report by the Cabinet Office (2020), the Japanese government is adopting fiscal measures to sustain the economy while controlling the coronavirus. The Cabinet Office mentions that suppressing economic activity may reduce fatalities but also result in insurmountable economic losses worldwide, Japan being no exception. This led to eased restrictions to revitalize the economy, as seen in the Go to Travel campaign that started in June 2020.

Socio-economic impact of COVID-19 in Japan

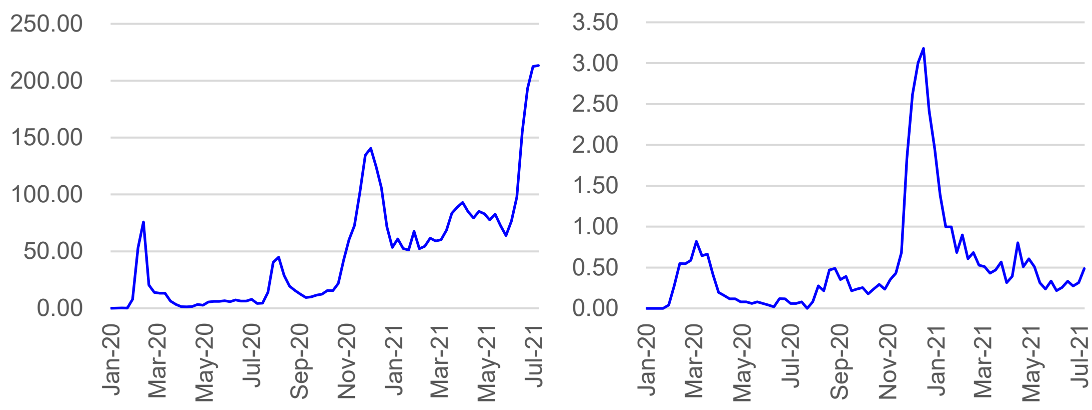
The Japanese economy was greatly affected by COVID-19. The GDP for Q1 of 2020 fell 0.9 per cent compared to the previous quarter, owing to drops in exports, consumption, and equipment investment from February as COVID-19 cases increased (Nikkei, 2020b). In Q2 of 2020, the GDP fell 7.8 per cent from its previous quarter – a bigger fall than during the 2008 financial crisis. One of the main causes was the sudden decrease in domestic consumption, which accounts for over half of Japan's economy (Nikkei, 2020c). In Q3, the GDP increased by 5 per cent compared to the previous quarter, because of the state of emergency being lifted and personal consumption escalating due to increased outdoor activities and the government's policy support. Exports also increased as overseas markets recovered (Bloomberg Japan, 2020). In Q4 of 2020, Japan's GDP fell by 1.6 per cent quarterly and 6.3 per cent annually (Cabinet Office, 2020).

2.1.11 Republic of Korea's response strategy

COVID-19 situation and reaction of the government

By late February 2021, there were approximately 80,000 confirmed cases in Republic of Korea. Its first case was detected on 20 January 2020. February 2020 saw a mass infection following outbreaks at places of worship, call centres, and nursing homes. The number of daily confirmed cases skyrocketed to over 200, most of them occurring in Daegu and the North Gyeongsang Province. The number then fell in April 2020 due to mask distribution

Figure 38: Weekly COVID-19 cases (left) and deaths (right) in Republic of Korea (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

policies and strong social distancing measures, and the curve remained flattened for about six months (see Figure 38).

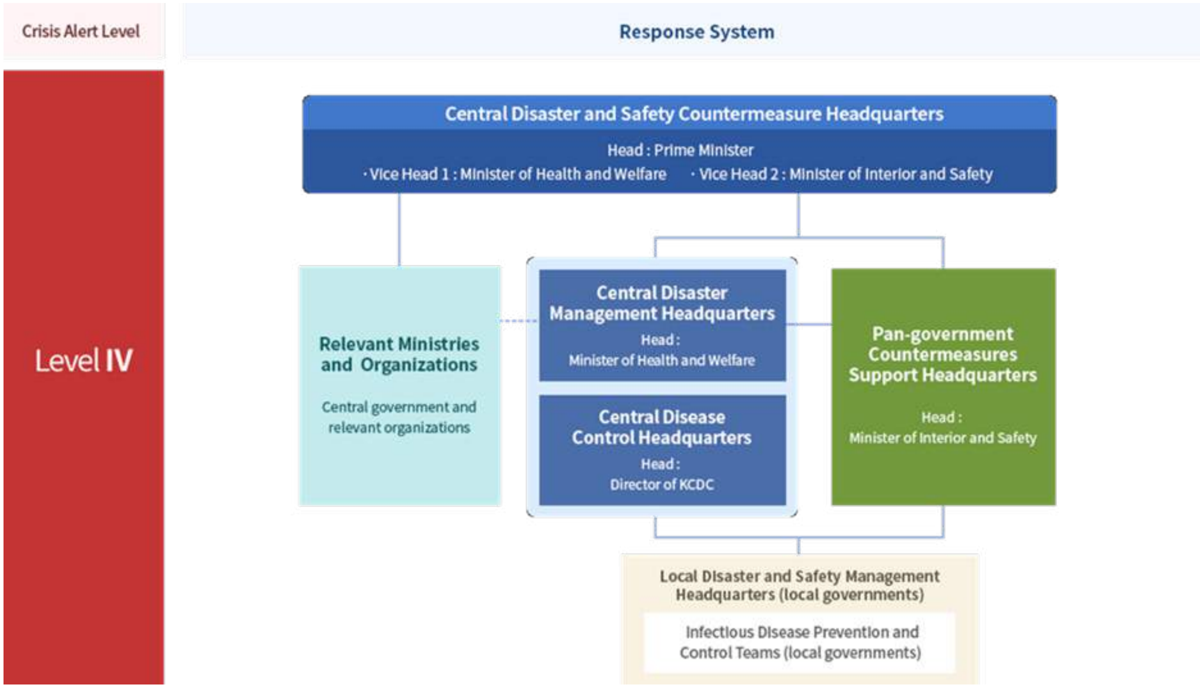
However, community infections continued to expand, stemming from transmissions within small clusters, and the second mass infection took place in August 2020 in the densely populated metropolis. Although cases subsided within a month due to swift measures by the government, Republic of Korea went through a third wave in November owing to infections in the capital area being spread through indoor sports and daily activities between family and friends. Consequently, the government raised the level of restrictions from 6 December, mandating a 9 p.m. curfew for cinemas, shopping malls, and restaurants, and banning gatherings of more than five people in the capital from 22 December. Although the number of daily cases gradually fell to 300, it started soaring once again to over 1,000 in July 2021 due to outbreaks in Seoul. Vaccinations began in February 2021, and the cumulative infection rate was 0.4 per cent as of 31 July 2021.

COVID-19 governance

Republic of Korea based its legislation and governance on the lessons learned from epidemics including SARS and MERS. The Infectious Disease Control and Prevention Act was revised following the MERS (Middle East Respiratory Syndrome) outbreak in May and June 2015, during which Republic of Korea had the second largest number of confirmed cases (182) and deaths (33). The MERS experience revealed the limitations of Republic of Korea's disease response system, including the absence of a control tower, lack of information disclosure, and no way of preventing mass infections in large hospitals. The Infectious Disease Control and Prevention Act was thereby amended to strengthen epidemiological surveys and facilitate information-sharing between the central and local governments and people. This included legal regulations that would become the basis for using data in contact tracing systems.

The Korea Centers for Disease Control and Prevention (KCDC) was launched in 2004 following the SARS outbreak in 2003, to reinforce the country's capacity to respond to new infections, through the reorganization of the Korea National Institute of Health. Revisions to the National Prevention and Control System were made on 1 September 2015 to address criticism on the government's failures in dealing with the MERS outbreak, including a lack of guidance from experts and delays in information disclosure. The KCDC was tasked with overseeing national quarantine measures, with support from the Office for Government Policy Coordination, the Ministry of Health and Welfare, and the Ministry of Public Safety and Security. During the initial stages of COVID-19, the KCDC successfully directed Republic of

Figure 39: Republic of Korea Government's response system to COVID-19



Source : Central Disaster Management Headquarters (2020)

Korea's early response through its Central Disease Control Headquarters. In September 2020, the KCDC became the Korea Disease Control and Prevention Agency (KDCA) and was granted more autonomy in its organization, personnel, budget operations and cooperation with local governments. The National Institute of Infectious Diseases was also established as an affiliated organization to promote the commercialization of vaccines and treatment (Health Chosun, 2020).

Republic of Korea's COVID-19 response system is based on the Framework Act on the Management of Disasters and Safety, and the Basic Guidelines for National Crisis Management, along with the aforementioned Infectious Disease Control and Prevention Act that was revised after MERS. The Minister of Health and Welfare follows these laws when issuing alerts from levels 1 to 4 and stipulating the relevant response framework.

Depending on the level of alert, the Central Disease Control Headquarters, Central Disaster Management Headquarters and Central Disaster and Safety Countermeasure Headquarters may be directed to work organically with all central and local government agencies under the Office of the President.

The Central Disease Control Headquarters (headed by the director of the KDCA) is the "control tower", providing measures and actions, monitoring, and briefing (see Figure 39). The Central Disaster and Safety Countermeasure Headquarters (headed by the Prime Minister) oversees the pan-governmental response, reinforcing the support system between the central and local governments. The Central Disaster Management Headquarters (headed by the Minister of Health and Welfare) supervises community disease control and bolsters the disinfection efforts of the Central Disease Control Headquarters. The Pan-Governmental Support Headquarters (headed by the Minister of the Interior and Safety) assists in necessary areas including temporary residential facilities and cooperation between central and local governments.

The head of each local government manages their own Local Disaster and Safety Countermeasure Headquarters to secure hospitals dedicated to infectious diseases, and to support resources including beds, personnel, and supplies (Central Disaster Management Headquarters, 2020).

3T policy

Republic of Korea's control policy is based on the 3T strategy (testing-tracing-treatment), which seeks to detect confirmed cases promptly through rapid mass testing and tracing for prevention and treatment. Testing refers to the diagnostic techniques and screening station system. Accurate and quick diagnosis of COVID-19 was available through the early development of the RT-PCR test, expansion of the daily testing capacity to 40,000, drive-through screening, and anonymous testing. Meanwhile, Republic of Korea's health authorities introduced a Self-Quarantine Safety Protection App to support the monitoring of close contacts and arrivals from overseas during their mandatory 14 days of self-isolation. The app allows users to report their health status twice a day and check the health regulations, while also alerting the authorities in case of a quarantine violation. Those who are exempt from self-isolation are required to download the "Mobile Self-Diagnosis App" and submit their daily health information, which is automatically sent to the authorities for monitoring purposes.

Tracing (epidemiology/tracking) was facilitated through mobile applications for self-testing and quarantine management, electronic medical records, and the Epidemic Investigation Support System (EISS). The EISS supports automated tracing of confirmed cases by compiling information from GPS, base stations, credit and debit card transaction records, cash receipts, medical and prescription records, public transportation, taxis, QR code entry logs, and CCTVs. The time for epidemiological investigation was reduced from over 24 hours to less than 10 minutes, by automating the manual process of storing and using information from related organizations. The information is only viewed and analysed by epidemiological investigators and the system will only be maintained during the COVID-19 pandemic to prevent privacy infringement.

The third key to disease control is fast treatment following diagnosis. The Republic of Korean Government introduced residential treatment centres on 2 March 2020 for patients with mild symptoms, so that severe cases could be readily hospitalized. As outbreaks became concentrated in specific areas, the accommodation of patients was harmonized between regions according to the availability of hospital beds. Moreover, big data from the National Health Insurance was used to inform medical workers of underlying conditions so that they could triage patients, which relieved the pressure on the system and lowered the fatality rates.

Social distancing policy

In addition to the 3Ts, Republic of Korea responded to COVID-19 through policies such as travel advisories, special entry procedures, and the designation of countries subject to strengthened quarantine to stem the inflow of the disease. Control measures have also included delayed school openings, online classes, and stabilization of supplies of hand sanitizer and masks, for example through a five-day rotation system for mask distribution where people were permitted to buy masks on certain days based on their birth year.

Vaccination Strategy

Republic of Korea was not in haste to procure or administer vaccines until the second half of 2020, based on its relatively favourable containment situation. Plans to secure vaccines for 30 million people (60 per cent of the population) were first announced in September 2020, a third of it to be secured from the COVAX Facility. However, the government took on a more aggressive approach in late 2020 as the results for Phase III of the clinical trials for Pfizer, Moderna, and AstraZeneca were all positive and the number of domestic cases began to surge. Through a press release on 24 April 2021, the Republic of Korea Government disclosed plans to secure vaccines for 99 million people in 2021 – a three-fold increase from its September 2020 goal. Meanwhile, as of April 2021, five domestic companies were going through clinical trials with plans to enter Phase III by the second half of 2021. The Republic of Korea Government supported the expenses for these trials by committing a budget of 49 billion won (USD 40 million) in 2020 and 68.7 billion won (USD 57 million)in 2021.

Vaccinations began in February 2021 with priority given to high-risk groups, such as patients in elderly care facilities and healthcare professionals and workers on the front lines of disease prevention and treatment. As of March, 590,000 vaccines were administered and a total of 11.5 million people are set to be vaccinated in Q2 of 2021, including residents and workers in risk-prone facilities, those 65 years of age and older, and workers in schools and care homes. The government planned to achieve herd immunity by November 2021 through additional vaccinations in Q3 and Q4. As of 8 September, 31.71 million people had been vaccinated in Republic of Korea, 62 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

Measures to deal with financial and economic impacts as well as control policies are decided at the Emergency Economic Council meetings and an unprecedented supplementary budget was drawn up for damage relief, financial and employment stability, and economic resilience. The first budget amounted to 11.7 trillion won(USD 9.7 billion), 12.2 trillion won(USD 10.1 billion), 35.1 trillion won(USD 29.1 billion), 277 trillion won(USD 230 billion). A fourth budget worth 7.8 trillion won was announced in September to respond to the resurgence. The government's emergency support policy includes direct payments to individuals and families, employment support, public welfare support (insurance and utility bill deduction), special disaster relief funds, and industrial support (deregulation).

Public approval of disease control policies

Republic of Korea citizens' approval of using personal information to release information on transmission routes of confirmed cases and carry out control measures is relatively high. According to a February 2020 survey by Realmeter on disclosing case information, 40.6 per cent approved the scope of the data being disclosed and 49.2 per cent responded that more data should be disclosed (Realmeter, 2020). In a survey conducted by the Presidential Committee on the 4th Industrial Revolution in April 2020, 90.3 per cent of those polled answered that the analysis and disclosure of personal information of confirmed cases were appropriate (YNA, 2020).

Characteristics of Republic of Korea's responses to COVID-19

Firstly, Republic of Korea has a leading ICT infrastructure (e.g., high-speed and mobile Internet, smartphone distribution rate) and its people and businesses boast of a high ICT literacy level. Secondly, there was a revision of the legal system and a social consensus to allow the use of private personal information (e.g., mobile phone locations, credit card transactions) for disease control purposes, following the MERS outbreak in 2015. At the time of writing, public support remains high for disclosing routes of confirmed cases and using personal data for the disease response. Lastly, Republic of Korea owns a collaborative public-private system wherein the government proactively discloses public data which is used by the private sector to develop the necessary apps.

As a whole, Republic of Korea's response to COVID-19 is deemed as a global success case, having minimized socio-economic ramifications without resorting to strict lockdown measures. Control measures were able to be maintained at low levels to lessen the economic impact. Republic of Korea scored 39.6 on the IMF's Stringency Index on COVID-19 containment measures, which was lower than the global average of 41.2, showing that it could prevent economic shocks to a greater extent than other countries.

An OECD report entitled Inclusive growth review of Republic of Korea: Creating opportunities for all (2021) gives a positive evaluation of this response, pointing out that Republic of Korea's use of innovative digital solutions enabled it to control the pandemic at an early stage without lockdowns and that Republic of Korea experienced the least economic damage of all OECD countries.

Socio-economic impact of COVID-19 in Republic of Korea

Among the IMF's estimate of 2020 growth rates for 11 advanced economies, Republic of Korea's stands at -1.1 per cent, demonstrating the lowest economic impact from COVID-19. The country's growth forecast for 2021 is 3.1 per cent, suggesting expectations of a swift recovery to pre-COVID levels for the real economy (Republic of Korea policy briefing, 2021b).

2.1.12 Malaysia's response strategy

COVID-19 situation and reaction of the government

Malaysia first experienced an outbreak of COVID-19 on 24 January 2020, when 22 cases were confirmed. The number of cases increased slowly until Q3 of the same year, only to soar in Q4, gradually falling once again in early 2021. However, the number of cases rose again from April 2021, reaching over 10,000 daily infections in July (see Figure 40). The cumulative infection rate was 3.4 per cent as of 31 July 2021.

The key events related to the government's response are as follows. The number of cases increased in February owing to the Tablighi Jamaat event in Kuala Lumpur. On 16 March, Prime Minister Yassin proclaimed the Movement Control Order (MCO) and the first COVID-19-related death occurred the following day on 17 March. A second MCO was enforced for two weeks on 1 April. The MCO was eased on 1 May and most businesses were reopened. A Recovery MCO was implemented on 10 June. There were no new domestic cases between 1 and 8 July but a third mass infection broke out on 1 October following the elections in Sabah. On 8 November, the Malaysian Government announced an expansive version of the MCO, and on 3 February 2021 extended the lockdown for two weeks. Vaccinations began on 24 February. The government eased travel restrictions on 5 March but reintroduced a nationwide lockdown on 12 May as the number of cases and deaths surged again. Nonetheless, cases increased rapidly in July 2021 due to the Delta variant.

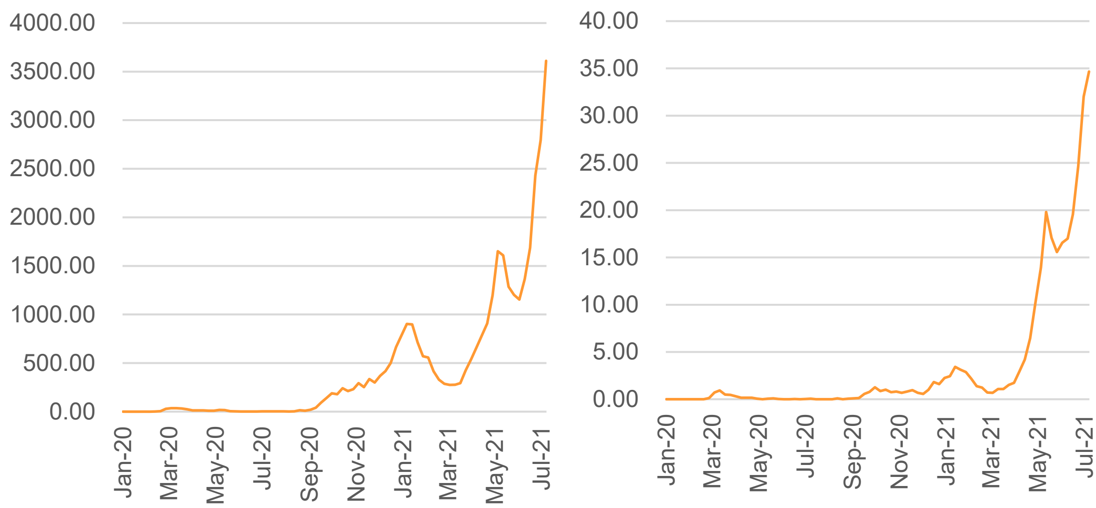
COVID-19 governance

The COVID-19 governance is controlled by the National Security Council (NSC). The Malaysian Government designated COVID-19 as a threat to national security and deployed the NSC according to the National Security Council Act 2016 (Act 776). The NSC orchestrated and mobilized both governmental and non-governmental bodies to control the pandemic at a national level. The Ministry of Health (MOH) offered technical advice and recommendations to facilitate the NSC's decision-making process (Ministry of Health Malaysia, 2020).

The MOH operates the COVID-19 situation room, prepares press updates, administrates testing and quarantine, examines symptoms, enhances the capacity of labs and hospitals conducting tests, and raises public awareness through social networks (e.g. WhatsApp) and print media. The Crisis Preparedness and Response Center (CPRC) utilizes the MOH's support system to prepare, organize, and deploy human resources and medical response measures in relevant regions.

Malaysia's key pieces of legislation for COVID-19 are as follows. First, the Prevention and Control of Infectious Diseases Act 1988, Act 342, authorizes control measures to be taken as designated by the Minister of Health, placing suspected confirmed cases and close contacts into quarantine or monitoring them.

Figure 40: Weekly COVID-19 cases (left) and deaths (right) in Malysia (Jan 2020~Jul 2021, per million people)



Source : adapted from Our world in data (2021)

They may also ask medical personnel to report confirmed cases to the health authorities. The Act also allows the MoH to exert authority over the regions in the case of a pandemic. It even permits the confiscation and destruction of commodities, animals, and buildings if this is needed, to contain the spread of an infectious disease. In addition, the Act gives authority to the Minister of Health to legislate regulations for pandemic response purposes. The Regulation of Measures within Infected Local Areas 2020 was enacted accordingly, to enable the Minister to not only ban activities but also implement movement restrictions and control gatherings and processions in infected areas.

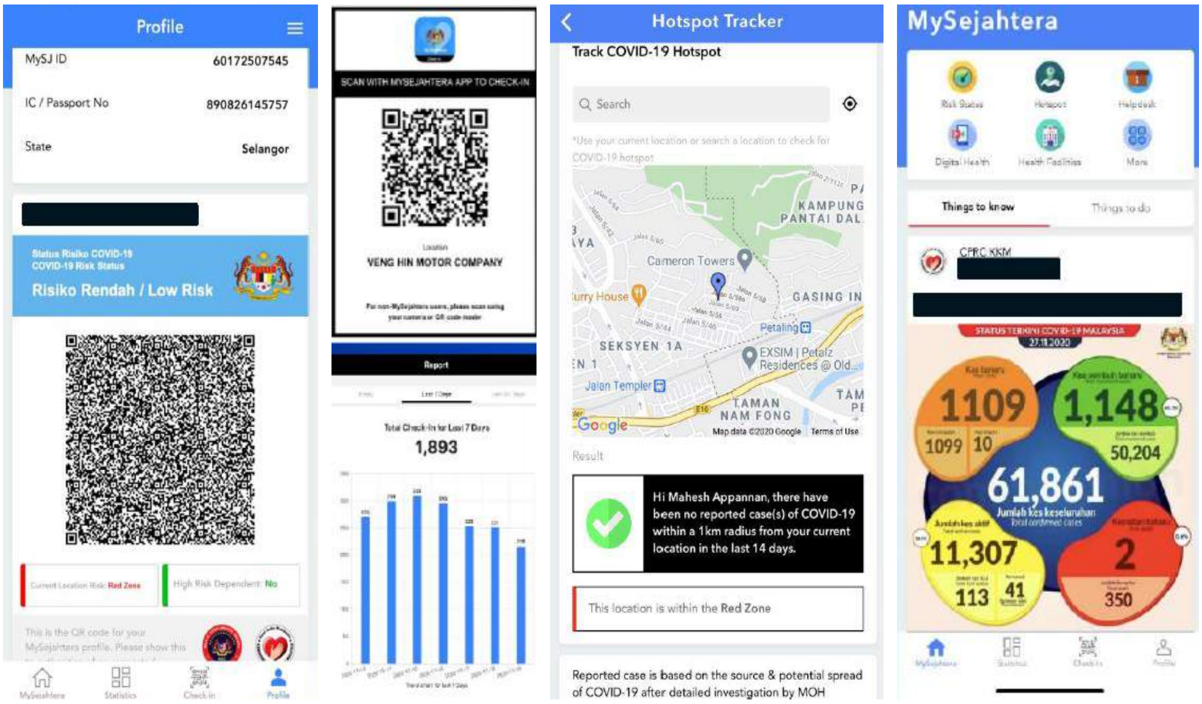
3T policy

Examining Malaysia's response to COVID-19 from the 3T perspective, the first principle is that those with symptoms should be tested, following orders from a designated hospital. A self-diagnosis is performed before visiting the hospital through the MySejahtera app. If the patient tests positive, they are isolated and hospitalized, and the treatment expenses are covered by the government.

For tracing contacts, the Malaysian Government developed the app MyTrace Malaysia. MyTrace utilizes Bluetooth technology to allow the exchange of information between devices in close proximity to each other. The data of confirmed cases is collected from their smartphones and uploaded in a database managed exclusively by the MOH. The MyTrace app service was terminated when the function was added to the MySejahtera app (see Figure 41), which offers the "Hotspot Tracker" for regional updates of confirmed cases, travel restrictions, and a monitoring system for quarantined patients; and "Check In", which replaces manual records of visitors in a certain place by keeping records of the scanned QR codes, allowing for quick and easy identification of close contacts. "Check In" is the most popular function of the app and accounts for 20 million usages daily, contributing to the detection of 15~38 per cent of daily confirmed cases. Although MySejahtera is equipped with Geofencing technology to monitor location, the function was deactivated due to concerns over privacy infringement. A vaccine management module is also under development to be included in the app, which will turn the MySejahtera app into a digital health passport containing all of the user's vital medical information.

The Malaysian Government guarantees that the data collected from the MySejahtera app abides by the government's information security standards, and that there is no

Figure 41: Malaysia's MySejahtera app



Source : Ministry of Health Malaysia (2020)

collection or utilization of personal details via the app. Data is stored for over one month without being deleted based on Malaysia's Occupational Safety and Health Act 1994 (OSHA 1994). Sensitive information such as basic identity, contact, and health details may be processed through the app and personal data is protected through supplementary measures according to the Personal Data Protection Act (PDPA). Meanwhile, sensitive information may be used and collected without prior consent in unavoidable circumstances as per the Prevention and Control of Infectious Diseases Act.

For treatment, Malaysia classifies its suspected cases into five categories: Class 1 for asymptomatic cases; Class 2 for symptomatic cases without pneumonia; Class 3 for symptomatic cases with pneumonia; Class 4 for symptomatic cases with pneumonia and requiring supplemental oxygen; and Class 5 for critically ill cases with multiple organ failure. The third mass outbreak in late 2020 led to an increase in hospital beds, and private hospitals are also being mobilized through the Emergency Ordinance to Mobilize Resources of the Private Healthcare Sector (CodeBlue, 2020).

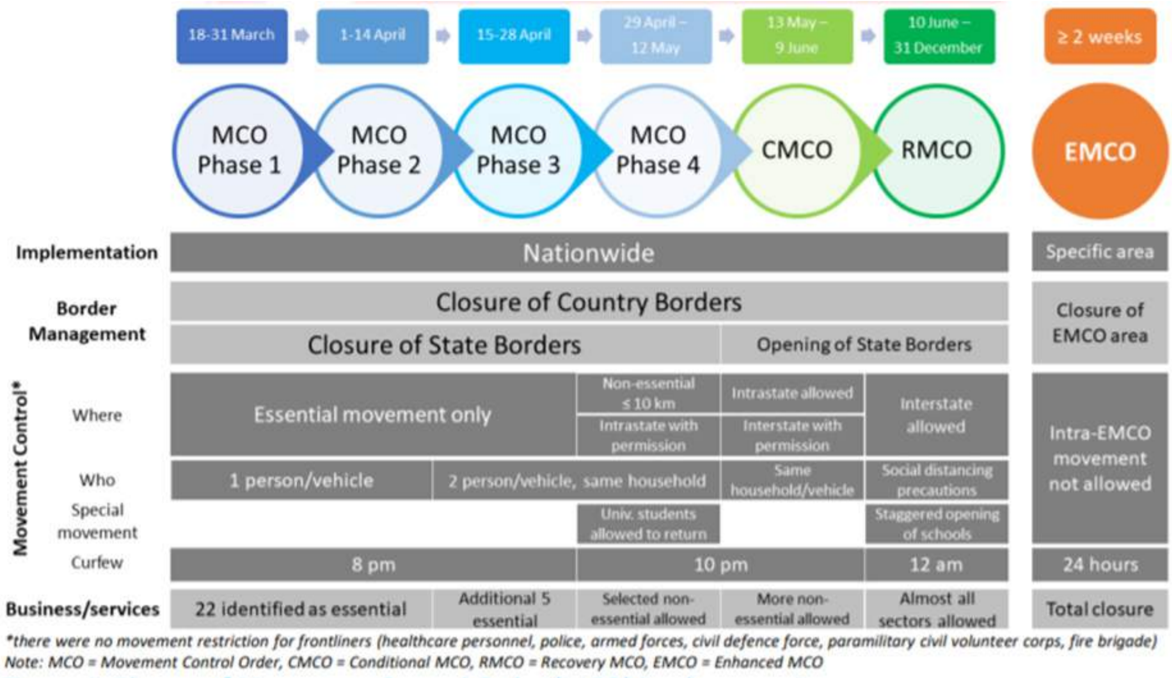
Social distancing policy

Four MCOs (Movement Control Orders) were enacted during the initial phases in March and April of 2020 (see Figure 42). The first MCO included the closing down of all offices with the exception of businesses providing essential services, the prohibition of group activities including all religious gatherings, and stay-at-home orders except for grocery shopping and hospital visits. The second MCO was also highly restrictive and included additional rules on staying within a 10 km radius of one's home. The Conditional Movement Control Order (CMCO) was announced in May to ease the restrictions of previous MCOs, and additional mitigation decisions were taken in June. However, a third wave of infections led to an Enhanced Movement Control Order (EMCO) in January of 2021 (WHO, 2020a).

Vaccination strategy

The strategy of the Malaysian Government is to vaccinate 80 per cent of the adult population by February 2022 to reduce infections, hospitalizations, and deaths. The first phase of

Figure 42: Execution and relaxation of Movement Control Orders



Source : WHO (2020a)

this strategy gives priority to frontline workers, especially those in the healthcare sector, and aims to vaccinate 500,000 people from between February and April 2021. The second phase focuses on reducing the pressure on the public health system by vaccinating people at risk of serious illness. The goal of this phase is to vaccinate 9.4 million people between April and August. The third and last phase concentrates vaccinations in vulnerable regions, and endeavours to vaccinate 13.7 million people over 18 years of age from May 2021 to February 2022.

Malaysia has signed deals for 75 million doses of vaccines as of March 2021, with 32 million from Pfizer, 14 million from Sinovac, 13 million from AstraZeneca, 13 million from Gamaleya, and 4 million from Cansino. This amounts to enough dosage for 40.93 million people, which is equivalent to 125 per cent of its population. As of 8 September, 20.94 million people were vaccinated in Malysia, 64 per cent of its population (Our world in data, 2021).

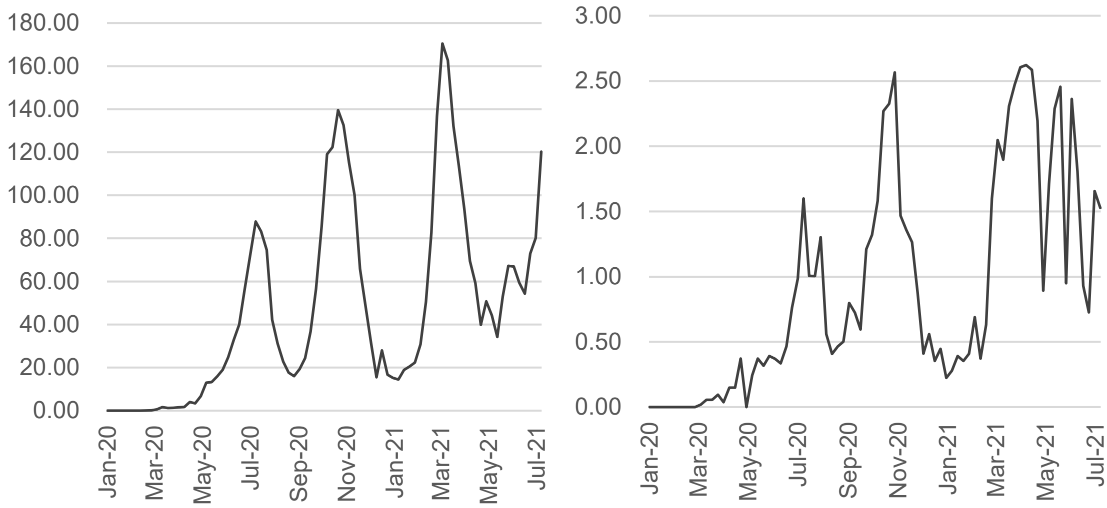
Economic countermeasures against COVID-19

The Malaysian Government announced a fiscal stimulus plan in March and April of 2020, worth 295 billion ringgits (approximately USD70 billion, 20.3 per cent of GDP) to reduce the impact of the lockdown on the economy. The plan includes direct government spending of 45 billion ringgits in cash assistance and SME subsidies for medical and supporting workforces as well as vulnerable social groups. The plan also contains measures led by the Bank Negara Malaysia (BNM, the Central Bank of Malaysia) for the suspension of loan payments for businesses and households (100 billion ringgits) and a government guarantee for business loans (50 billion ringgits).

Public approval of disease control policies

The approval level in Malaysia's control policies for COVID-19 was initially relatively high, but there was a general sense of fatigue by the second half of 2020. The number of confirmed cases, which began to soar in March 2020, subsided in May as people readily embraced the strong control measures including the

Figure 43: Weekly COVID-19 cases (left) and deaths (right) in Kenya (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

MCO. But the third wave of outbreaks in September 2020 led to stricter MCOs, resulting in lower approval levels demonstrated through protests and refusal to wear masks. According to health experts, this change in behaviour resulted from people becoming weary of the consecutive control measures (*The Straitstimes*, 2021).

Socio-economic impact of COVID-19 in Malaysia

Malaysia's GDP grew 0.7 per cent in Q1 of 2020 compared to its previous quarter, as restrictions such as the MCO had not yet been enforced. The impact of the MCO became apparent in Q2 when the GDP dropped 17.1 per cent. This was the sharpest quarterly fall since Q4 of 1998 during the Asian financial crisis (-11.2 per cent). Despite a better result in Q3 at -2.7 per cent, the rate fell once again in Q4 by -3.4 per cent (Department of Statistics Malaysia, 2021).

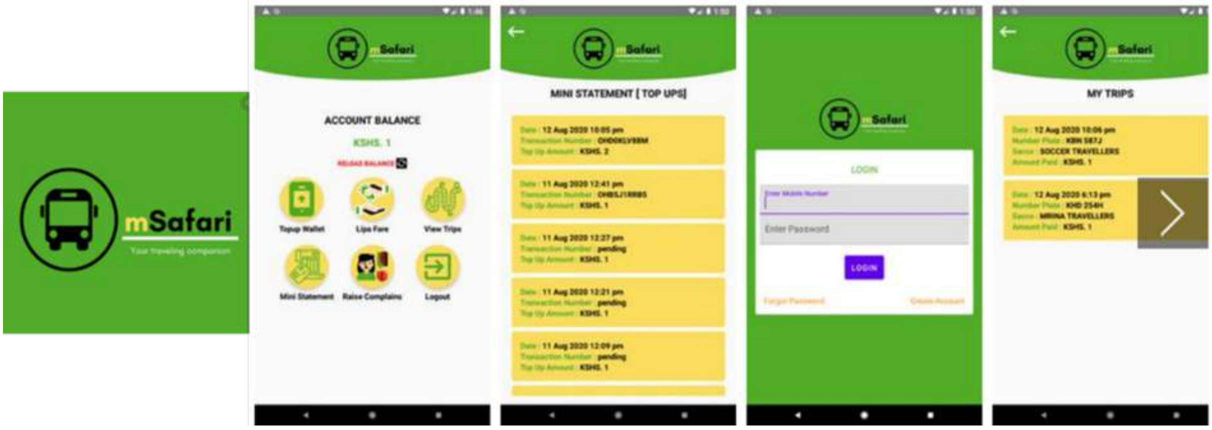
2.1.13 Kenya's response strategy

COVID-19 situation and reaction of the government

Kenya's first COVID-19 case occurred on 13 March 2020, and the total number of cases had reached over 100,000 by January 2021, standing at 159,318 as of 30 April. Kenya experienced three waves in August 2020, November 2020, and March 2021 (see Figure 43). The cumulative infection rate was 0.4 per cent on 31 July 2021.

The government responses that affected the trajectory of COVID-19 are as follows. On 15 March, two days after the first case, President Uhuru Kenyatta announced guidelines to contain the spread of COVID-19, including travel restrictions, mandatory quarantine for arrivals (including 14 days of self-quarantine), school closures until 20 March, work-from-home guidance, and free installation of telephones to report suspected cases. On 22 March, the government shut down all bars and imposed social distancing measures even for public transport. Gatherings of more than 15 people were also prohibited in religious facilities. Passenger inflow through international airports was blocked from 25 March and overnight curfews came into effect (19:00~05:00) and were extended in April, May, and November. On 1 April, the government asked the city of Nairobi and Kenya Power not to disconnect water or electricity over unpaid bills. The successive waves of infections forced the government to extend its measures prohibiting gatherings and suspending microbusinesses.

Figure 44: Kenya's online COVID-19 route tracing app, mSafari



Source : Googleplay (2021a)

Governance and legal system against COVID-19

Kenya's response governance is headed by the President and overseen by the Cabinet Secretary of the Ministry of Health, in accordance with the Public Health Act. The Ministry of Health establishes and executes containment policies, enacts lower statutes such as orders and regulations, and communicates relevant information to the public. The Kenya Medical Research Institute (KEMRI) – a state corporation established through the Science, Technology and Innovation Act of 1979 (amended 2013) – conducts evaluations of COVID-19 test kits and supports the national screening centers. Meanwhile, the government's Kenya Medical Supplies Authority (KEMSA), which was set up through the KEMSA Act 2013, is engaged in procurement, storing, and distribution for public health programmes, national strategic stock reserves, prescribed essential health packages, and national referral hospitals.

Lower statutes include the curfew order in 2020, travel restrictions, and rules on the prevention, control and suppression of COVID-19, as well as provisional guidance announced by the Ministry of Health. There were also guidelines announced by related departments such as the Ministry of Labor and Social Protection and local governments.

3T policy

To observe Kenya's response strategy from the test-trace-treat perspective, mass tests were carried out by order of priority in April 2020 through kits provided by China and the United States The first priority was given to high-density neighbourhoods and high-risk areas (hospitals and quarantine facilities). As of late March 2020, approximately 1.28 million tests have been conducted, although testing is not always carried out daily.

The Msafari app (see Figure 44), developed by FabLab, has been used for tracing since 23 March 2020. Transport operators and passengers (minibuses or matatus, taxis, and motorcycles) should be able to provide information to help trace infections. Drivers and owners are required to register all their vehicles and collect passenger information, while passengers are required to register through their mobile phones when using public transportation. This process is exempt from telecommunication fees.

According to the developers' data, one out of two Kenyans use public transport every day, and 60 per cent of households have at least one member that uses it daily, thereby making the use of PSVs (public service vehicles) a high-risk activity in terms of COVID-19 infection.

Meanwhile, the Kenya Human Rights Commission (KHRC) expressed concern over the collected data and its storage method

(Inclo, 2020). The Ministry of Health also launched the Jitenge MoH Kenya app, through which contact tracing, symptom reporting, and monitoring are available. The app is being used at the Ministry of Health's Emergency Operations Center, which runs the Emergency Alert and Report system (EAR).

In terms of treatment, Kenya was proactive in its early response, preparing in advance an Emergency Operations Center at the Ministry of Health, and establishing a dedicated counselling centre. A treatment and quarantine facility was installed at the Kenyatta National Hospital – Kenya's largest educational and referral hospital – and 1,500 healthcare workers in different facilities received training on the management of COVID-19 patients. However, there were issues between the county and national levels in coordinating the procurement of core equipment (respirators) and hiring new medical workers. As such, although most medical facilities were equipped with pulse oximeters and oxygen equipment, the treatment of critical patients was hampered due to the poor infrastructure and supply chain for oxygen (WHO Africa, 2021a).

Vaccination strategy

Kenya received 1.02 million doses of the AstraZeneca vaccine through COVAX and UNICEF on 3 March 2021 and will receive an additional 24 million through COVAX. According to its comprehensive vaccine strategy, Kenya will be able to secure 49 million vaccines by June 2023, which is equivalent to the dosage for 30 per cent of its population. Kenya will first vaccinate the medical professionals in its 47 counties and give priority to frontline workers such as security guards and teachers. Various bodies participated in the establishment of Kenya's vaccine strategy. The government proposed a total of nine strategies, including authorizing vaccines approved by other international agencies or governments within seven days, placing the Ministry of Health in charge of vaccine planning and coordination with the support of related institutions, securing the finances for vaccines for 30 per cent of its population from COVAX (20 per cent) and self-funding (10 per cent), and dividing the distribution of vaccines into three stages to vaccinate 1.25 million people by June 2021, 9.76 million by July 2022, and 4.9 million by June 2023. (Ministry of Health, Republic of Kenya, 2021) The existing supply chain will be used with the expansion of low-temperature storage facilities. Other plans include safety monitoring and training of the existing medical staff. As of 8 September 2021, 2.12 million people were vaccinated in Kenya, 4 per cent of its population (Our world in data, 2021).

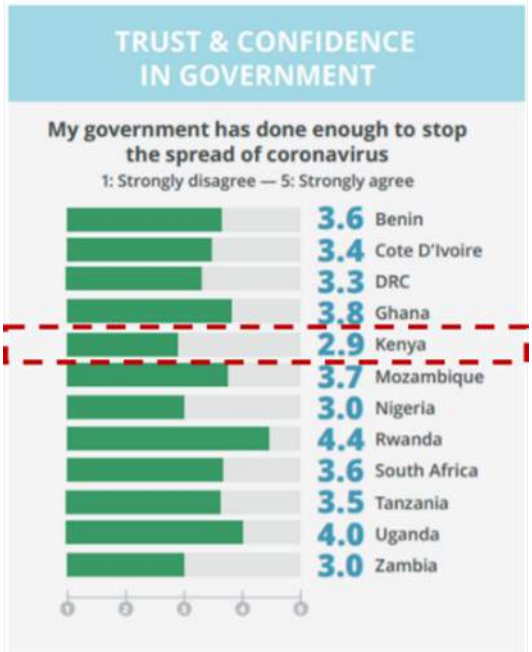
Economic countermeasures against COVID-19

The Kenyan Government implemented various fiscal policies to minimize the economic shocks from COVID-19, most of them enacted around March of 2020. Three policy areas were announced by President Uhuru Kenyatta on March 26, 2020. The first was taxation, mainly entailing tax deductions. The second was economic stimulus policies, including additional cash assistance for vulnerable groups. The National Taxpayers Association was to immediately return additional taxes and the Universal Health Coverage Institution to appropriate one billion KES to hire additional human resources in the medical service area.[4] Thirdly, there were plans to deduct the personnel expenses of high-ranking officials including the President. Meanwhile, to increase credit supply in the private sector to improve its cash flow, the Central Bank of Kenya reduced the central bank rate (CBR) to 7.25 per cent (from 8.25 per cent) and lowered the cash reserve ratio to 4.25 from 5.25 per cent. The CBR was lowered once again on 29 April from 7.25 to 7 per cent.

Public approval of disease control policies

As for public engagement, the overall credibility of the government's disease control policies was low. Kenya recorded the lowest score out of 13 African countries (see Figure 45) in a public survey on trust and confidence in the governments' response measures (Geopoll, 2020).

Figure 45: Public level of trust in Kenya's COVID-19 response measures



Source : Geopoll (2020)

Socio-economic impact of COVID-19 in Kenya

The GDP growth rate was 4.9 per cent in Q1 of 2020, similar to its rate in the previous quarter. However, travel restrictions and other containment policies pushed the rate down by 5.7 per cent in Q2 compared to the same quarter the previous year. The rate for Q3 was -1.1 per cent. Thereafter, Kenya's GDP was expected to grow owing to increased exports of flowers, fruits, and tea (Kenyanwallstreet, 2020).

The World Bank reported in November 2020 that roughly two million Kenyans were living in poverty because of the social and economic shocks from COVID-19. While available jobs and income have decreased, the unemployment rate is almost twice the pre-pandemic level. Wage earners, in particular women, experienced significant reductions in their working hours and one in three independent business owners were not operating, with revenues falling in all sectors. Remittances also decreased and few households benefited from the direct cash assistance (World Bank, 2020a).

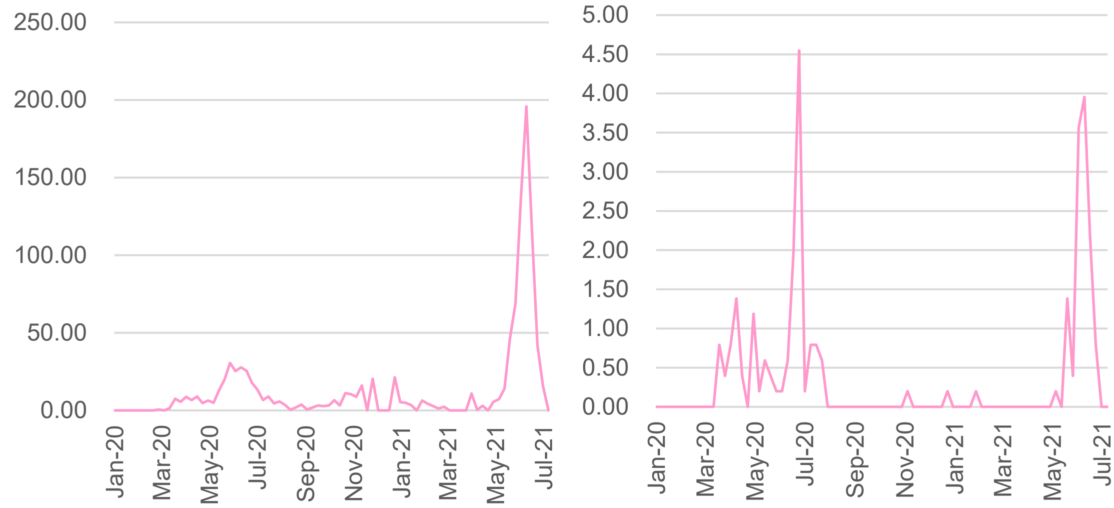
2.1.14 Liberia's response strategy

COVID-19 situation and reaction of the government

The first case and death in Liberia occurred on 16 March and 4 April 2020, respectively. Although the number of newly confirmed cases was in the two-digit range between April and July as well as in December of 2020, the infection rate subsided in March and April 2021, with daily cases in the single digits or at zero (see Figure 46). The cumulative infection rate was 0.1 per cent on 31 July 2021.

Key events related to the government's response are as follows. The Minister of Health and Social Welfare declared a national health emergency on 22 March 2020 after three confirmed cases were reported within Liberia. On 7 April, President George Weah appointed Mary Broh, former mayor of Monrovia, as the National Coordinator of the Executive Committee on Coronavirus (ECOC) and Finda Bundoo as National Compliance Officer to supervise the resource distribution and allocation. On 8 April, President Weah proclaimed a lockdown for certain regions for three weeks from 10 April. The President also declared a national state of emergency

Figure 46: Weekly COVID-19 cases (left) and deaths (right) in Liberia (Jan 2020~Jul 2021, per million people)



Source: adapted from Our world in data (2021)

on 8 April, which was approved by both the Senate and House of Representatives to come into effect on 21 April. The President declared a "Proclamation by the President of Liberia extending the State of Emergency" without the legislature's approval on 22 June. On 23 July, the Ministry of Health and Social Welfare (MoHSW) announced the Revised COVID-19 Declaration of National Health Emergency, a stronger revision of the declaration based on Article 14 of the Public Health Law.

COVID-19 governance

Liberia was struck hard by the Ebola virus during 2014 and 2015, which led to swift and effective responses at the onset of COVID-19, including quarantine at airports and the establishment of the Special Presidential Advisory Committee on Coronavirus. Liberia's response governance for COVID-19 policies is characterized by cooperation between local authorities, led by the MoHSW, following the aforementioned Article 14 of the Public Health Law. The Ministry has the authority to preside over the establishment of various infectious disease policies, the enactment of legislation, and the execution of policies. The Minister also appoints chief health officers within counties to execute these orders on infectious diseases within their jurisdictions (Article 4). The Liberian Government established the National Public Health Institute of Liberia (NPHIL) to respond to the 2014 Ebola outbreak in the West African region. The NPHIL cooperates with the MoHSW to reinforce existing infection prevention efforts, laboratories, surveillance, epidemic monitoring, disease control, and public health capacity-building.

Another pillar of Liberia's COVID-19 response consists of international agencies. The government receives support from e.g. the UN and IMF to establish organizations and procure supplies and vaccines. For example, the MoHSW and the NPHIL concluded a partnership agreement with the UN for the COVID-19 National Multi-sectoral Response Plan. In March 2021, the WHO donated essential medicines and laboratory supplies for testing through the MoHSW and also provided vaccines through COVAX.

3T policy

From the 3T perspective, Liberia requires testing for all arriving passengers except for those who are exempt[5]. The tests are carried out by the National Public Health Reference Laboratory team and carry fees of USD75 each. The fees are used to support contact tracing, epidemiological surveys, and data management. Test results are available in two to three days on the self-check portal.

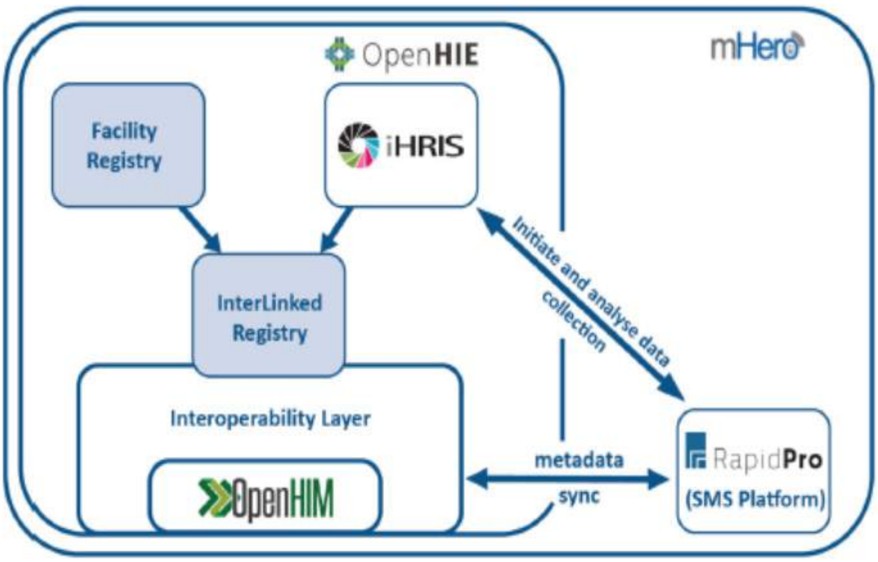
Liberia mandates that all travellers must download the Lib Travel app (created and distributed by the MoHSW) before they enter the country. Regardless of whether they are exempt from the tests, all arriving passengers must install the app, self-quarantine for seven days, report their temperatures and any symptoms for 14 days, and allow activity tracing by the government. The collected personal information is only shared with the MoHSW. However, the number of Lib Travel downloads on Android is relatively small at just over 10,000.

Liberia quickly recruited contact tracers following the outbreak of COVID-19, based on their experience with the Ebola virus. But adopting ICT measures such as digital tracing was a challenge due to the insufficient infrasructure. Positive cases are taken to a government treatment unit according to Liberia's case management guidelines. The treatment unit is an army hospital operated by the MoHSW in Monrovia.

Liberia also deployed the mHero platform, which had been introduced in 2014 during the Ebola crisis to allow health workers to share information through text messaging for their capacity enhancement (see Figure 47). The open-source SMS platform, co-developed by IntraHealth, UNICEF, and USAID, was created in response to the MoHSW's need to quickly provide essential information to healthcare professionals and to understand the demands of those on the front lines during the Ebola outbreak. The platform supports bi-directional communication in real time for the Ministry and workers nationwide. The Ministry sent out 30 workflows through mHero between November 2014 and June 2016, as well as in the recovery period of the Ebola crisis. This key information was communicated to over 8,000 healthcare workers. UNICEF supported all related text-messaging fees through consultation with Liberia's mobile operators (ITU, 2020a).

The mHero platform facilitated communication between the Ministry and healthcare personnel during the COVID-19 pandemic. It enabled the coordination of health promotion strategies and crisis responses, the training of health workers and creation of COVID-19 knowledge tests, the reporting of suspected cases and other high-risk diseases, the tracking of inventories of essential consumables such as PPE, and the identification of regional health and safety concerns. There are six countries that utilize mHero in addition to Liberia, including the Democratic Republic of the Congo (DRC)[6].

Figure 47: Information flow of mHero



Source : ITU (2020a)

Social distancing policy

For its social distancing policies, the MoHSW declared a national health emergency on 7 March 2020, and the Revised COVID-19 Declaration of National Health Emergency on 23 July to respond to the rising numbers of cases and deaths. The declaration implemented mandatory measures for mask-wearing, social distancing of a minimum of three feet, and protocols for public places or facilities including government buildings, banks, and marketplaces. The declaration also included penalties of fines or imprisonment for violations. Businesses had to be closed by 9 p.m. and capacity at churches and mosques was restricted to 25 per cent.

Vaccination strategy

On 1 April 2021, Liberia started administering the 96,000 doses of AstraZeneca vaccines that it had received through COVAX. Vulnerable groups and frontline workers were vaccinated first. As of 8 September, 104,000 people were vaccinated, 2 per cent of its population (Our world in data, 2021).

Economic countermeasures against COVID-19

The Liberian Government submitted policy measures to the legislature reflecting a budget increase, in consideration of the impact that stay-at-home orders would have on microbusinesses and vulnerable groups. Key measures included i) the USD25 million COVID-19 Household Food Support Programme implemented by the World Food Programme to provide food assistance for poor and vulnerable households; ii) free electricity and water; iii) financial support for microbusiness owners and female market workers; iv) suspension of pre-shipment inspections and import surcharges; and v) a minimum of USD15 million in FY 2020~21 national budget for domestic arrears.

The government also designed fiscal policies to provide business support and food assistance for people whose livelihoods have been threatened by COVID-19, but chose to revise the allocation due to budget limitations. The government has also been promoting food aid programmes for vulnerable groups with various agencies (e.g. the World Bank).

Public approval of disease control policies

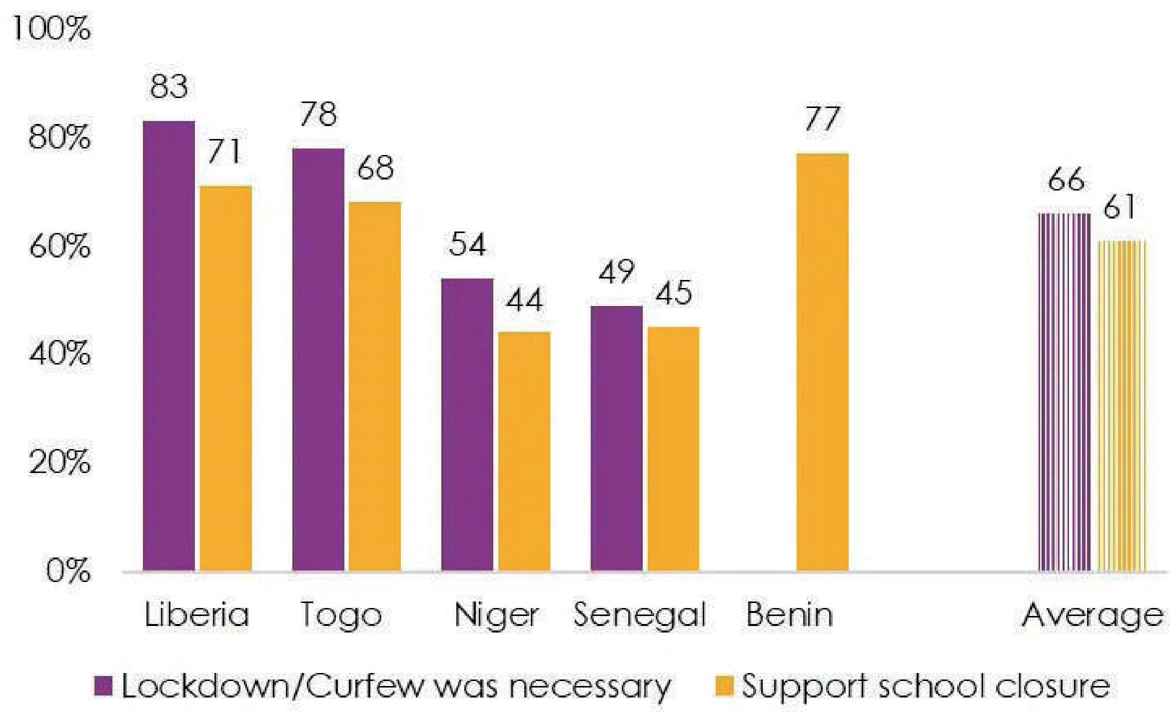
A large portion of Liberians (64 per cent) support their government's COVID-19 policies and trust the information it provides (64 per cent). Although there is some opposition to suspending transportation and market shutdowns, most people agree that government intervention is necessary. Support for suspending transportation (57 per cent) and market shutdowns (54 per cent) was lower than the support for self-isolation (74 per cent), prohibition of physical contact (94 per cent), , closure of schools (94 per cent), shutdown of restaurants and nightclubs (90 per cent), and restricted public gatherings[7] (Ipsos, 2020).

Generally, the Liberian public showed a higher level of support for government measures (e.g. travel restrictions, curfews, and school closures) than other African countries, as shown in Figure 48 (Washington Post, 2021b). However, most citizens were dissatisfied over the unfair food distribution as the relief assistance failed to fully benefit the targeted vulnerable groups (Afrobarometer, 2020).

Socio-economic impact of COVID-19 in Liberia

Liberia's GDP for 2020 fell 3 per cent compared to the previous year, due to lockdowns and restricted international trade and travel. Meanwhile, the GDP for 2021 is projected to grow by 3.2 per cent (Macaubusiness, 2021).

Figure 48: Response of key African countries including Liberia on policies including lockdowns



Source: Washington Post (2021b)

2.1.15 Mauritius' response strategy

COVID-19 situation and reaction of the government

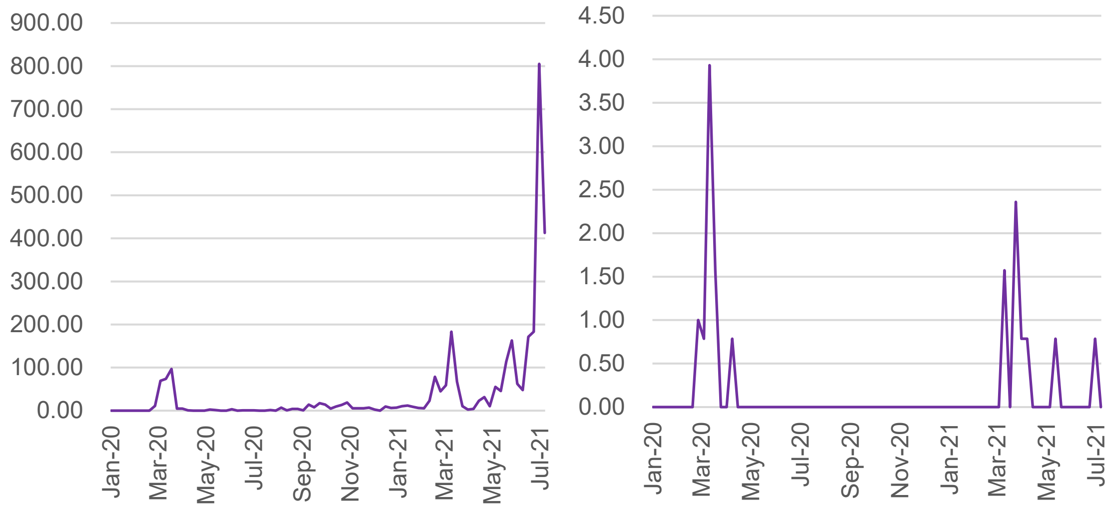
Mauritius, the East African island country in the southwest region of the Indian Ocean, experienced its first three cases of COVID-19 on 18 March 2020, with the total number of cases reaching over 1,000 a year later (see Figure 49). There were dozens of new cases each day in March and April of 2020, after which the curve was temporarily flattened. The number increased to dozens of daily infections again in March 2021 but fell in April. However, the number of COVID-19 cases started growing fast once more from mid-July of 2021. The cumulative infection rate was 0.3 per cent on 31 July 2021.

The key events related to the response of the Mauritian Government are as follows. The Prime Minister enacted regulations on 19 March, the day after the first cases were identified. The regulations were based on Section 4 of the Quarantine Act that allowed the government to prohibit aircrafts and ships from entering the country. A two-week lockdown was imposed on the same day, and was extended several times including on 30 March, 8 April, and 1 May. Thanks to the strict lockdowns, by June of 2020 there were no new cases and the lockdowns were completely lifted. However, the number of new cases rose to two-digit numbers in March 2021, leading to a new set of lockdowns which were extended for three weeks on 6 April. There were fewer than 10 cases per day in April due to the lockdown. The government reopened the country's borders to international travellers on 15 July (MedicalXpress, 2021; Khaleej Times, 2021).

Governance and legal system against COVID-19

The governance model adopted for the Mauritian Government's response to COVID-19 is based on the Quarantine Act 2020. Following the Act, governance is centred on a high-level COVID-19 committee formed on 31 January 2020, headed by the Prime Minister and the

Figure 49: Weekly COVID-19 cases (left) and deaths (right) in Mauritius (Jan 2020~Jul 2021, per million people)



Source : adapted from Our world in data (2021)

Ministry of Health and Wellness (MoHW). Along with other ministers, they issue ordinances and orders related to infectious disease prevention and containment. The Prime Minister enacted regulations on 19 March 2020 to prohibit the entry of aircrafts and ships and the Minister of Health and Wellness introduced a Home Visit Service system, dispatching people to the homes of COVID-19 patients. The central government has also been issuing and extending lockdowns. Anyone violating the regulations of the Act are liable to a fine of up to 500,000 rupees or up to five years of imprisonment.

The high-level committee convened daily after the country's first outbreak and switched to a weekly basis in June when there were no new cases. The Communicable Diseases Control Unit (CDCU) within the MoHW manages the administrative work and conducts data collection, analysis, promotion, surveillance of entry points, quarantine, tracing, case management, and the provision of information and guidelines. The government also collaborates with international organizations (the WHO and UNDP) for information and assistance. Mauritius's robust governance and leadership in response to COVID-19 are deemed as contributing factors to its successful control of the pandemic.

3T policy

Mauritius is undertaking strong surveillance, testing and tracing measures. All passengers entering Mauritius by air or by sea are subject to 14 days of quarantine in a designated area. Public health inspectors are to visit these individuals every four days to check for symptoms, and Rapid Response Teams were scaled up to transfer suspected cases from the airport to hospitals or quarantine facilities. When there is an incidence, the CDCU carries out contact and transmission route tracing through inspectors. Each contact-tracing team, composed of a doctor and nurse, deals with 150 cases on average every day. The MoHW carried out full-fledged tests for frontline health workers as well as citizens who come in contact with many people. The Ministry also opened up a dedicated COVID-19 hotline in February 2020 for people with suspected symptoms. They offer the Home Visit Service for patients with mild symptoms, and for more severe cases, prescriptions are given to transfer the people to local hospitals. These aggressive testing, tracing and treatment measures led to a temporary flattening of the curve within three months of the first cases.

ICT is applied extensively for these 3T measures. First, the government is utilizing

ICT to greatly expand the testing capacity. Three months into COVID-19, the MoHW decided to scale up the capacity for mass tests as well as the capacity for effective and timely reporting. As such, the government requested an Electronic Laboratory Information System (ELIS), following the WHO guidelines. The OpenELIS software was customized to support various response functions, such as reporting batch processing of bio samples, and more printer-friendly barcodes. OpenELIS significantly enhanced the testing capacity of the Central Health Laboratory. The MoHW also provides real-time information to users of the beSafeMoris app, developed specifically for Covid by Mauritius Telecom. The app does not cause privacy infringement issues since it is not used for tracking purposes.

Social distancing policy

Mauritius imposed several lockdowns to suppress COVID-19, including the shutdown of airports, seaports, and schools; curfews, personal travel restrictions, and quarantine; and the testing and tracking of passengers coming from infected countries. In addition to the travel restrictions placed on individuals, the days during which people were allowed to purchase essential goods were designated based on the first letter of their surnames. For example, those whose surnames began with the letters A~F were only allowed to shop on Mondays and Thursdays, G~N on Tuesdays and Fridays, and O~Z on Wednesdays and Saturdays.

Vaccination strategy

The Mauritius Tourism Promotion Authority is securing and administering vaccines with the goal of reaching herd immunity by June 2021. This decision was based on its need to attract tourists owing to its large tourism sector. As of 24 March 2021, the AstraZeneca vaccine was administered to 117,323 people and approximately 1.9 million doses were expected by 3 April from COVAX and other import countries (including China). The government is also providing free AstraZeneca vaccines manufactured in India for long-term visitors. As of 8 September, 816,000 people were vaccinated in Mauritius, 64 per cent of its population (Our world in data, 2021).

Public approval of disease control policies

The citizens of Mauritius were compliant with the strict lockdown measures, including the aforementioned orders only allowing them to purchase essential goods on allocated days. Consistent and transparent information provided by the government ultimately contributed to successful disease control (Musango et al., 2021).

Economic countermeasures against COVID-19

The government adopted tax and fiscal policies to relieve the economic burden of households suffering from the pandemic. First, the Central Bank provided a six-month loan-repayment moratorium for households impacted by COVID-19 starting on 1 April 2020. The Bank of Mauritius bore the interest burden of outstanding household borrowing from commercial banks and removed ATM fees. The government introduced tax reduction schemes for employers to promote working from home as well as a 5 per cent tax credit for respecting the pensions of remote-working employees and for acquiring IT systems. All companies were eligible to apply for wage assistance subsidies to maintain their staff levels. Priority was given to export companies as well as those in the travel sector due to the country's heavy dependence on tourism.

Socio-economic impact of COVID-19 in Mauritius

The economic shock from COVID-19 led the real GDP to drop by -15 per cent due to lockdowns, strict social distancing, and the suspension of tourism activities. The GDP for Q1 of 2020 was 116,233 million rupees (USD 2.6 billion) – a 2.1 per cent decline compared to the same quarter in 2019. The YoY GDP plunged by 32.9 per cent to 84,189 million rupees (USD 1.9 billion) in Q2, with the economic depression worsened by the border closures and domestic travel restrictions. The GDP for Q3 was 107,781 million rupees (USD 2.5 billion), which was an increase from the previous quarter but a 12.5 per cent YoY decrease. The GDP for Q4 also fell by 10.8 per cent YoY (Statsmauritius, 2021).

2.2 Role of International Organizations

2.2.1 COVID-19 response of the United Nations

International organizations including the UN and its bodies have been proactive in providing recommendations, technology, and workforce and financial support to the international community during the COVID-19 pandemic.

The UN quickly deployed a comprehensive response with three pillars addressing health, humanitarian and socio-economic impacts. The health response is led by the WHO and has included measures for controlling the virus; supporting the development of vaccines, diagnostics and treatment; and strengthening preparedness. The humanitarian pillar, coordinated by OCHA, concentrates on multi-sectoral needs in over 50 vulnerable countries. The third pillar is focused on addressing the socio-economic impact of the pandemic, with the UNDP serving as the UN system's technical lead. Efforts are also centred on fostering a recovery process that pursues a better post-COVID world by addressing the climate crisis, inequalities, exclusion, gaps in social protection systems, and many other fragilities (UN, 2020b).

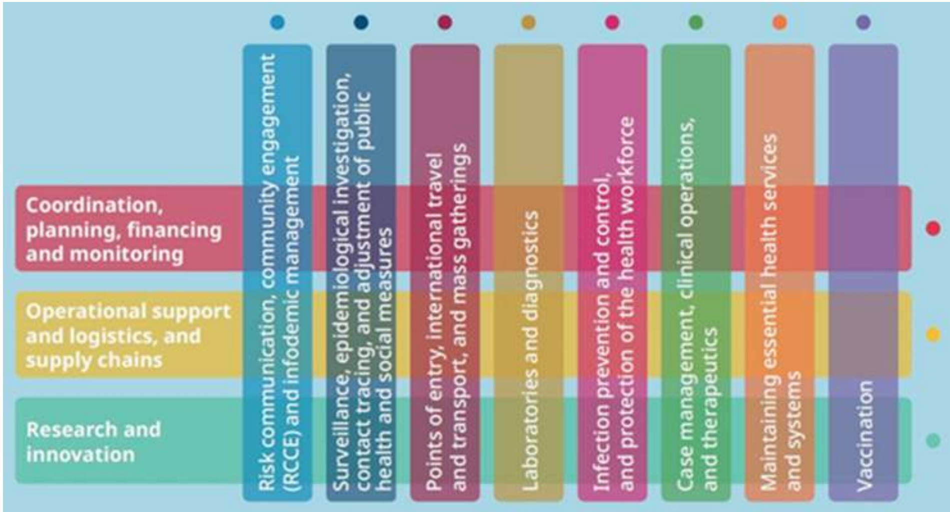
First, for the "large-scale, coordinated and comprehensive health response", the WHO established the Strategic Preparedness and Response Plan (SPRP) on 3 February 2020, offering guidelines on international, national, regional, and community levels. Through this plan, the UN controlled the virus, supported diagnosis and treatment, and established a system to promote the development and preparation of vaccines. The containment of the pandemic being a global public interest, the emphasis is on solidarity between developing countries, response measures that may be implemented immediately, and the special management of vulnerable social groups with high risks of being exposed to the virus.

The SPRP is composed of 10 main pillars (see Figure 50). They may be classified into three groups – coordination and planning, operational support and logistics, and accelerated research and innovation. They entail seven individual technologies and operations: 1) infodemic management, risk communication, and community engagement; 2) surveillance, contact tracing, and case investigation; 3) travel, trade, and points of entry; 4) laboratories and diagnostics; 5) infection prevention and control; 6) clinical management; and 7) the maintenance of essential health systems (WHO, 2021c). The WHO assisted countries according to their requirements, providing consulting or direct involvement and technical guidelines and standards for countries with a well-established control system.

Meanwhile, the UN OCHA established the Global Humanitarian Response Plan (GHRP), concentrating on services to protect people's lives and livelihood from substantial damage in the short term due to COVID-19 (see Figure 51). Its policy priorities for 63 countries with inadequate disease control infrastructures (see Figure 51) include 1) containing the spread of COVID-19 and decreasing morbidity and mortality; 2) preventing the deterioration of human rights, livelihoods, and social cohesion; and 3) protecting and assisting refugees, internally displaced people, and migrants.

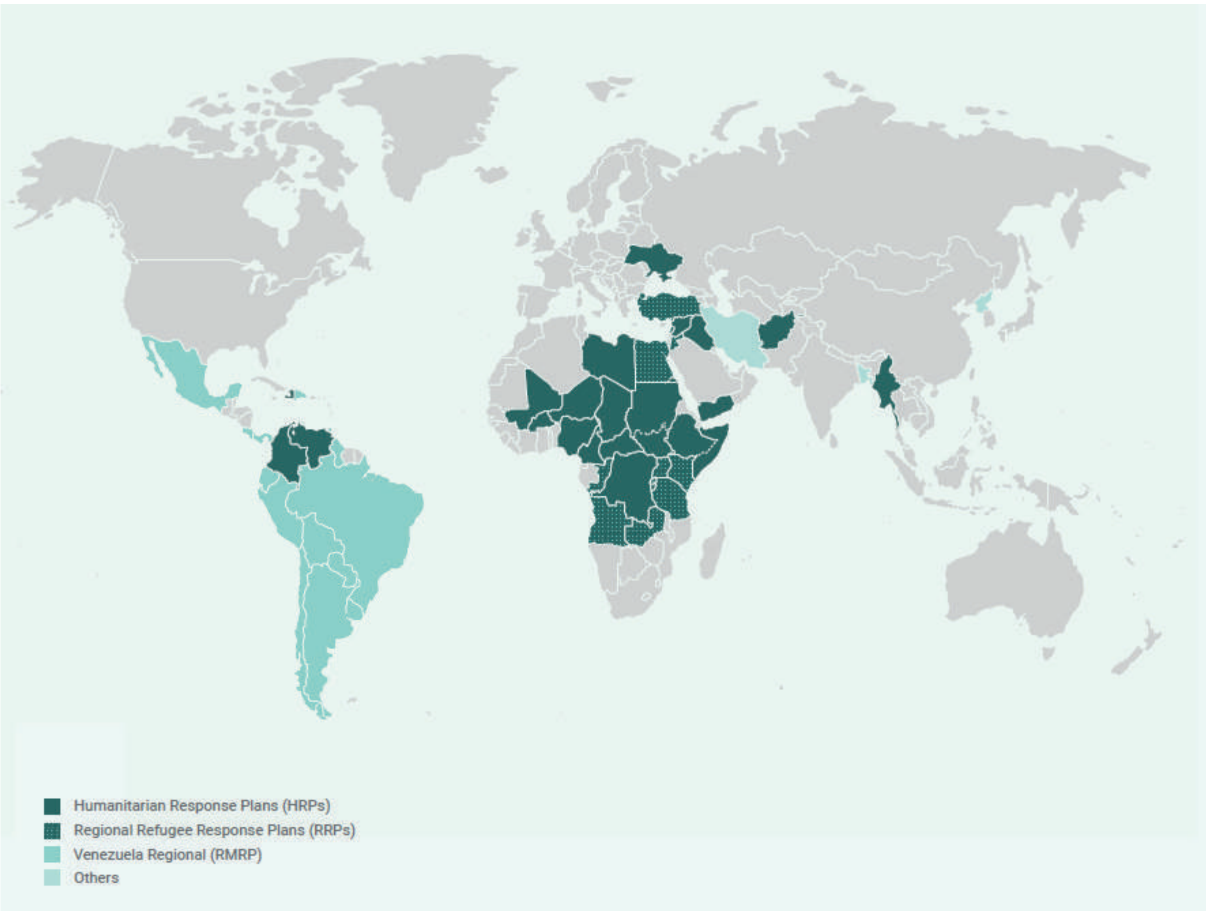
The UN Development Coordination Office (UNDCO) is also formulating mid-to-long-term provisions for sustainable development to minimize the socio-economic impact of COVID-19 through the protection of medical services and systems, social security and basic services, and jobs and SMEs; and the facilitation of macroeconomic responses, multilateral cooperation, social cohesion, and community restoration.

Figure 50: 10 pillars of the WHO's SPRP



Source : WHO (2021c)

Figure 51: Countries subject to the GHRP (63 countries)



Source : UN OCHA (2020b)

2.2.2 Vaccine distribution efforts of international organizations

Beginning in January 2020, the WHO undertook research, manufacturing, regulation, and evaluation to develop vaccines for the COVID-19 pandemic. The WHO monitored the process for all vaccines and encouraged communication between researchers and vaccine developers for faster and more precise evaluation. Additionally, the UN General Assembly introduced the ACT-Accelerator programme in April of 2020 to ensure equitable access to vaccines.

The COVAX Facility is jointly operated as part of a programme run by the WHO, Gavi (the Global Alliance for Vaccines and Immunization), and CEPI (the Coalition for Epidemic Preparedness Innovations). COVAX is a type of group-purchase programme, wherein a pre-purchase contract is signed with pharmaceuticals using funding from the participating countries to secure the supply of vaccines upon their development. Countries are guaranteed priority distribution of vaccines for 20 per cent of their population and the rest is provided in order. The IMF and the World Bank Group also support policies for fundraising and debt relief so that developing countries may procure the necessary funds to purchase and distribute COVID-19 vaccines. The WTO has policies on bulk management, trade restrictions, and streamlining of the national registration process to facilitate the safe and prompt supply of vaccines.

Despite such efforts, the global endeavour to return to normal is being hindered by the unfair distribution of vaccines (UN News, 2021). As of 15 September, the percentage of people who received at least one dose is only 3.07 per cent for low-income countries but 60.18 per cent for high-income countries, according to the Global Dashboard for Vaccine Equity, which is run by the UNDP, WHO, and University of Oxford (UNDP, 2021c). The vaccine price, ranging from USD2 to USD37, and the per-capita distribution cost of USD3.7 could be a critical financial burden for low-income countries, according to UNICEF (2021b). The Dashboard indicates that without immediate international financing, low-income countries will have to increase their healthcare spending by 30~60 per cent to vaccinate 70 per cent of the population. As such, there should be more international assistance for equitable access to vaccines if we are to meet the WHO goal of vaccinating 70 per cent of the global population by mid-2022.

2.2.3 ITU's contribution to the COVID-19 response

The ITU analyses the response measures for COVID-19 and discusses means to utilize digital technology to guarantee the continuity of response activities and meet objectives.

Working with mobile carriers through "Be Healthy, Be Mobile" – a joint initiative by the ITU and WHO – text messages about COVID-19 are sent out to people in countries with poor telecommunication infrastructures such as Niger, Senegal, and Tunisia. With financial support from the WHO's COVID-19 Solidarity Response Fund and in collaboration with Pan American Health Organization (PAHO), SMS and other digital communication channels are used in the Eastern Caribbean to help disseminate reliable information and guidance on vaccines and preventive health measures. The aim is to tackle the spread of rumours and disinformation and reduce vaccine hesitancy.

The importance of digital solutions in dealing with the spread of infectious diseases is also being emphasized to the G20 Health Ministers. As countries, businesses, and individuals undergo digital transitions to respond to COVID-19, a global network-restoration platform is being built to relieve the extra burden placed on telecommunication networks. The platform guarantees reliable access to the network for people using telecommunication services to respond to the pandemic, including policy-makers, health authorities, and industry workers.

The ITU participated in the COVID-19 Global Education Coalition, led by UNESCO, which supports students who do not have access to the Internet. To this end,

The ITU accelerate the development of financing structures for countries including Nigeria, Kenya, Kazakhstan, Uzbekistan, and the Eastern Caribbean states.[8]

It also joined hands with Cisco to develop a free programme offering tools and technologies for online classes, assisting 658 students from

28 countries in studying English, French, Portuguese, and Spanish.

Meanwhile, the ITU established the REG4COVID platform – an online venue for sharing emergency response measures and exchanging best practices between regulators, mobile operators, and equipment manufacturers – reinforcing network resiliency and helping its maintenance at a time when digitalization is paramount.

The ITU's Connect2Recover is a global initiative to enhance the digital infrastructure and ecosystem in order to facilitate the application of ICT (telework, e-commerce, online education, and telemedicine) in preparation for the recovery from the pandemic, while helping to sustain socio-economic activities by containing COVID-19. To achieve this, Connect2Recover will devise measures for affordable and credible connectivity. The focus of Connect2Recover will be on Africa, where the ICT infrastructure is weakest and where there have been grave impacts from COVID-19. Along with its traditional activities, the ITU will intensify its prolonged efforts to promote digital transformation in the African continent and establish a framework for long-term development goals. The initial stage of Connect2Recover concentrates on ensuring additional scalability. The programme is funded by the Japanese Ministry of Internal Affairs and Communications and the King Salman Humanitarian Aid and Relief Center. Through its research on digital tools and strategies in its COVID-19 "infodemic" response, the ITU has also contributed on the WHO Public Health Research Agenda for Managing Infodemics.

2.2.4 UNESCO's contribution to the COVID-19 response

The COVID-19 pandemic has caused the worst shock to education systems in a century, with more than 1.6 billion children and youth not being able to attend school for months. Many are still not back in school at the time of writing. UNESCO is working with ministries of education, public and private partners, and civil society to ensure continued learning for all children and youth. Actions have been undertaken through high-level ministerial meetings, the Global Education Coalition, and global monitoring through interactive maps to follow the evolution of school closures and learning loss across the world. In addition, UNESCO has been working on the prioritization of teachers for vaccination, global surveys, technical assistance, knowledge-sharing events, and a COVID-19 global grant funded by USD25 million from the GPE (Global Partnership for Education). The GPE is a consortium composed of UNESCO, UNICEF and the World Bank, which is leveraging global expertise to generate solutions to the learning crisis.

The GEC (Global Education Coalition) was launched by UNESCO in March 2020 as a cooperative exchange platform to protect learning rights from being disrupted due to COVID-19. The coalition encompasses 175 members of the UN family, civic groups, academia and the private sector. All members are encouraged to protect the learners' personal information, privacy, and security (UNESCO, 2021a). The three flagships guiding the coalition are connectivity, teachers, and gender. In March 2021, the GEC released a report entitled "Supporting learning recovery one year into COVID-19", reflecting on its progress over the past year. According to the report, the coalition's members are planning or engaged in activities in 112 countries with over 400 million learners and 12 million teachers. The 233 projects implemented so far range from standalone actions to comprehensive initiatives. A series of knowledge-sharing events were hosted across the year, including 11 webinars, with over 30,000 viewers from 151 countries. Five global surveys on educational responses to COVID-19 were conducted to generate comparative data. The GEC also undertook four large-scale missions, providing one million youth with skills for employment, one million teachers with remote education skills, one million learners with remedial lessons in STEM, and five million girls in 20 countries with the right to education. There were also three large campaigns, including "Save our Future" and "Keeping Girls in the Picture", to protect disadvantaged groups and guarantee that "learning never stops" (promoted on social media with the hashtag #LearningNeverStops). Fostering unique partnerships with multilateral bodies, private sector businesses, NGOs, civil society organizations, networks, associations, and the news media, enabled the GEC to offer innovative responses. Digital learning, including online resources and digitalized curricula and evaluations, is one of its core activities (UNESCO, 2021b).

UNESCO also hosted a high-level ministerial meeting on 29 March 2021 to reflect on lessons from the previous year, identify the greatest educational risks, and plan strategies so that no learner would be left behind. UNESCO's Director-General Audrey Azoulay made the following remarks at the meeting:

> Launched at the beginning of the COVID-19 pandemic, the Global Education Coalition has become a force for change. Based on solidarity and innovation, it exemplifies the new model of cooperation we need for our education systems. Its 175 members, active in more than 100 countries, contribute to ensure continuity of learning in all circumstances, as we look to transform and reimagine the education of the future. (UNESCO, 2021c)

UNESCO's emphasis during the pandemic has been on open access to scientific information and open data to enable better and faster R&D for vaccines and inform public health measures. UNESCO worked with its Category 2 Centre, the International Research Centre on Artificial Intelligence (IRCAI) in Slovenia, by providing a global view of the state of the COVID-19 pandemic. Coronavirus Watch[9] summarizes collective knowledge about the virus, including infection statistics and media reports in each country. In cooperation with the Indian Statistical Institute (ISI) in India and Redalyc in Mexico, the COVID-19 Universal Resource gateway (CURE) was created to aggregate verified openly-licensed information on the entire life cycle of the pandemic from different sources, facilitating access to relevant and accurate information on the virus for the scientific community and general public. The importance of indigenous languages as means of receiving accurate life-saving information and health care is being highlighted through work with various communities, e.g. in Ecuador where a booklet called "Instructions for Preventing Coronavirus in Ecuador's Indigenous Communities" has been disseminated to Waorani community members.

UNESCO is gathering a wide range of data to analyse the impact of COVID-19 on education and has disclosed three of them on an Interactive Map – global monitoring of school closures, total duration of school closures, and where the vaccination of teachers is prioritized (UNESCO, 2021d). Along with UNICEF, the World Bank, the World Food Programme, and the UNHCR (UN Refugee Agency), UNESCO published a framework for reopening schools (UNICEF, 2020a) and released a related supplement in April 2020. The supplement includes specific lessons and case examples on the four dimensions of the framework: safe operations, focus on learning, well-being and protection, and reaching the most marginalized (UNESCO, 2020a). UNESCO is also collaborating with GPE, UNICEF, and the World Bank to develop, distribute, and deliver global and regional learning approaches related to COVID-19 through a grant of USD25 million (GPE, 2021).

Moreover, UNESCO is endeavouring to tackle myths arising from the pandemic and deliver accurate information to the public. Its EU-funded #CoronavirusFacts project seeks to provide the necessary messaging for COVID-19 responses and contain the spread of disinformation which is detrimental to democracy, sustainable growth, and stability. By advocating for freedom of expression and access to information, the project builds the capacity of media to help it become more professional, diverse, and independent;

enhances the regional fact-checking bodies to counter disinformation; and allows critical assessment of COVID-19 information by youth and other citizens by training them in media and information literacy (UNESCO, 2021e).

The outcomes have been as follows. Over 25,000 journalists, fact-checkers and communicators from 157 countries have been trained through 3 MOOCs (massive online open courses) and a global webinar on vaccines, fact-checking, and reporting about the pandemic (UNESCO, 2021f). Thousands more have been trained by UNESCO field offices, including over 1,100 journalists and government officials in Iraq, over 120 journalists in Haiti and over 1,500 journalists and content producers across target countries and regions in Africa including Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Ethiopia, Kenya, Mali, Mozambique, Niger, Nigeria, Senegal, Somalia, Togo and Zimbabwe. At the global level, the project contributed to the 2020 Global Media and Information Literacy (MIL) Week, which was themed "Resisting Disinfodemic: Media and Information Literacy for Everyone and By Everyone", and reached over 480,000 people. This included 144 shortlisted participants from 42 countries who competed in the Global MIL Youth Hackathon.

In April 2021, the project co-funded the launch of the new curriculum resource called Media and Information Literate Citizens: Think Critically, Click Wisely. Over 2,000 participants connected live to the launch, which also reached some 17,000 people through social media streaming. Also, the Resource Center for Responses to COVID-19 was set up and made available in seven languages under this project, with co-funding from the Norwegian Ministry for Foreign Affairs and UNESCO's Multi-Donor Program on Freedom of Expression and the Safety of Journalists.

UNESCO's field offices worked with local partners to establish regional and country-level resource hubs tailored for local needs. For example, the platform PortalCheck.org was developed with an alliance of 35 fact-checking organizations in three languages with resources and tools to help combat mis/disinformation surrounding the COVID-19 pandemic in Latin America and the Caribbean. In Kenya, over 200 young people from 138 youth organizations were trained to identify, debunk and counter disinformation and online abuse. In Cameroon, 120 leaders of 35 CSOs from 10 regions were trained on hate speech and discrimination in relation to COVID-19. Through a series of activities they formed a CSO network and set up an online platform for continued collaboration. A community radio collaboration platform was established as a joint activity under the #CoronavirusFacts project and International Programme for the Development of Communication (IPDC) in 14 sub-Saharan African countries, across which 300 radio professionals use it. Now they are formalizing their collaboration into a network. In Haiti, UNESCO and its partners raised awareness about the consequences of disinformation, hateful narratives and incitement to violence and launched a platform with key documents to report on gender-based violence as part of 16 days of activism on this problem, which had increased during the lockdowns.

Moreover, UNESCO and the WHO have worked together to produce radio messages to provide reliable health information and deconstruct myths on COVID-19 (UNESCO, 2021g). Three radio messages on vaccines and seven on prevention and protection were produced in five languages, and are freely downloadable for broadcasting by public, private and community radio stations. Capacities to broadcast Stay-at-Home Radio are being built up. UNESCO has developed a strategy for the realization of a one-week multilingual online training programme aimed at equipping local radio stations to produce accurate and professional content in the event of lockdown measures or emergency situations, and the associated financial difficulties. Moreover, in helping media tackle the crisis, UNESCO (2021h) produced nine professional audio spots for radio programmes, which were broadcast worldwide. Four of them were available in more than a dozen languages including Arabic, Castilian, English, French, Fulfulde, Hausa, Kazakh, Mandinka, Russian, Spanish, and Swahili. Two series of pre-rolls[10] for social media and TV spots were produced in

Table 8: Three nodes of the CoMo Consortium Development phase

Table 1 The three nodes of the CoMo Consortium Development phase

Development node	In-country expert nodes	Policymaker nodes
► Lead modeller ► Experienced modellers ► Clinician modeller (public health specialist) ► App developer ► Coordinator (junior modeller) ► Economist	► Research clinician/preparedness modellers ► Epidemiologists/surveillance specialists (field/public health) ► Modellers (early stage/senior) ► Public health specialists ► Health economics modellers ► Medical statisticians ► Representatives from WHO/other NGOs	► State government ► State ministries of public health ► National ministries of public health ► Local governing bodies and their health departments

Source : Aguas et al. (2020)

Arabic, English and French (UNESCO, 2021i). More than 10 international networks involving hundreds of media institutions disseminated the content. UNESCO also produced visuals, graphics and social media messages on e.g. information overload, quality journalism, and conspiracy theories, to counter disinformation, fight discrimination, and promote best practices in various languages (UNESCO, 2021j).

2.2.5 The CoMo Consortium's COVID-19 modelling support for LMICs

Whilst high-income countries rely on self-modelling to predict epidemics and set containment strategies, many LMICs adopted health policies by following the initial modelling done in Global North settings, often without considering how the predictions may be influenced by local contextual factors. To address this problem, on 16 March 2020 the CoMo (COVID-19 Modelling) consortium was created by researchers at the University of Oxford together with academic colleagues at Cornell University. It is partnering with 100 infectious disease modellers and other public health experts from more than 40 countries across Africa, Asia, and South and North America as well as global entities such as the WHO. The consortium allows for experts from different countries to take part in developing models while highlighting the need for contextual factors to be reflected in policy design, such as population age structure, financial status, labour force, health system capacity, and sociocultural elements. CoMo provides a list of these factors so that they can be taken into consideration in epidemiological models.

The CoMo consortium adopts a participatory approach to modelling. Models are developed by three sets of expert groups, each consisting of one of three nodes (see Table 8): the development node, in-country expert node, and the policy-maker node. Each node is composed of a diverse team of experts from both international and domestic settings.

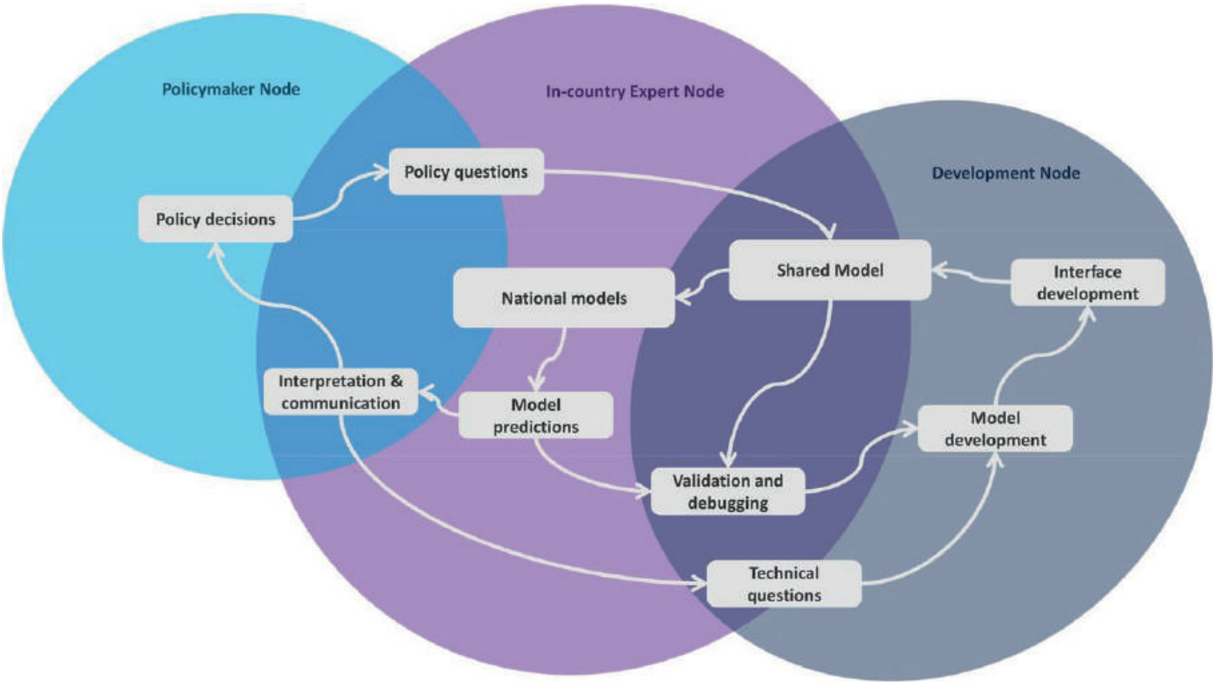
CoMo operates according to the interaction flow in Figure 52. Questions on the shared model by in-country experts act as the catalyst for customization. The in-country experts engage with technical experts on validation and with policy-makers on model predictions (Aguas et al., 2020).

The success of the participatory approach adopted by the CoMo consortium lies in the in-country expert node. This node contains experts in communicating with policy-makers and forming reactive models. This expedites the processes of turning analytical requirements into policy outcomes and adjusting models and online applications according to the country's needs.

2.2.6 UN Global Pulse's COVID-19 modelling of refugee and internally-displaced-person (IDP) settlements

UN Global Pulse (UNGP) was founded under the UN Secretary-General's initiative to apply big data and emerging technology such as AI, for development, humanitarian action, and peace. UNGP has been working to support

Figure 52: Interaction flow of the CoMo Consortium



Source : Aguas et al. (2020)

multiple UN agencies and governments throughout the pandemic by developing a range of new tools, methods and analytical capabilities including epidemic simulations, natural language processing (NLP) for infodemic responses, and econometric modelling for cross-border migration. UNGP is also a member of the Broadband Commission for Sustainable Development.

Since early 2020, UNGP has been working closely with the Africa Infodemic Response Alliance (AIRA) coordinated by the WHO to create tools for analysing social media data to assess disinformation and disinformation. Regular monitoring through off-the-shelf and custom-built NLP methods have fed into weekly AIRA reporting and supported social listening efforts and the development of communication campaigns. UNGP have also embarked on a range of capacity-building exercises with the WHO, presenting at the WHO's Infodemic Manager training courses and conferences.

Radio remains one of the most reliable and affordable ways of accessing and sharing information with some 44,000 stations worldwide as reported by UNESCO. Despite wide coverage across developing nations, with the majority of household having access to the radio, few methods exist with which to collect and analyse radio discourse on a large scale. To address this, the UNGP has been building a radio monitoring pipeline, in collaboration with the WHO's infodemics team. The pipeline collects audio data from online radio stations, transcribes them using machine-learning models, and exploits NLP techniques to analyse the content. An interactive visualization tool has also been produced to allow decision-makers to explore the data and derive actionable insights (WHO, 2021f).

The spread of COVID-19 and other pandemics not only aggravates existing inequalities but hits hardest on the most vulnerable population. Settlements for refugees and IDPs with high population density and poor infrastructure are especially prone to the spread of diseases. In order to support data- driven decision-making, the provision of detailed information on potential transmission mitigation strategies can be of vital importance. In May 2020, UNGP began to work with public health and camp management officials from the UNHCR and WHO in the Cox's Bazar settlement in Bangladesh to investigate how computational epidemic modelling efforts could inform decisions on operational interventions. The group designed an agent-based modelling approach which involved building a "digital twin" of the settlement that could then be used to simulate the effects of different NPI policies in Cox's Bazar. UNGP also developed a visual analytics tool for policy-makers to compare different simulations and outcomes, and evaluate the effectiveness of measures such as mandatory face masks and the reopening of educational facilities. Insights from this project have been used for advocacy purposes, as well as to inform current and future decision-making in the settlement. Although the model was developed and tested mainly for refugee settlements, it can also support decisions in other contexts.

UNGP has also partnered with the WHO's Eastern Mediterranean Regional Office (EMRO) team to deploy this modelling approach to better understand and categorize the risks posed to IDP communities in Somalia, and is assessing further development in the EMRO region. The team has also begun collecting insights from other teams carrying out modelling efforts in similar geographies to promote future work and coordination in supporting these vulnerable populations (Aylett-Bullock et al., 2021).

Endnotes

1 The Gini coefficient is based on the comparison of cumulative proportions of the population against cumulative proportions of income they receive, and it ranges between 0 in the case of absolute equality and 1 in the case of absolute inequality (OECD Data, n.d.).

2 A collegiate health body composed of the health ministers of the regional governments and autonomous cities, and the Minister of Health

3 https://www.dw.com/en/covid-19-why-is-chinas-vaccination-rate-so-low/a-57183859

4 VAT refunds amounting to KES 10 billion to be accelerated by the Kenya Revenue Authority for all verified claims. KES 1 billion to be appropriated from the Universal Health Coverage to recruit additional human resources in health services. https://www.bowmanslaw.com/insights/tax/covid-19-the-kenya-governments-economic-stimulus/

5 All arriving diplomats and their families and honorary consuls are exempt from testing https://moh.gov.lr/covid-19-testing-protocol/

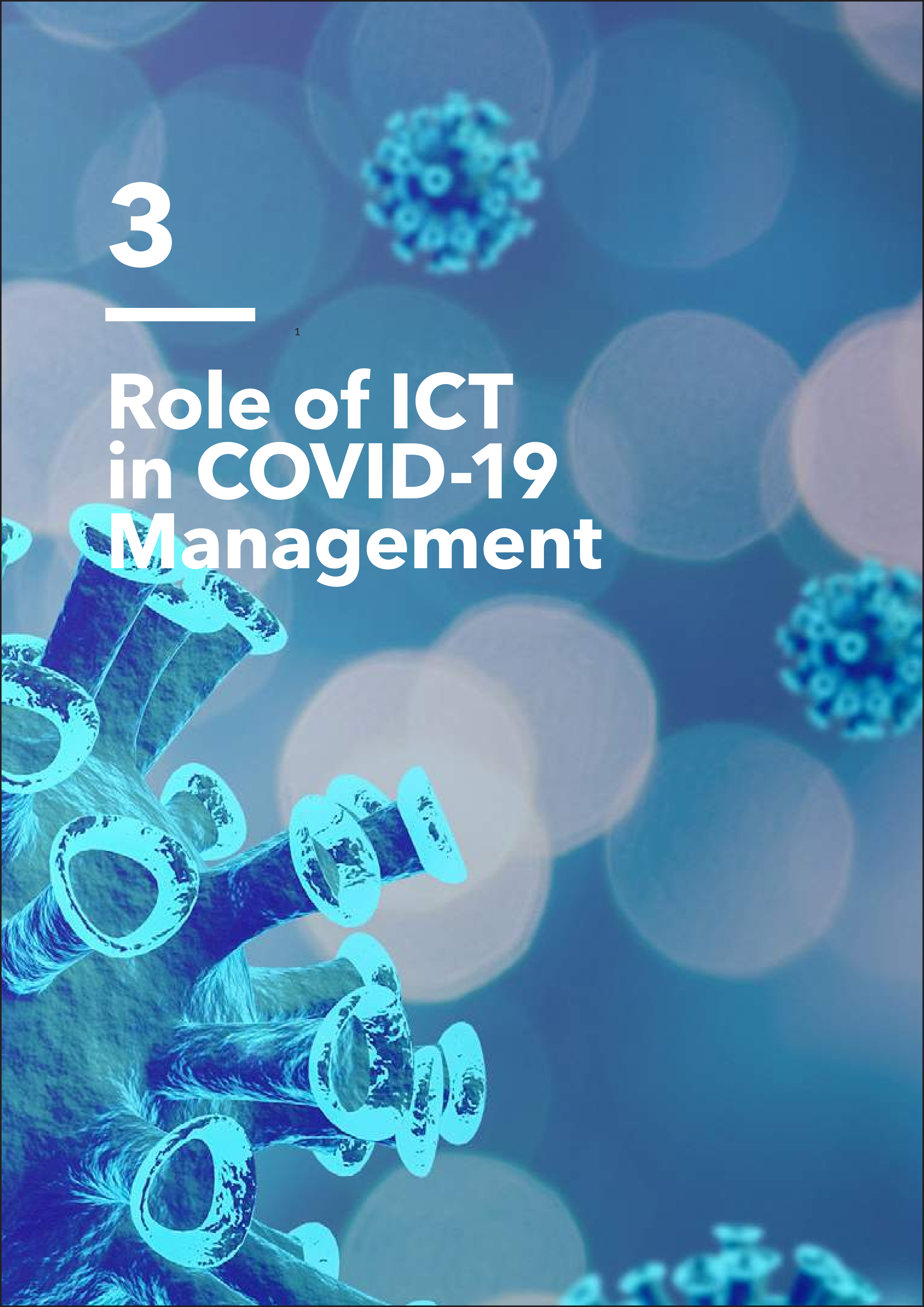
6 Now there are 7 African countries utilizing mHero - DRC, Kenya, Mali, Uganda, Guinea, Liberia and Sierra Leone. https://www.mhero.org/country-deployments

7 Stopping sport fixture(97%), musin concerts(95%) and prayer gathering(72%). https://www.ipsos.com/sites/default/files/ct/publication/documents/2020-05/liberia_report_0.pdf

8 https://www.itu.int/en/SiteAssets/COVID-19/ITU-COVID-19-activities.pdf

9 https://en.unesco.org/news/corona-virus-media-watch-launched-unescos-international-research-centre-artificial-intelligence

10 Short advertisements that play before online videos



3

Role of ICT in COVID-19 Management[1]

3 Role of ICT in COVID-19 Management

3.1 Importance of ICT Responses to New Infectious Diseases

ICT has often been crucial in pandemic responses and is being deployed to an unprecedented extent for COVID-19. As observed in section 2.1, it is used not only to contain diseases but also as a means to carry on with essential activities such as education, health, and shopping, that sustain social functions amidst control measures. This chapter explores actual cases to determine the part that ICT plays in COVID-19 management, as well as its potential role in the future.

In their paper "Digital technologies used in the COVID-19 pandemic", Budd et al. (2020) suggest five frames for how ICT has been used to fight COVID-19 according to medical demand: digital epidemiological surveillance, rapid case identification, interruption of community transmission, public communication, and clinical care. Specific applications of each one are shown in Table 9 and discussed in turn below.

Digital epidemiological surveillance

When responding to an infectious disease, the key function of public health authorities is to find out when, where, and how the transmission occurred and to come up with effective strategies to mitigate the risk factors. Various digital data sources can be used in this process to provide insight to public health institutions. For new infectious diseases, the existing syndromic surveillance network tracks evidence provided by hospitals or healthcare facilities such as "influenza-like illness". However, the network cannot track cases that have not passed through medical facilities, creating a weak point in the containment effort. The recent adoption of machine learning and natural language processing in disease surveillance makes up for this weakness by allowing efficient and timely tracing through data collection and analysis from social media, online news, and websites. Strategy-making is also facilitated through advanced data analytics which use real-time statistics on tests and confirmed cases and deaths. A wide range of

Table 9: Digital technologies used in the COVID-19 pandemic

Public health need	Digital tool or technology	Example of use
Digital epidemiological surveillance	Machine learning	Web-based epidemic intelligence tools and online syndromic surveillance
	Survey apps and websites	Symptom reporting
	Data extraction and visualization	Data dashboard
Rapid case identification	Connected diagnostic device	Point-of-care diagnosis
	Sensors including wearables	Febrile symptom checking
	Machine learning	Medical image analysis
Interruption of community transmission	Smartphone app, low-power Bluetooth technology	Digital contact tracing
	Mobile-phone-location data	Mobility-pattern analysis
Public communication	Social-media platforms	Targeted communication
	Online search engine	Prioritized information
	Chat-bot	Personalized information
Clinical care	Teleconferencing	Telemedicine referrals and appointments

Source : Budd et al. (2020)

COVID-19 dashboards display statistical data and containment trends by region through charts and heatmaps. Open-source solutions also allow for quick collection and analysis of data to better respond to COVID-19.

Rapid case identification

The essence of containing an epidemic is to detect confirmed cases at an early stage, isolate them, and identify their contacts. People with symptoms can be identified through online reporting, and secondary infections for even asymptomatic cases can be prevented through quick contact tracing – using digital or offline efforts. Sensors such as thermal imaging cameras may be used for crowded spaces like airports to detect potential infections. The development of wearable technology and connected diagnostic tests[1] relieve the burden on labs. Machine learning algorithms have also been explored to automatically analyse hospital chest scans to identify COVID-19 cases.

Interruption of community transmission

Once a case has been confirmed and the person is quarantined, their contacts should be traced and isolated as soon as possible to prevent further infection. ICT is essential in this process as it is difficult to manually trace the vast number of contacts in the places most prone to infections. The tracing process can be automated digitally in ways that are incomparable to previous methods in terms of both speed and scale. Analysing data from GPS, cellular networks, Bluetooth, and Wi-Fi, enables monitoring of the population flow and hotspots and offers insight for effective public health interventions (e.g. social distancing and travel restrictions). ICT has the potential to play a leading role in containing pandemics if properly implemented. These interventions should be designed in collaboration with citizens, while protecting privacy and security.

Public service delivery, communication and socio-economic engagement

Appropriate communication strategies are necessary to win public trust and cooperation so that the government's interventions can be effective. Digital platforms and channels – including social media – allow immediate communication with large groups of people, and can support people's daily lives during pandemics by allowing them to remotely learn, work, and receive medical consultations.

Clinical care

Telemedicine technology can be used appropriately to manage COVID-19 patients as it can support symptom management and provide advice on self-isolation (Greenhalgh et al., 2020). Hollander et al. (2020) identifies telemedicine as a 21st century approach to "forward triage", a strategy to deal with increasing medical demands, as it effectively screens patients and prevents contagion among patients, doctors, and the community.

Pharmaceutical interventions

Although Budd et al.'s (2020) framework is mainly about ICT in non-pharmaceutical interventions because the analysis was mostly focused on responses in the early stage of the pandemic, ICT can also support pharmaceutical interventions. AI and big data contributed to the speedy development of COVID-19 vaccines and treatment, including isolating the structure of the virus through the selection of substance candidates as well as delivering supplies during the vaccination process. AI was used in predicting the protein structure of the COVID-19 virus to discover the most potential substance from tens of thousands of candidates. It also contributed to accelerating the drug development process, identifying existing drugs that can treat the infection. When Remdesivir was proven to be effective for treating COVID-19, pharmaceutical companies used AI to find similar medication and as a result, Baricitinib – traditionally used to treat rheumatoid arthritis – was added as well.

The impact of AI on the development of vaccines and treatments led to various initiatives on both the public and private levels to fund AI-based research. Governments and scientific institutions have been discussing measures to share documents and data related to the virus. At the private level, researchers have also been provided with power through grid computing to facilitate the analysis of large amounts of data (OECD, 2020e).

Building on the framework proposed by Budd et al. (2020), the use of ICT in COVID-19 can be categorized into six purposes (see Table 10).

The impact of ICT in promoting disease response policies for successful prevention has been proved through computer simulations. Researchers from the University of Oxford compared contact tracing conducted through mobile applications with traditional interview surveys to find out whether ICT increased the efficiency of containment policy efforts in communities (Ferretti et al., 2020). The traditional epidemiological investigation inevitably took time as it consisted of receiving a report of a confirmed case, manually tracing the contacts, and going through the stages of intervention such as self-isolation. The time delay amounted to an average of a week, indicating a higher likelihood of secondary infections. On the other hand, digital contact tracing, which stores temporary records of contacts through the Bluetooth signal of smartphones to quickly alert them when there is a confirmed case (see Figure 53).

The research results (see Figure 54) show that the quick isolation of cases (X axis) and quarantine of contacts (Y axis) lead to higher success rates for intervention, thereby lowering the reproduction number for effective control of the disease (green area). However, the longer it takes to quarantine cases and contacts, the lower the efficiency of the disease control. Unlike the ICT-based contact tracing method which shows immediate effect, the threshold for epidemic control (solid black line) curves upward as time passes.

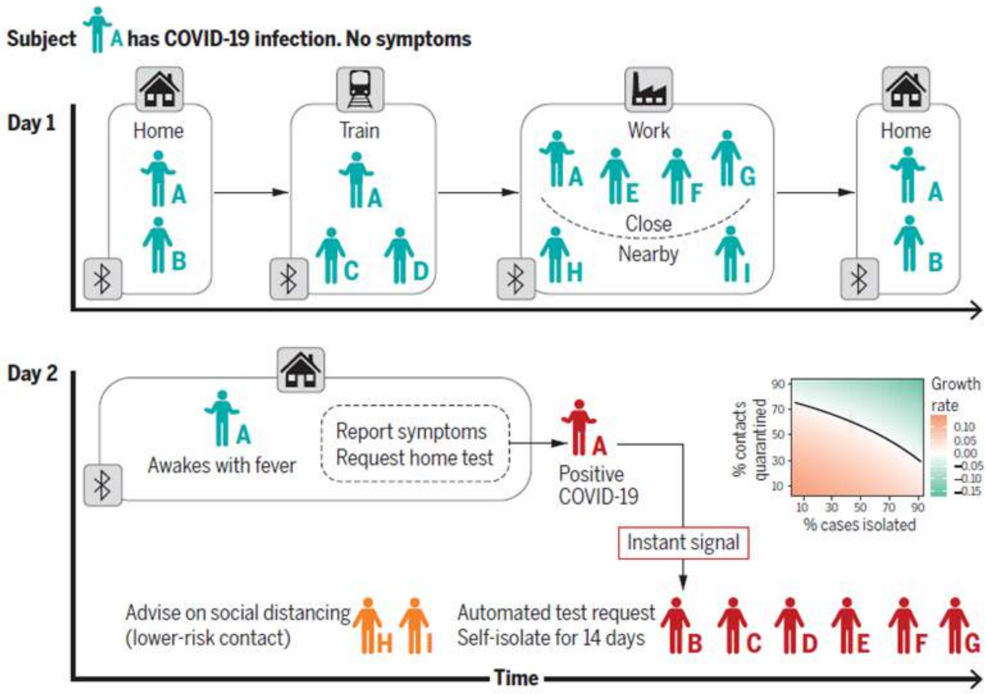
For the contact alert system to be truly effective, it is important to have as many people as possible use the app. Apps can play an essential role in ending the pandemic, as long as a sufficient proportion of people use them. According to a simulation carried out by the Oxford Big Data Institute, a resurgence of COVID-19 could be effectively inhibited if 56 per cent of the United Kingdom population and 80 per cent of smartphone users were to use digital contact tracing apps.

Moreover, apps may contribute substantially to infection control and lower fatality rates even if its adoption rate is not as high. Joint research by the University of Oxford and Google found that with high adoption rates (75 per cent), the total number of deaths would fall by 78 per cent and confirmed cases by 81 per cent. When the rates stand low at 15 per cent, the

Table 10: ICT-based approaches in COVID-19 responses by purpose

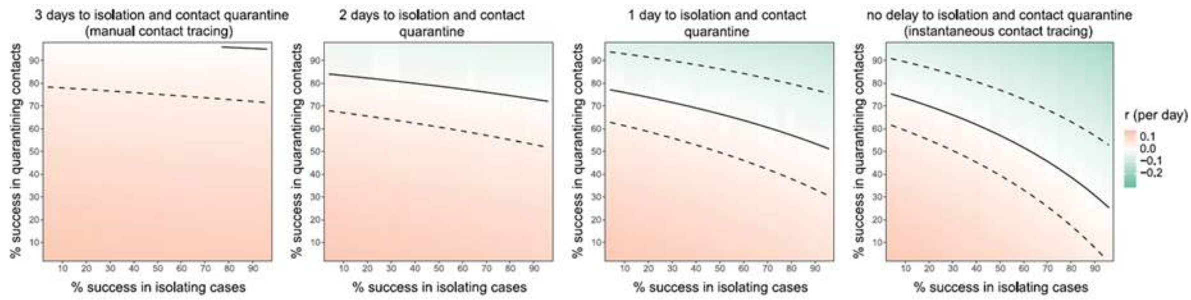
Purpose	ICT-based approaches
Digital epidemiological surveillance	Prediction of infectious disease using AI and big data COVID-19 surveys through SNS (Social Network Services)
Rapid case identification	Analytics-based thermal detection solution Digital credentials to support safe and convenient travel Early diagnosis of COVID-19 through wearable devices
Interruption of community transmission	3T-based contact-tracing ICT solutions
Public service delivery, communication and socio-economic engagement	COVID-19 emergency alert text messages Online public education service E-commerce
Clinical care	Telemedicine
Pharmaceutical intervention	Development of vaccines and treatment using AI Digitalization of COVID-19 vaccine cold chains

Figure 53: Principle of Bluetooth-based digital contact tracing app



Source : Ferretti et al. (2020)

Figure 54: Effectiveness of pandemic control by time taken to quarantine contacts



Source : Ferretti et al. (2020)

number of confirmed cases would decrease by only 11.8 per cent, and total deaths by 15 per cent. Nonetheless, even if they are less effective because of low adoption rates, the apps may be used to complement social distancing and epidemiological surveys to save countless lives in the long run.

Meanwhile, the gap in ICT accessibility between countries as well as between domestic income levels should be examined. For example, as of 2019 when 3.78 billion people had mobile Internet access, the usage rates for North America, Europe and Central Asia, and East Asia and the Pacific Region, were 76, 70, and 60 per cent respectively, whereas the rate for sub-Saharan Africa and South Asia was only 26 per cent (GSMA, 2020). ICT-based interventions should therefore be tailored to the target region and group. Specific measures to increase broadband access include public-private investments in infrastructure and R&D, subsidies for service fees and devices, and reviews of applications and devices that do not require seamless connectivity for regions where broadband is simply unavailable (Whitelaw et al., 2020).

The next section examines some examples of what facilitated the response to COVID-19 by looking at each of the six purposes in Table 10.

3.2 Examples of ICT-based Responses to COVID-19

3.2.1 Digital Epidemiological Surveillance

3.2.1.1 Prediction of infectious diseases using AI and big data: BlueDot

The era of AI and big data has paved the way for revolutionary changes in the real-time monitoring, prediction, and tracing of transmission routes in the outbreak of infectious diseases. The onset of the new coronavirus was detected by AI-based anticipatory computing, warning of a pandemic risk. AI algorithms such as BlueDot and HealthMap collect and analyse a tremendous amount of online data including keywords, news, social media, and health organization websites, for evidence of infectious disease. The speed and accuracy of the algorithm's warnings define the successful early response of health authorities. Although the frequency and pace of disease transmission are increasing, so is the rapid development of analytics technology such as AI and big data.

Early predictions based on data-sharing are crucial for addressing the risks of global pandemics. The WHO employed advanced technology following the Zika virus outbreak in 2016 to analyse data on infections. This led to the development of various solutions by related institutions and companies that contributed to the detection of COVID-19.

After detection, data and analytics facilitate diagnostics and treatment. IoT development is also expected to assist the use of data- based solutions for predicting infectious diseases. Predictions and advanced responses can also be enabled through the analysis of health data created from our daily lifestyle for advanced response. More quality data will ensure better detection accuracy.

BlueDot – a start-up company offering AI services for infectious diseases – was the first to report signs of the new coronavirus. The Canadian company, founded in 2003 by Dr Kamran Khan following the SARS outbreak, offers global monitoring of outbreaks and disease transmission through AI. BlueDot detected the new virus in 2019, and it sent an alert to its clients on 30 December. The company became widely known for having warned of the virus nine days prior to the WHO's official declaration (Bluedot, 2020; CNBC, 2020b).

COVID-19 was not the first pandemic predicted by BlueDot. It analysed billions of passenger itineraries and the medical data of confirmed cases during the 2014 Ebola outbreak in West Africa, projecting that it would spread to other countries and continents. Indeed, the virus spread to the United States. BlueDot was also accurate in its prediction about the Zika virus in 2006 when it emerged from South America. Eighty-four pregnant women contracted the virus in Florida, approximately six months after BlueDot's warning that Zika would reach the state.

BlueDot's AI algorithm uses machine learning and NLP to collect and analyse data every 15 minutes from disease-related news articles, government press releases, anonymized flight itinerary data of the International Air Transport Association (IATA), discussions on medical forums and symposium websites, reports by relevant organizations, and blog posts by experts. It can also collect disease-related information from about 150 sources, including Global Infectious Disease Alerts, real-time weather forecasts, and national statistics on e.g. population density.

BlueDot understands 65 languages and can review over 10,000 documents in a single day. The company's affiliated doctors, veterinarians, and data experts review the data that is collected and analysed by the AI algorithm and alert their clients if they believe the information is credible.

It is through such big data analysis that BlueDot's system was able to catch signs of "unusual pneumonia" in Wuhan, China, which marked the beginning of the COVID-19 pandemic. BlueDot went on to analyse location-based services data provided by the Chinese company Baidu from 2013 to 2015, and IATA's air transport data from 2018, to predict the transmission path of COVID-19. It was thus able to compile a list of cities most prone to the disease. It indeed turned out that early outbreaks of COVID-19 occurred mainly in the countries whose cities topped the list.

3.2.1.2 GSMA's AI4I-Based COVID-19 Response Activities

The AI for Impact (AI4I) initiative run by the Global System for Mobile Communications Association (GSMA) is a global taskforce of 21 mobile network operators and 12 UN agencies launched in 2017, that develops best practices and increases awareness of utilizing mobile data to respond to global challenges. With the outbreak of COVID-19, GSMA reinforced the collaboration between governments of LMICs and mobile operators to support the analysis of mobile big data (MBD) and tools for AI decision-making (GSMA, 2021).

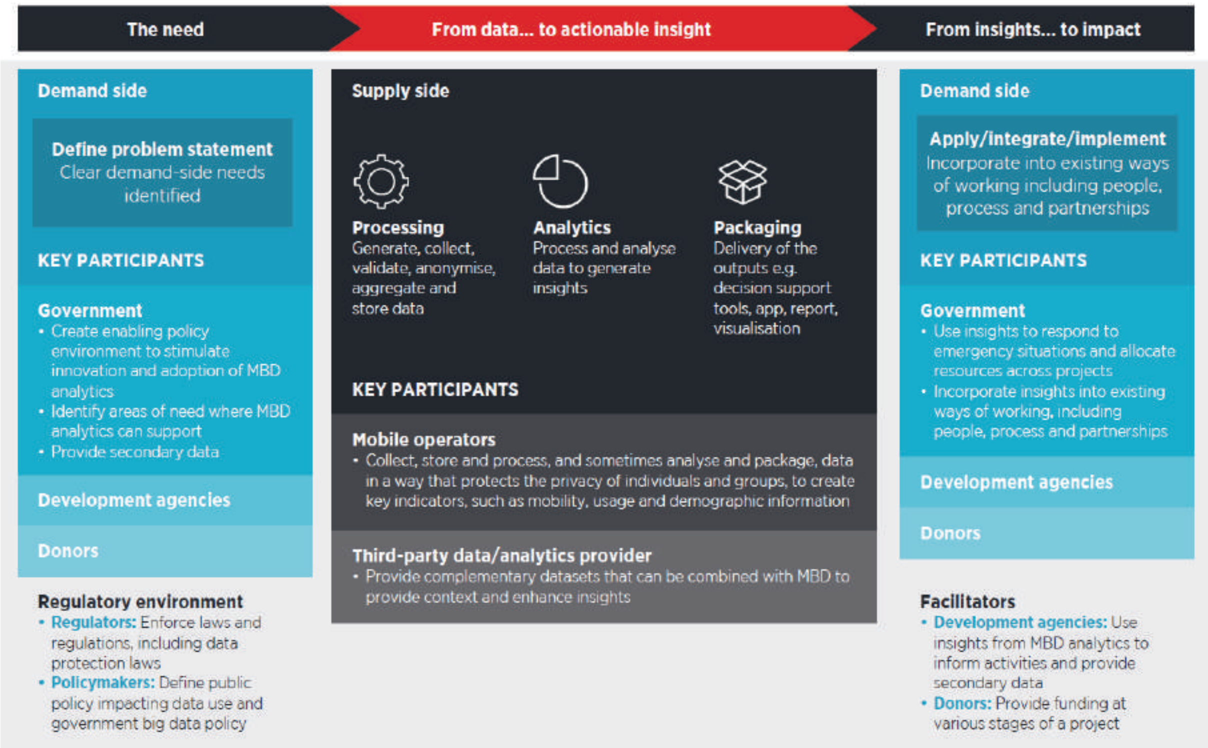
Funded by the United Kingdom's FCDO (Foreign, Commonwealth & Development Office), the goal of the 10-month project was to build local capacity, share knowledge, and maintain high ethical standards in using MBD and AI. AI4I's ecosystem consists of various stakeholders who transform MBD into applicable insights and valuable goods and services (see Figure 55). Demand-side bodies (e.g. governments, development agencies and donors) apply the insight gained from the movement patterns of goods and services obtained through MBD analytics to key decision-making processes, response measures, and resource planning. Mobile operators are on the supply side of the ecosystem and produce data for insight into specific population characteristics and mobility patterns. AI4I's response to COVID-19 is based on four pillars: 1) global insight captures knowledge and best practices from MBD applications around the world; 2) public-private collaborative partnerships develop local capacity and create scalable and sustainable goods and services; 3) privacy and ethics ensure compliance with key principles throughout the entire value chain and project lifecycle; and 4) knowledge-sharing entails the widespread and open dissemination of lessons and best practices.

AI4I is implemented in a six-phase engagement process to facilitate cooperation between local stakeholders and successfully deliver scalable, sustainable, and replicable solutions (see Figure 56). In practice, the iterative feedback loops last throughout the project lifecycle.

The GSMA report introduces four AI4I case studies from the DRC, Benin, Burkina Faso, and Rwanda. In the DRC, AI4I was introduced through a MBD dashboard providing insights on population mobility patterns, hospital capacity, and hotspots; a report on mobility with preliminary signs of economic pressures; and an epidemiological model based on mobility and health indicators. The government was therefore able to evaluate the compliance levels of lockdowns, check for unintended consequences arising from the lockdowns and border restrictions, and assess the risk of viral transmission.

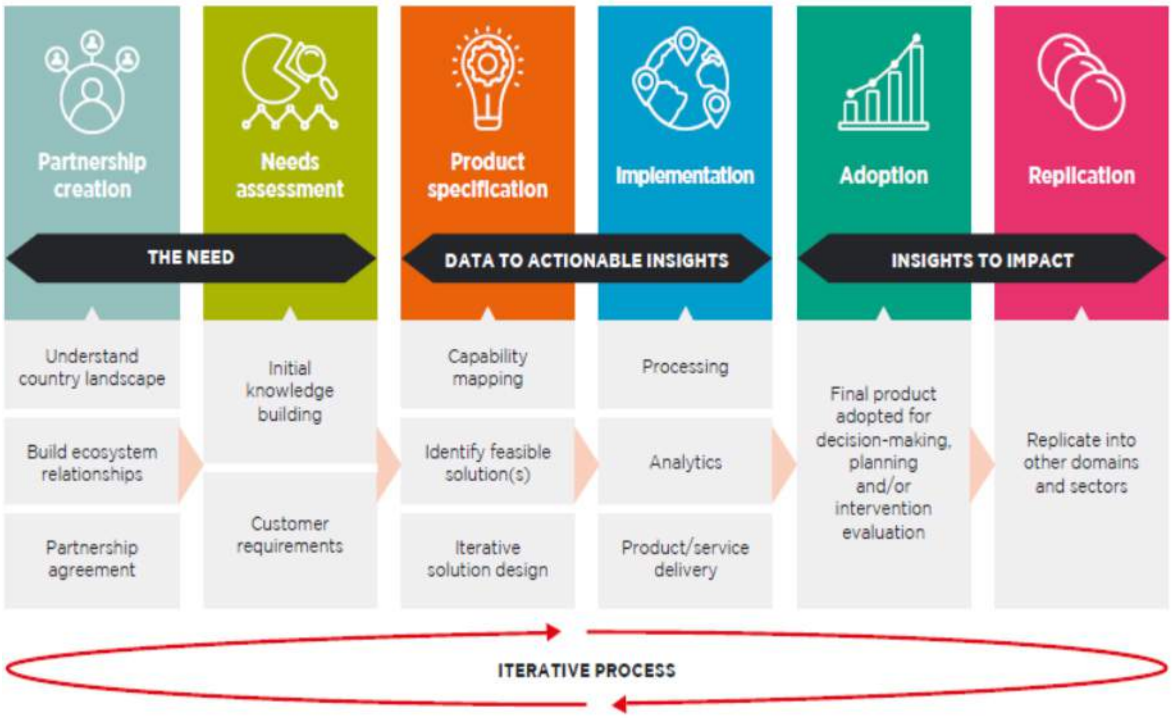
In Rwanda, AI4I analysed the changes in public transport usage according to COVID-19 control policies based on MBD. The project reported routes that were overused or underused and recommended measures to optimize the bus system, through which the government was able to improve it and meet passengers' demands. The knowledge gained through this model will be applicable to the government's smart-city and transport initiatives in the future. In Benin, the AI4I project supported the decision-making process of various government ministries by introducing MBD analytics. Together with the Francophone Agency for Artificial Intelligence in Africa (AFRIA), the GSMA developed a dashboard showing population mobility and COVID-19 risk modelling. Collaboration with local partners enabled the GSMA to come into contact with more stakeholders and make the work sustainable from the initial stages.

Figure 55: The AI4I ecosystem



Source : GSMA (2021)

Figure 56: AI4I implementation engagement process



Source : GSMA (2021)

In Burkina Faso, AI4I promoted public-private collaboration to utilize MBD analytics. The GSMA created key partnerships between e.g. the Ministry of Health, the World Bank, and the Paris-based company Orange Business Services. Through such collaborations, Orange Business Services created a dynamic dashboard to allow population mobility patterns to be used for decision-making. The insights based on MBD analytics shown on the dashboard will help authorities to decide which policies are the most relevant and actionable.

3.2.1.3 COVID-19 surveys through Facebook

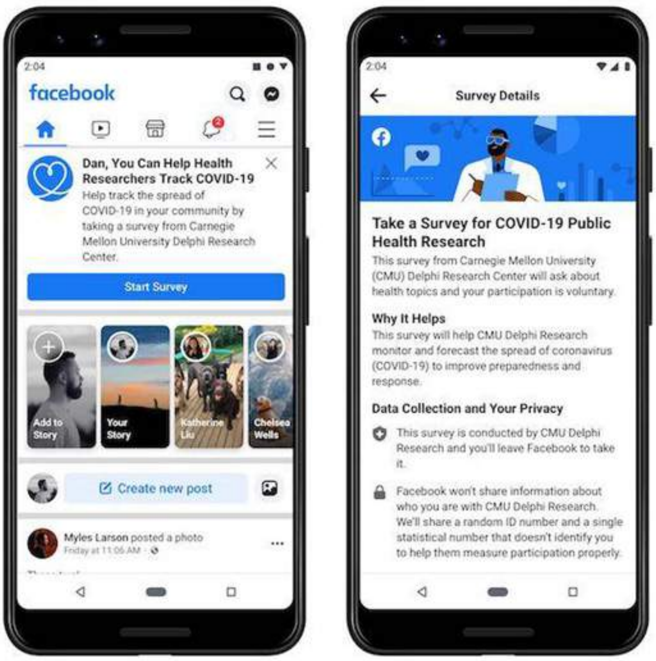
In April 2020, Facebook requested that its users complete a survey to help track the spread of COVID-19. Users were prompted to do so through a pop-up window when they accessed the app (see Figure 57). The survey was drawn up by the Delphi Epidemiological Research Center at Carnegie Mellon University as part of a mapping project to predict where the virus would hit next (Carnegie Mellon University, 2020).

Each participant is assigned a random ID number which is then provided to the research team and sent back to Facebook once the user has completed the survey. Facebook also provided a statistic known as the weight value to correct any sampling bias.

The number of participants is important in epidemiological research. According to Tibshirani[2], joint leader of the Delphi Research Group, since there is no fixed source to validate the survey results, data should be collected from as many participants as possible for reliable findings. Although Facebook did not directly participate in the survey or mapping project, its billions of users played a central role in providing meaningful data to the research institutions.

Although originally carried out domestically for United States respondents, the survey was eventually conducted globally in 50 languages through collaboration with the University of Maryland. The number of responses for the domestic and global surveys were 10.6 million and 20.3 million respectively. The domestic survey results were used to predict the demand for short-term hospitalization (Carnegie Mellon University Delphi Group, 2020; Facebook et al., 2020) Since then, MIT (2021) also conducted a Facebook survey entitled COVID-19 Beliefs, Behaviors and Norms.

Figure 57: Screenshot of survey request on the Facebook app



Source : Carnegie Mellon University (2020)

3.2.2 Rapid case identification

3.2.2.1 Nokia's analytics-based thermal detection solution

The Nokia Automated Analytic Solution identifies people with high temperatures and/or without masks and is used in crowded facilities to detect COVID-19 infections. Through advanced analytics, machine learning, and ubiquitous connectivity, it helps to reduce costs, sustain businesses, and secure supply chains. This open-architecture technology is deployed in several locations including Nokia's factory in Chennai (Nokia, 2020a).

The Automated Analytic Solution records video footage and temperature through thermal cameras to determine whether people should go through additional screening (see Figure 58). In such cases, real-time text messages or e-mails are sent to the related personnel for follow-up measures. Detection for thousands of people may be processed at multiple access points (Reuters, 2020d).

The solution also enables the blurring of faces to comply with privacy regulations, and the monitoring of multiple check points from a single central location. Nokia announced that this technology had screened over 200,000 people within two months at its Chennai facility (Silicon.co.uk, 2020).

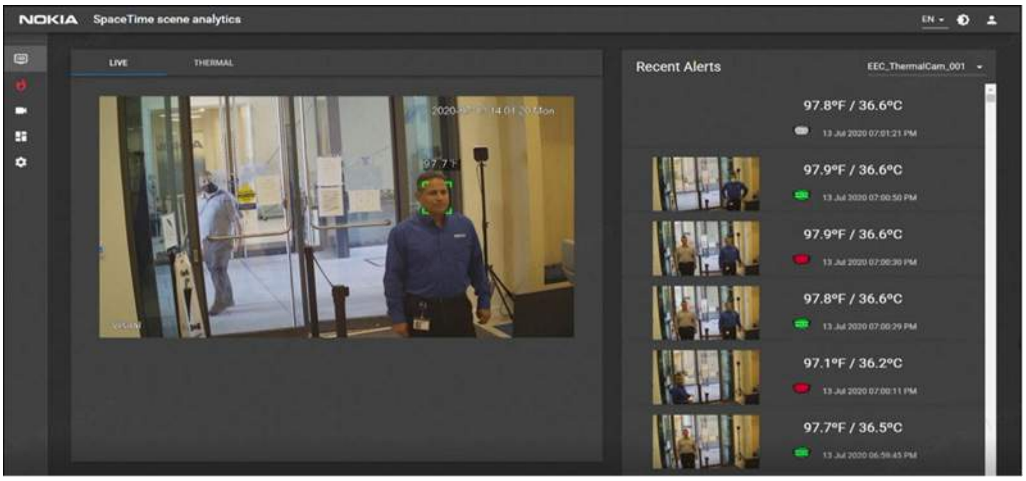
3.2.2.2 Digital credential service to support freedom of movement in the post-COVID era

The aviation and tourism industries accounted for the biggest economic loss globally from COVID-19. These industries will benefit from eased border control but the highly contagious virus, spreading disproportionately depending on the season and population influx, makes the tourism sector unlikely to flourish within the next few years.

Amidst this uncertainty, a few countries are seeking measures for freedom of movement under special conditions, examining the necessity and application of digital credentials, i.e. the so-called digital passes. These are services that support the immigration certification of travellers by digitalizing their PCR test results and inoculation records (see Figure 59). Such systems are being developed by international agencies such as the WHO (2021e) and the World Economic Forum (CommonPass, 2021).

The WHO is consulting with global agencies and vaccine groups including the UN, ITU, and Gavi on the creation of an international framework for an e-vaccine certificate (Smart Yellow Card), which would serve as a certification system for the COVID-19 vaccination. The private sector has undertaken these efforts as well: the IATA (2021) is developing the Travel Pass app solution which

Figure 58: Nokia's automatic detection of COVID-19 infections through thermal cameras



Source : Reuters (2020d)

Figure 59: Development of COVID-19 digital certificates

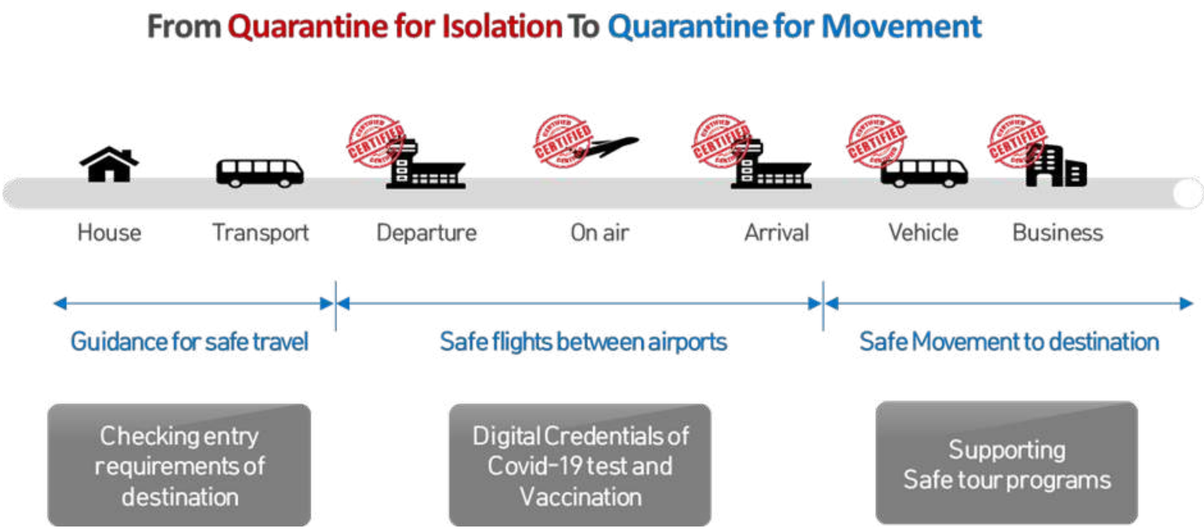
Source : ICT Works (2020)

provides PCR test results and inoculation records, as well as a list of nearby hospitals offering screening tests and entry requirements for the destination country.

KT also developed a digital credential pass, Safe2Go (S2G), in response to such global demand (see Figure 60). The Safe2Go service helps travellers to easily prepare for their international travel by providing mobile booking of COVID-19 tests before departure and issuing digital credentials for vaccinations and negative test results. This allows people to avoid paper-based credentials, which may be exposed to greater risks of forgery and accidental loss (KT, 2021). The service process requires the user to book their PCR test on the app, attend the airport's Corona Test Center at the reserved time, and then check for their PCR test result on their mobile.

Recently, Safe2Go has been adopted to the application for the travel bubble programme (Vaccinated Travel Lane) between Republic of Korea and Singapore. Inbound travellers from Singapore are guided to book tests on the Safe2Go App before departure (*Korea Herald*, 2021; Singapore Airlines, 2021).

Figure 60: KT's Safe2Go Service



Source : KT (2021)

3.2.2.3 Early diagnosis of COVID-19 through Fitbit research

Fitbit is a San Francisco-based start-up that makes wearable devices. Users can monitor their heart rates and daily activities around the clock through their devices. In May 2o20, Fitbit started clinical experiments based on algorithms for the early identification of Atrial fibrillation by monitoring heart rhythm irregularity. The company then announced that it would research algorithms for the early detection of infectious diseases such as COVID-19 (Fitbit, 2020). Participants in the study were required to provide their health data picked up on the Fitbit app and answer a few additional questions. Over 100,000 people filled out the questionnaire within two months, of which more than 1,000 had COVID-19.

On 19 August, the company said that Fitbit was able to detect 50 per cent of COVID-19 cases one day ahead of the users reporting symptoms, using logistic regression and classifiers based on neural networks. It was also reported that the heart rate variability was lowest the day following the report of symptoms; the resting heart rate was normalized in five to seven days; and the breathing rate reached a peak on the second day of the symptom onset. The results were published in *NPJ Digital Medicine* (Natarajan et al., 2020).

Fitbit also carried out joint research with the Scripps Research Institute and Stanford Medicine, which found that COVID-19 may be identified from data on self-reported symptoms that are collected from smartwatches and activity trackers using a mobile app. This was a more successful way of detecting cases than looking at symptoms alone (Scripps Research, 2020). The research team found that health data from fitness wearables led to an 80 per cent accuracy rate when identifying confirmed cases among people reporting symptoms. A total of 30,529 people participated in the study, of which 3,811 reported symptoms with 54 testing positive and 279 negative. An important factor in predicting infections was the presence of more sleep and less activity than normal. The results of this study were published in *Nature Medicine* (Quer et al., 2021).

3.2.3 Interruption of community transmission

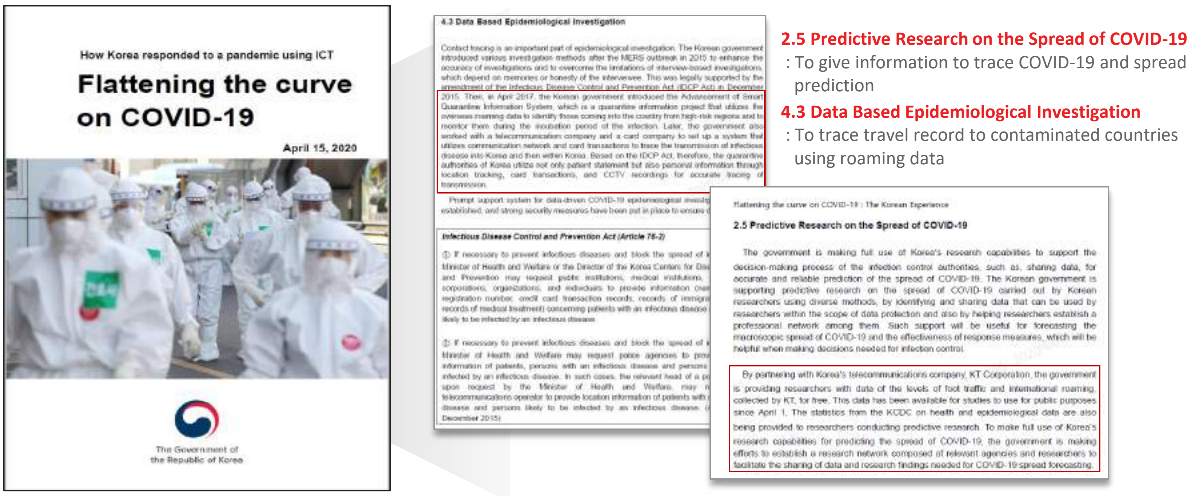
3.2.3.1 KT's GEPP and other 3T-based contact tracing ICT solutions

The Republic of Korea Government successfully controlled COVID-19 during its early transmission stage in 2020.. Swift employment of the 3Ts (test, trace, and treat) is regarded as a contributing factor and the government also continues to cooperate with the private sector on innovative technologies for faster responses. The Global Epidemic Prevention Platform (GEPP) is a representative public-private project. KT joined hands with the Ministry of Science and ICT and the Korea Disease Control and Prevention Agency (KDCA) to develop the GEPP in 2016, following the outbreak of MERS in 2015. The GEPP contributed to the prevention of another MERS outbreak in 2018 as well as the containment of COVID-19 in 2020. GEPP expanded its solutions based on the 3Ts and is contributing to national efforts to fight the pandemic (see Figure 61) in line with the Republic of Korea Government (KT, 2020a).

The testing capacity depends heavily on the streamlined process of rapid tests, accurate and quick confirmation of cases, and follow-up measures such as quarantine and treatment. When screening centres use different management systems or when the testing, care reporting, and epidemiological investigation take place manually, the national response system could be put at risk because of errors in the counting of results. As such, KT developed a Screening Test Management System that could be connected to the government's Integrated Infectious Disease Information System, offering the service in January 2021 to the KDCA.

The Screening Test Management System features a mobile application for users to make real-time reservations at nearby screening centres and to receive test results and response guidelines in a convenient and timely manner

Figure 61: Flattening the curve on COVID-19



<Korea Gov't COVID-19 policy paper >

<Introducing KT's case>

Source : Government of the Repulic of Korea (2020b)

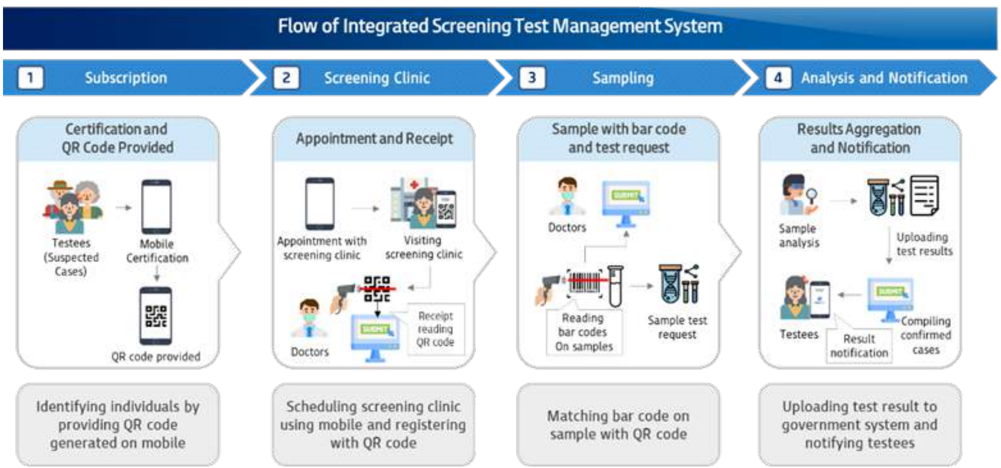
(see Figure 62). Hospitals and screening clinics can promptly register test results and report them to the central government for early management of patients. Regional statistics can be used to improve containment policies. Lastly, the system facilitates data management for the central administrative agency, allowing multiple procedures, such as information input, test result registration, and investigation and treatment outcomes, to be managed in an integrated system.

The Screening Test Management System may be synced with Digital Tracing, which identifies close contacts based on the entry log history of confirmed cases for early containment.

Digital Tracing is an early model of the GEPP, developed in collaboration with the KDCA in 2016.

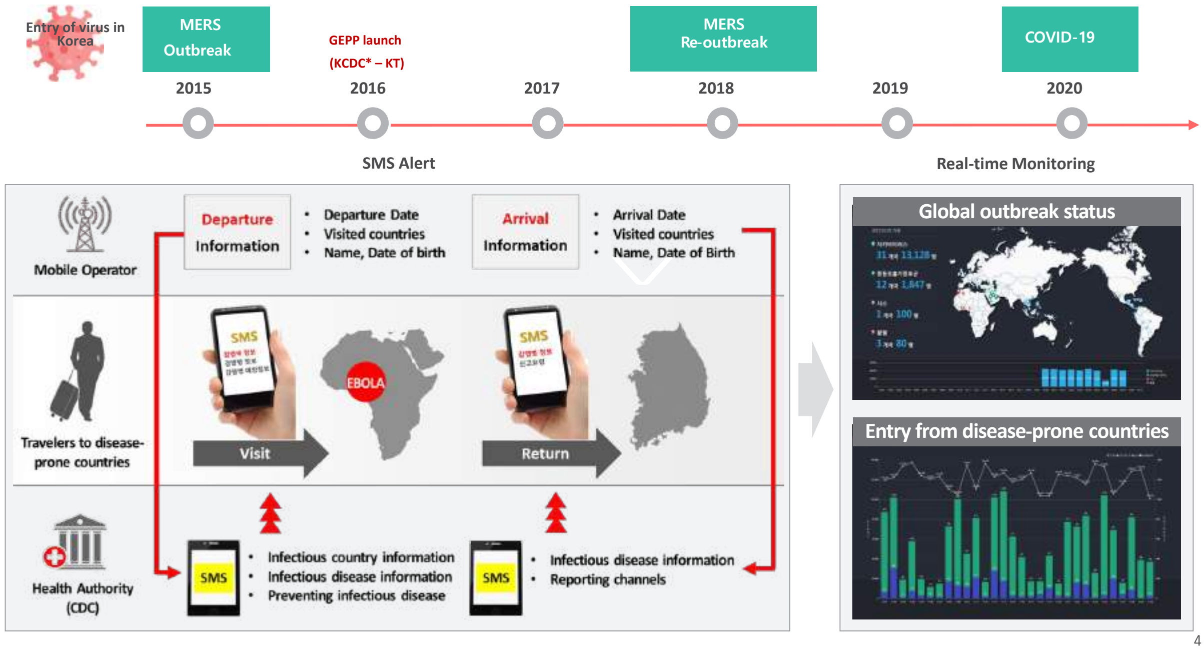
The GEPP's Digital Tracing function includes International Tracing and Contact Tracing. People visiting countries affected by pandemics are informed by International Tracing about its risks and symptoms to prevent infection (see Figure 63). The roaming data from telecoms are used to identify and monitor entry records of affected countries to prevent the inflow of the disease. Visitors to such countries are informed of ways to prevent and report the disease so that they may take firsthand measures on an individual level.

Figure 62: Procedure for KT's Screening Test Management System



Source : KT (2020a)

Figure 63: International Tracing function

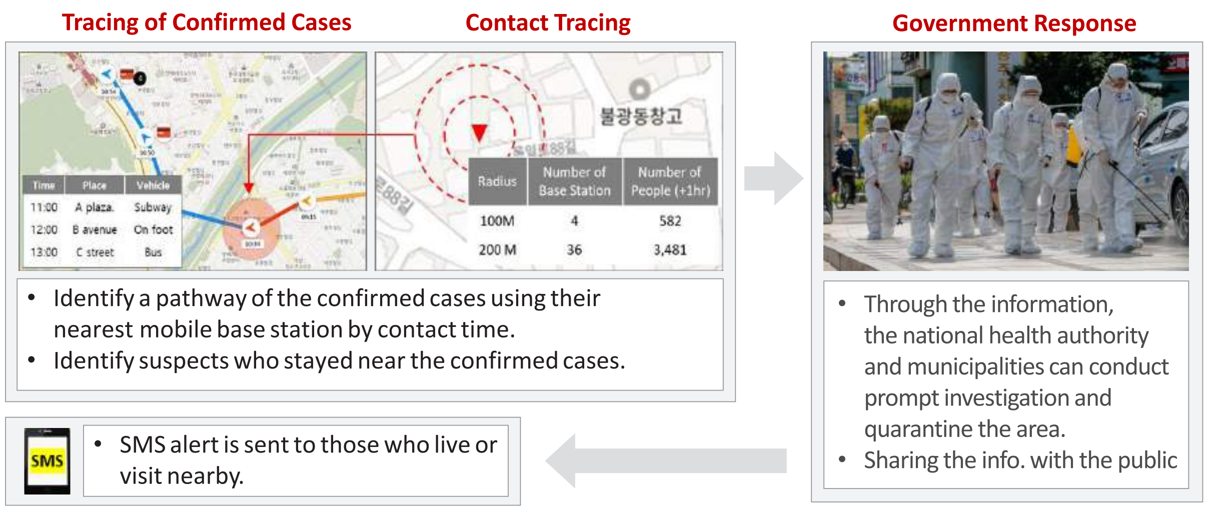


Source : KT (2020a)

Contact Tracing traces the transmission routes and contacts of confirmed cases to provide essential data to the epidemiological investigation system. Investigations carried out through interviews are prone to errors or omission, relying mostly on people's memories. The Contact Tracing system uses mobile data records to immediately provide information on the person's movements over the past two weeks. The government can then disinfect the places that were visited and send text messages to the person's close contacts, alerting them to the infection risks and the need to get tested (see Figure 64).

The QR code[3] check-in service was introduced to replace the manual entry log as part of the contact-tracing policy. However, some individuals find it difficult to use smartphones, and the check-in takes more than 10 seconds to process. KT's check-in service facilitates entry-log management with just a phone call.

Figure 64: Identification of community infections



Source: KT (2020a)

Each location has a designated number that the visitors can call to get a text message allowing them to be admitted, which takes around five seconds. An unlimited number of concurrent calls are supported so there is no need to wait in a queue. Moreover, the call log is deleted after four weeks, reducing the danger of personal information leakage. In the event of a confirmed case, the relevant local government or health clinic will request the call records from KT for quick identification of close contacts (KT, 2020b). As of August 2021, the service had been live for 11 months and had one million subscribers and 6.3 million daily users (IT Chosun, 2021). It had been accessed 425 million times, which is the equivalent of all Koreans having used the service eight times.

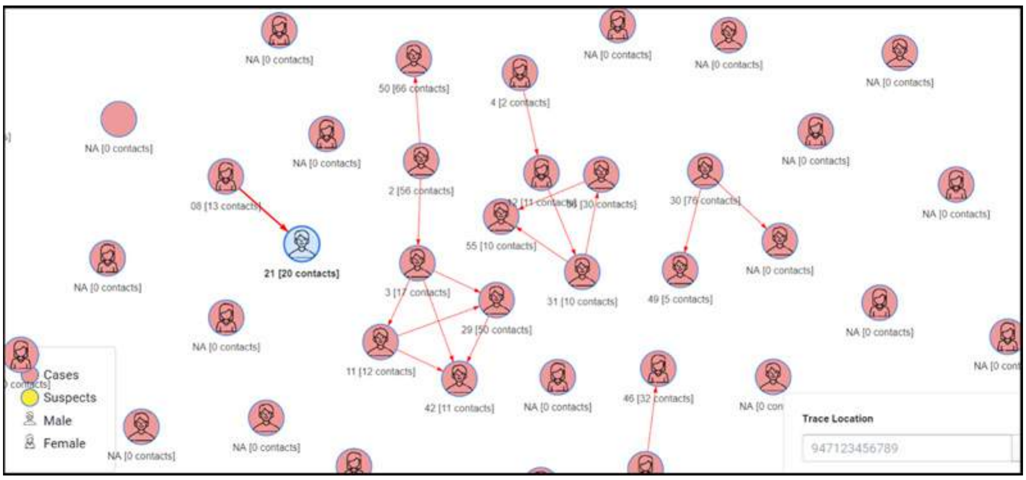
3.2.3.2 DHIS2 tracker and apps for COVID-19 surveillance in Sri Lanka

The first COVID-19 case in Sri Lanka was identified on 27 January 2020, and within two days, the Health Information Systems Programme (HISP) had built the District Health Information Software 2 (DHIS2, 2020)

The DHIS2 tracker monitors COVID-19 at the request of the Ministry of Health. The main purpose of the system is to register and track the large number of travellers from high-risk countries as part of the government's precautionary measures. Travellers are screened upon their arrival and placed under active surveillance during the incubation period of COVID-19. To meet the demand for an information system to register their information and support their follow-up, the Ministry of Health partnered with HISP Sri Lanka to develop DHIS2 for the active surveillance of COVID-19 (see Figure 65). The solution supports secure entry and analysis of both long-term and one-time individual-level data, and stages that may be customized to enable health workers to follow up on individual cases. The tracker data is used for national-level reporting and dashboards while protecting the individuals' privacy and security. The system may be implemented at the national, state, district, and medical health officer levels.

HISP Sri Lanka supported capacity-building by offering training, establishing SOPs, and creating a simple user guide. They also contributed to the global dissemination of technology by sharing the technical details with the DHIS Community of Practice and the user guide with the global DHIS2 COVID-19 response team. HISP also integrated the DHIS2 data with Sri Lanka's immigration system, location information from mobile phone towers, and local health apps, to facilitate contact tracing. Sri Lanka's multi-sector collaboration, local innovations, and information integration from different sources and sectors also made it possible for HISP to develop systems that could track and manage ICU bed availability.

Figure 65: App developed by HISP Sri Lanka to visualize and analyse contact relationships



Source: DHIS2 (2020)

3.2.4 Public service delivery, communication and socio-economic engagement

3.2.4.1 Republic of Korea's disclosure of information regarding confirmed patients through an emergency text alert system

The Cellular Broadcasting Service (CBS), launched by the Republic of Korea Government based on the Framework Act on the Management of Disasters and Safety, sends out automatic text messages to mobile users during emergencies or natural disasters. These messages have been used to inform people of COVID-19 incidences and epidemiological investigation results for follow-up actions (see Figure 66). Originally designed for 2G mobile phones in 2005, CBS's technical incompatibility with 3G mobile phones led the Framework Act on the Management of Disasters and Safety to be amended in 2012, making the service mandatory for all mobile phones from 2013 (IT Donga, 2020).

A total of 48,440 emergency text messages related to COVID-19 were sent out in 2020. The monthly number of messages has a high correlation with the number of cases. The text messages may include information on real-time incidences and close-contact tracing, transmission routes, testing and diagnostics information, or COVID-19 briefings. The messages also cover information on mask availability, COVID-19 subsidies, the closing of schools and public facilities, and access control for crowded venues (ETRI, 2021).

3.2.4.2 Online learning to cope with disruption in public education

The public education sector went through a global crisis with the spread of COVID-19. New semesters were delayed starting in early 2020, affecting elementary, middle, and high schools as well as colleges and universities. Accordingly, online education emerged as a solution.

The first semester of 2020 was delayed from 2 March to 9 April for schools in Republic of Korea. However, "voluntary online learning" was available during this four-week period, giving students access to digital materials and monitoring their progress. With the implementation of "enhanced social distancing", online classes were made available for third year students of middle and high schools from April 9 and further expanded to include first- and second-year students at these schools as well as elementary school students in years four to six.

To support this, the Ministry of Education promoted the "expansion of the public infrastructure", "enhancement of teachers' competence", and "revision of the online education system". In terms of expanding the public infrastructure, the Ministry reinforced

Figure 66: COVID-19 emergency text message

Source : IT Donga (2020)

two public online learning platforms (KERIS e-Learning and EBS Online Class) that could support 3 million users, added new EBS channels to cater to different students' needs, and offered 50,000 free public learning platforms through public-private partnerships. To enhance teachers' competence, the Ministry developed and distributed online learning models similar to in-class learning and selected 495 pilot schools as best-practice exemplars. Teachers were given guidelines on remote education and an online community was created for them to share ideas and solutions. As of April 2020, there were about 470,000 courses on the KERIS e-Learning website and EBS Online Class, with 3.97 million users accessing them on a daily basis. They provide both synchronous, interactive classes and content, and asynchronous learning based on assignments. Accessibility for teachers and students was enhanced through domestic and global platforms such as Naver Band, Kakao Talk, Google Classroom, and Microsoft Teams (KEDI, 2020).

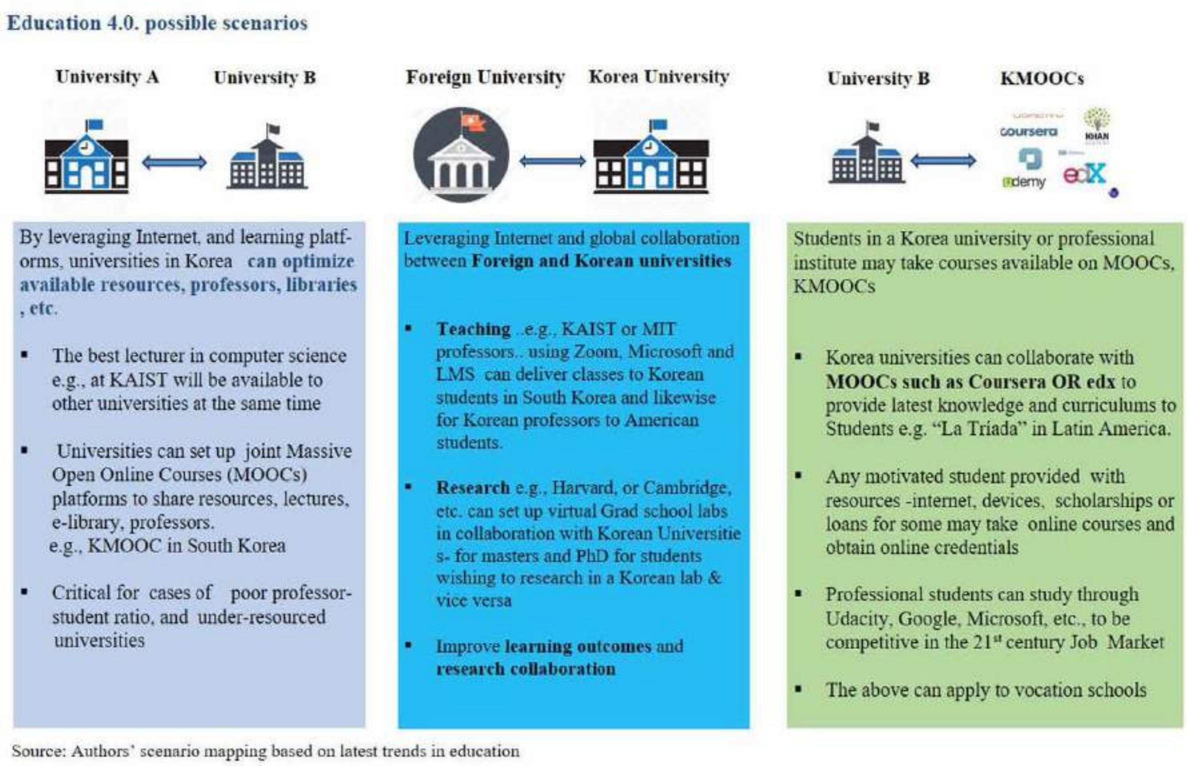
Republic of Korea owns one of the world's best IT infrastructures and 4G coverage reached 99 per cent of the country's population before COVID-19. Moreover, Republic of Korea commercialized 5G and approximately 75 per cent of its households own computers and 99.5 per cent have access to the Internet (ITU, 2018). This IT infrastructure facilitated the introduction of online education. The government took great pains to reduce the education gap stemming from the online transition. Students could borrow IT devices free of charge, and quality learning content was provided through online platforms built through cooperation with the private sector. These efforts created synergy with the teachers' voluntary participation in recreating their lesson content.

But there were also downsides to online education. In a survey of professors and students in colleges of engineering, 33 per cent claimed that the lectures were ineffective and only 5 per cent were satisfied with them. Moreover, 42 per cent of science and engineering professors answered that they were dissatisfied, with only 12 per cent being satisfied. This implies that it is often difficult for online classes to be as effective as offline classes. In addition, whereas online classes have now come to replace public education, students are finding it harder to concentrate. As such, there is a growing gap between the students of low-income households who depend heavily on public online education and students of high-income households who may resort to other measures such as private schools (Dong-A Ilbo, 2020).

To overcome these limitations, some universities have introduced the "hybridtact education" model, combining and optimizing the merits of online and offline learning (see Figure 67). Republic of Korea is also part of this trend; the Ministry of Science and ICT launched the K-MOOC service, opening up top-quality university lectures in science and engineering to the public (WEF, 2020).

Vulnerable groups have limited access to online learning due to network and device issues, especially in developing countries. The ITU launched the Giga initiative in 2019 with UNICEF to connect all schools to the Internet and provide information, opportunities, and choices to the younger generation. The project aims to equip all children with the public digital goods they need. Giga is based on a four-pillar approach – map, finance, connect, and empower. The school is the base point to check the gap in connectivity and map the necessary information. Data on 800,000 schools in 15 countries have already been mapped, and are available on the Project Connect website. Finance entails coordination with governments for recommendations on customized fiscal and deployment models that are both affordable and sustainable, support for market creation costs, and incentives for private investment. Digital connection solutions for individual schools are provided based on the mapping results. "Empower" consists of cooperation with governments to recognize, localize, and implement public digital goods on a large scale. Giga's efforts are concentrated in 13 countries in Central Asia, the Eastern Caribbean, and sub-Saharan Africa (ITU, n.d.). Efforts in Central Asia include the "Regional Lead" agreement with Kazakhstan (January 2020).

Figure 67: Hybridtact approach to higher education



Source : WEF (2020)

The lack of Internet access for schools in remote areas became an issue when the Kyrgyzstan Government moved all classes online. In response, the Internet Society (an international non-profit organization) delivered the ilimBox, a digital library and "Internet in a box", to schools in need (see Figure 68). The size of a tissue box, it offers transitional solutions for unconnected areas and is a repository of 500 books, 250 videos, and 4 million Wikipedia articles in Kyrgyz, Russian, and English. When powered up, the box becomes a Wi-Fi hotspot for students to download content using an Android app (ITU, 2021b).

Figure 68: ilimBox assisting digital education in Kyrgyzstan

Source : ITU (2021)

3.2.4.3 E-commerce supporting livelihoods during lockdowns

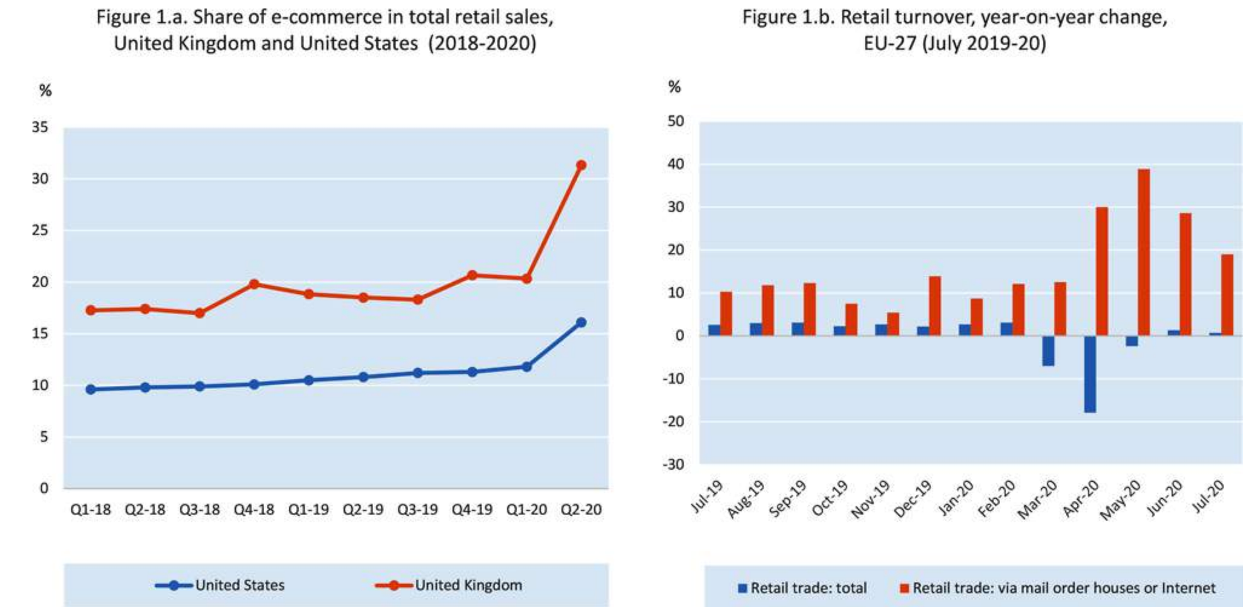
A substantial number of businesses in the brick-and-mortar retail industry attempted to transition into e-commerce as countries restricted physical interaction in response to COVID-19. The retail share of e-commerce in the United Kingdom and the United States was slow to increase in Q1 of 2020 but grew rapidly from Q2 on. In the 27 EU states, retail turnover fell significantly in March and April 2020 whereas the turnover for online shopping increased substantially compared to previous years (see Figure 69). Also, Google search volume for the word "delivery" in seven countries (France, Germany, Italy, Spain, the United Kingdom and the United States) surged in March 2020. (see Figure 70).

E-commerce allows individuals to maintain physical distance while accessing basic necessities, but it makes the digital gap more evident. Due to inequalities in access, income levels, digital capacity, and digital knowledge, it is difficult for some people to use e-commerce, especially older people and those on low incomes. For businesses, the adoption rate of e-commerce is low for SMEs as they lack the resources to make the transition, all of this leading to greater shocks from COVID-19. Protecting consumers from unfair, misleading, and fraudulent business activities that take place online is another important mission. Some e-commerce businesses are collaborating with governments and international agencies, both in developed countries and regions such as Africa with many LMICs, to support social distancing measures, protect consumers, and bridge the digital gap for vulnerable groups and SMEs.

Jumia is an e-commerce company established in 2012 which mainly provides services in Africa. It started out in Lagos, Nigeria, and expanded to other African countries to reach 6.7 million consumers as of September 2020, with over 110,000 vendors on its platform in December 2019 (see Figure 71). The annual Gross Merchandise Value (GMV) since September 2019 is EUR1 billion with 28 million orders. In addition to e-commerce, Jumia's services include Jumia Logistics and JumiaPay (Jumia, 2021a).

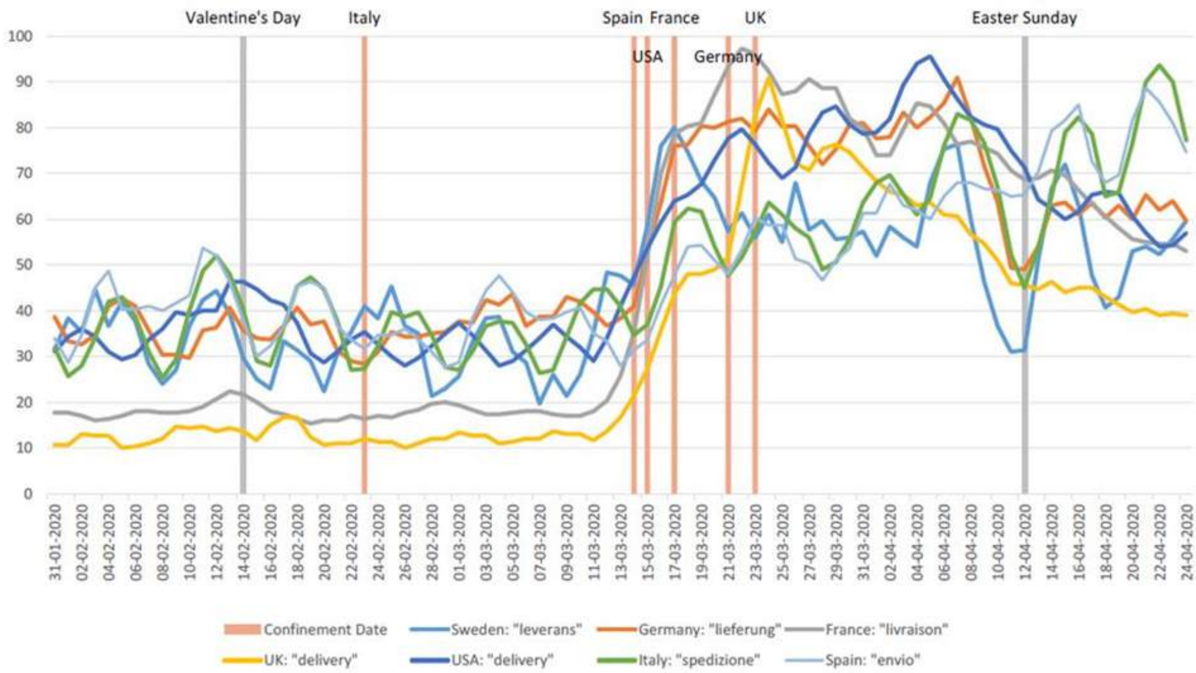
Jumia announced corporate response measures when the virus reached the African continent in April 2020. First, Jumia ensured the safety of their facilities and enforced containment measures, such as checking

Figure 69: Share of retail e-commerce in the United States and United Kingdom (left), retail turnovers YOY for 27 EU states (right)



Source : OECD (2020f)

Figure 70: Google search volume for the word "delivery" in seven countries from February to April 2020



Source : OECD (2020f)

Figure 71: Countries with Jumia services

Source : Jumia (2021a)

body temperatures and using masks and gloves. Customers were also given the choice of contactless services for the entire e-commerce process from purchase to delivery, with JumiaPay allowing them to receive their prepaid items in a contactless manner (Jumia, 2020).

The company also proposed measures to support communities (Jumia, 2021b). First, it entered into partnerships with retail brands to sell essential foods and supplies at a low price, removing commissions for hygiene products in particular. It utilized its logistics network to deliver purchased items to not just urban but rural areas as well. In addition, Jumia distributed 500,000 masks to medical workers in Nigeria, Egypt, Kenya, and Morocco, and provided free meals to frontline staff through its food delivery platform. When the Government of the Republic of South Africa announced lockdown measures that restricted access to non-essential retail stores and restaurants, Jumia began selling only essential goods on its website.

Jumia also collaborated with the UNDP in Uganda, launching an e-commerce platform to maintain the supply chain for micro, small and medium enterprises and connect them to online customers. The initiative may serve as a strategic opportunity to connect potential buyers with vulnerable groups and those from the informal trade sector, including women, youth, and disabled people. It could also connect farmers to urban markets, thereby sustaining the supply chain and mitigating the impacts of COVID-19. The e-commerce platform can benefit the hundreds of informal market vendors suffering from customer loss owing to movement restrictions, stay-at-home orders, and other lockdown measures (UNDP, 2020e).

The UNDP strengthened the e-commerce-related innovation ecosystem and provided smartphones, airtime, and data to market vendors. Jumia Food's platform, accessible via app and website, offers a last-mile distribution network, various payment methods, and quality assurance and training for vendors. Under this model, goods and services are validated before their distribution by market agents to check whether the quality meets customer expectations and whether the packaging is sanitary and safe. Jumia is using its infrastructure, including riders trained to provide safe and contactless delivery, to cater to customers under lockdown. Customers may leave feedback about their purchases in the Jumia Vendor App.

UNDP and Jumia had 3,000 registered vendors from seven markets on their platform by June 2021 and conducted joint online training sessions. Around 60 per cent of these vendors were women or young people. Most of them doubled their sales after registering on the platform – a vendor whose daily sales were USD10 in the early stages of the lockdown was selling USD22 worth of goods as of June 2021 (UNDP, 2021d).

3.2.5 Clinical care

3.2.5.1 New York State's Telemental Health

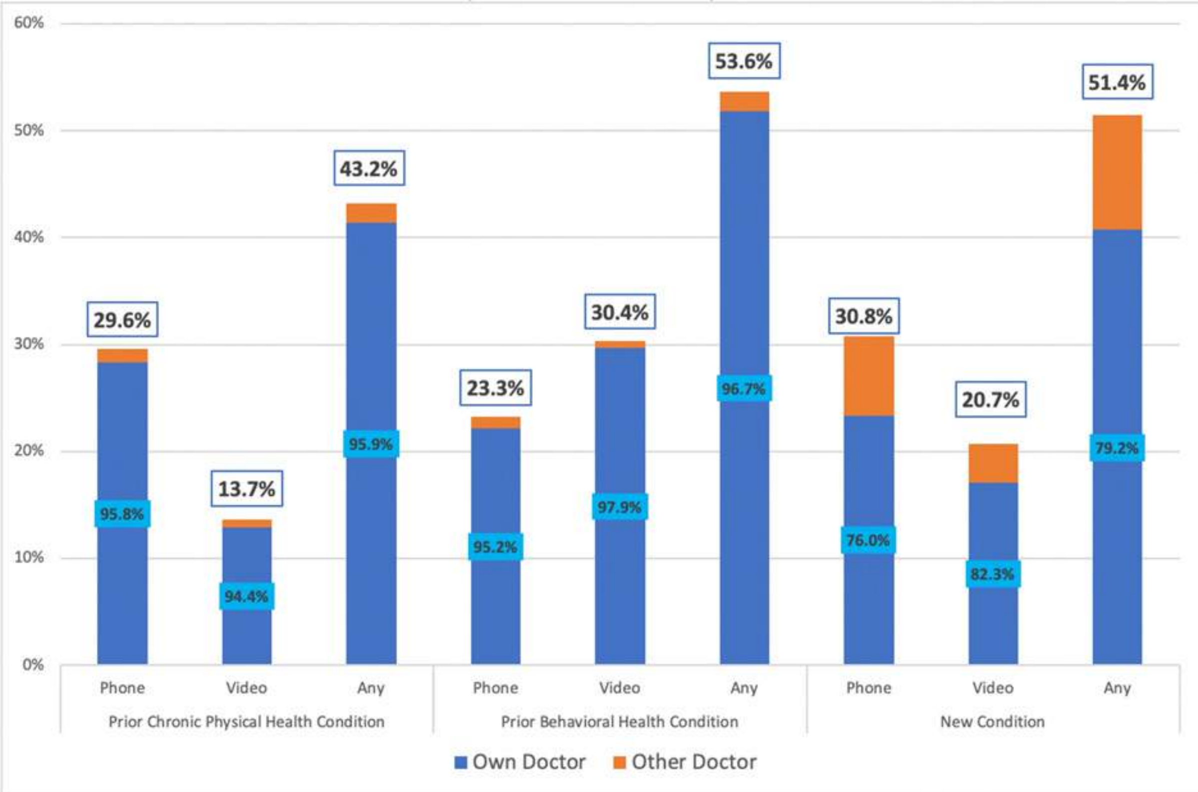
New York State declared an emergency on 7 March 2020 after its first confirmed case of COVID-19 on 1 March. The state implemented telemental health to provide uninterrupted mental health services during social distancing. This became an important tool for the safe treatment of citizens suffering from isolation due to social distancing as well as patients who had been receiving psychiatric care (KIHASA, 2020).

This was supported by legislation to accommodate the declaration of an emergency. Although security regulations were in place at the federal and state levels on the electronic transmission of a patient's health information for telemental services, the State of New York suspended the regulation to allow the use of universal applications providing audio or video communications.

As such, apps such as Apple FaceTime, Facebook Messenger Video Chat, Google Hangouts, Zoom, and Skype were used for telemental health care. The temporary suspension was effective during the state of emergency only.

New York offered online seminars for clinicians and providers who had no experience in telehealth through the Community Technical

Figure 72: Survey results on telehealth usage since COVID-19 by condition



Source : Fischer (2021)

Assistance Center and Managed Care Technical Assistance Center.

A survey of 2,000 people by the Rand Corporation in May 2020 found that approximately half of the patients being treated for chronic physical conditions (39.3 per cent), behavioural health conditions (15 per cent), and those seeking treatment for new conditions, had switched to telehealth following the onset of the pandemic (see figure 72). This was a significant increase from the 4 per cent of telehealth users in a 2019 survey. The demand for telehealth was the highest among patients with behavioural health conditions (54 per cent), followed by new conditions (51.4 per cent) and chronic physical health conditions (43 per cent) (Fischer, 2021).

The survey results indicate strong demand for increased access to telemental health owing to heightened stress, depression, and drug abuse. To address this, the Governor of New York announced a telehealth bill in January 2021 to bolster the accessibility and coverage of telemental health services, including measures such as the elimination of in-person exams[4], an expansion of the list of providers, and an extension of services to nursing homes (mhealth intelligence, 2021).

3.2.6 Pharmaceutical intervention

3.2.6.1 Development of vaccines and treatment using AI

The development process of COVID-19 vaccines and treatments was greatly reduced due to the use of AI to analyse the 3D structure of the virus, screen for candidates out of a myriad of compounds, and run simulations. Traditionally, the testing of candidate substances for new drugs was a time-consuming process. It involved lengthy procedures such as animal testing, molecular manipulation to avoid side effects, and clinical trials. With the adoption of AI however, the process could be accelerated by replacing manual labour. As an example, it only takes a few hours for an AI program to digitally screen billions of compounds likely to act against the biomolecules thought to be related to COVID-19 (Science, 2021).

Moderna succeeded in developing a vaccine based on mRNA (messenger RNA) approximately one year into the outbreak of COVID-19. Unlike previous vaccination methods which injected the whole virus, this only involves the nucleic acid of the virus. The mRNA delivers the virus's genetic information to the cell which reads it like a code and is instructed to create proteins through which the antibody is produced. The development of new drugs costs USD 1 billion on average, with the success rate at a mere 15%. But according to Moderna, the use of AI can boost this success rate to 50% and reduce the time-to-market[5] (HBS, 2020).

Moderna was designed to be an ICT-based company, unlike other biotechnology focusing exclusively on R&D, and this contributed to its development of vaccines. To begin with, Moderna had a vast amount of clinical data and accumulated success and failure data through continuous trials. Next, AI learned from the accumulated data to create algorithms, thereby enhancing prediction accuracy to develop a next-generation drug. Moderna deployed a cloud to increase computing power and storage, without resorting to hardware or a data centre, since the accuracy of vaccine structure prediction and simulation through machine learning not only depends on the volume of data but also on a tremendous amount of computing power.

The development of COVID-19 treatments so far has been geared towards repurposing antiviruses that were developed to treat other diseases. Although drugs such as Remdesivir and dexamethasone were unable to treat the virus itself, they relieved critical symptoms by inhibiting the immune reaction to reduce inflammation. AI played a significant role in screening numerous existing drugs to find the right ones to be repurposed.

Pharmaceutical companies began using AI to discover drugs when it became known that Remdesivir was effective for treating COVID-19. The UK's pharmaceutical company BenevolentAI used machine learning to find drugs with the closest molecular structure to COVID-19 and presented Baricitinib (Olumiant) as a potential drug to contain the virus. The drug for treating rheumatoid arthritis is expected to be effective in reducing the infection and inflammatory response from the coronavirus, since it prevents the creation of inflammatory cytokines. BenevolentAI was able to secure treatment for COVID-19 during the initial stages of the outbreak in February 2020 by discovering new efficacies of existing drugs through AI. In November, the FDA (The United States) allowed the emergency use of Baricitinib for COVID-19 inpatients in need of supplemental oxygen or invasive mechanical ventilation (BenevolentAI, 2021). These research results were published in the Lancet (Richardson et al., 2021).

Drug repurposing is extremely useful in the early stages of a pandemic when there is no sufficient treatment. However, the development of a dedicated antiviral agent is needed to fully end the pandemic and this should continue to respond to the various mutations. According to the biotech industry, 239 antiviral molecules are under development, targeting various points of the virus's lifespan. Researchers are focused on limiting structural and replication proteins, and with the advancement of AI analytics, drugs could be developed to target not just the proteins but also the RNA of the coronavirus (Science, 2021).

The United States biotechnology startup 1910 Genetics developed the AI engine ELVIS to accelerate the drug development process. ELVIS is composed of three AI platforms. The first stage, "hit discovery", screens 14 billion compounds using the AI platform SUEDE. This is a process that would otherwise have taken six months with a success rate of only 0.01 per cent. In the second phase, "hit to lead", the program BAGEL designs drugs by predicting methods to produce inhibitors for the target, dramatically reducing the development period from 24 months to 2. The third AI platform CANDID conducts multiparameter optimization using physical property prediction derived from the prior stages. These three AI platforms are integrated through the cloud using the company's biological automation wet lab platform[6]. New drug development is greatly enhanced through AI by creating more candidates, increasing the success rates, speeding up the development process, and saving operational costs (Science, 2021; BioSpace, 2021; 1910 Genetics, n.d.).

3.2.6.2 The World Community Grid supporting the discovery of infectious disease treatment

Supercomputers equipped with AI technology help solve scientific conundrums such as the genomics analysis of pathogens and selection of the most viable substance out of countless candidates. Computing power for the quick processing of large-scale computations is just as important as having researchers secure data. Several initiatives have been undertaken to make use of the fast data processing and analysis of supercomputers to tackle COVID-19.

A prime example is the World Community Grid – an initiative where millions of volunteers around the world offer large-scale computing capacity to support humanitarian research projects on problems faced by mankind. Since its launch in 2004, the world's biggest grid computing initiative has supported projects on incurable diseases, gene analysis, crop improvement, clean energy, and rainfall forecasting. With the outbreak of COVID-19, the initiative launched a new project, OpenPandemics, offering computer simulation for treatment development.

OpenPandemics provides scientists at Scripps Research with molecular modelling simulation to find the proper substance candidate to treat COVID-19. This requires the running of millions of simulations, using a vast amount of computing power. Scripps Research's main priority lies in discovering the necessary chemical compounds through their partnership with the World Community Grid. Going further, they hope to develop an open-source toolkit so that scientists may readily start developing medicine for future pandemics. The Grid would allow for virus mutations that lead to new variants.

All it takes to participate in the World Community Grid is to install the software on a computer. The simulation is run automatically using leftover resources in the background. The participant may write e-mails or search the Internet on their device with no interruptions. The analysis results are compiled through the Internet from countless people worldwide and delivered to the Scripps Research team. Researchers get results that would have taken years within a few months, thereby giving them time to put the findings into use.

Nokia is supporting the Grid by providing it with the Nokia Enterprise and Services Cloud (NESC) service, which is used for the R&D of 5G software. The NESC is the world's largest OpenStack cloud with 480,000 cores and 40PB of storage. It hosts Nokia's mission-critical development and will also support digital transformation projects for enterprises. The NESC is one of the largest contributors to COVID-19 research, having devoted 100 years' worth of computing time to it (Nokia 2020b).

3.2.6.3 Digitalization of cold chains for the supply of COVID-19 vaccines

With the production of COVID-19 vaccines, the demand for distribution cold chains is rising. Biomedicine must be kept at low temperatures for quality assurance, and the need for a supply chain to distribute vaccines for flu and COVID-19 at low temperatures was highlighted in 2020. Failure to maintain the right temperature could undermine the vaccine's stability and compromise its safety and efficacy. Moreover, the hereditary substance of the mRNA vaccine – introduced for the first time during the pandemic – is unstable and may easily be broken down with enzymes, requiring its storage in an ultra-cold environment (see Table 11). Pfizer's mRNA vaccine needs to be stored at -70°C and Moderna's at -20°C (ESCO, 2020).

The traditional cold chain for biomedicines is based on manual temperature control systems and logistics technology for refrigerated transportation. A temperature sensor is attached to the biopharmaceutical product

Table 11: Storage temperature for COVID-19 vaccines

VACCINE NAME		Sputnik V (lyophilized)	Johnson & Johnson	Moderna mRNA-1273	Pfizer & BioNTech BNT162b2
Vaccine Type		Adenoviral vector	Viral vector	mRNA	
Required Storage Temperature and Shelf Life	Short-term	2° to 8°C	2° to 8°C for 3 months	2° to 8°C for 30 days	2°C to 8°C for 5 days
	Long-term			-20°C for 6 months	-70°C for 6 months
Cold Storage Solution	Short-term	Laboratory Refrigerator		Laboratory Refrigerator	
	Long-term			Laboratory Freezer	Ultra-Low Temperature Freezer

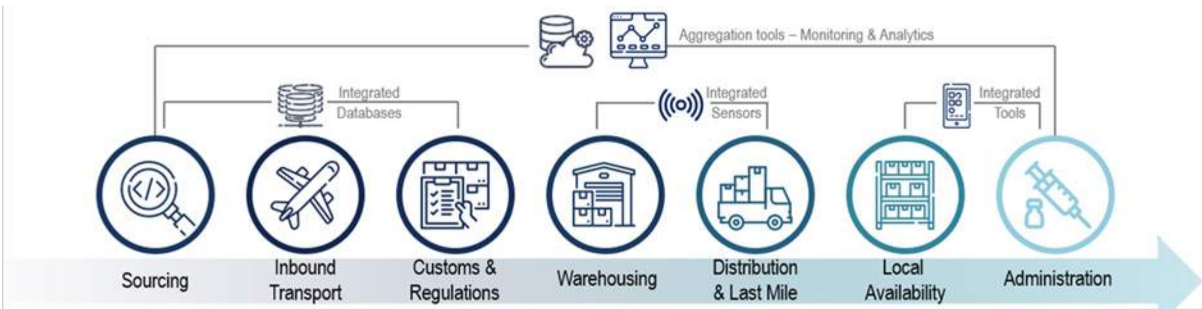
Source : ESCO (2020)

which is then wrapped with dry ice and special packaging and transported via refrigerated containers and warehouses. The person in charge scans a barcode to manage the distribution process, checking the adherence to the fixed temperature and tracking the process through e-mails and phone calls. However, this system delays the response in the case of contingencies, lacks visibility, and creates a time lag in sharing information. This could result in severe losses for COVID-19 vaccines that have strict transportation requirements such as cold storage temperature.

However, these issues can be solved through digital technology. This is used by the Digital Supply Chain Management System (DSCMS) to help manage the entire supply chain (see Figure 73). The DSCMS offers visibility, accuracy, responsiveness, productivity, sustainability, security, and integrity, thereby enhancing the efficiency and resilience of the chain. Specifically, DCSMS integrates data from all parties to enhance visibility and collaboration, and offers scalability in appliances that generate real-time data for more accurate monitoring and intervention. This enhanced visibility and accuracy contributes to better responsiveness to disruptions in the supply chain. The environmental benefits from the transition to 'paperless' and optimized use of resources also promote sustainability. Digital technology promotes security by enabling secure data sharing and hindering vaccine forgery and theft in the supply chain. [7]. Finally, the system provides integrated B2G portals; information from SIM-enabled location and temperature sensors attached to the cold chain equipment and warehouse; mobile apps for cold chain handlers to report the inventory, consumption, and transportation of the vaccines; and real-time connection to the immunization registries so as to confirm the administrative procedures (World Bank, 2021b).

Various ICT companies have already embarked on the DSCMS. Moderna is using Systems

Figure 73: Digital technologies applied to the COVID-19 supply chain



Source : World Bank (2021)

Applications and Products (SAP)'s digital solution to put serial numbers on its vaccines to prevent the distribution of counterfeit medicine and is strengthening its cooperation with manufacturers and distributors. The Israeli startup Varcode created a smart tag that can measure time and temperature based on cloud and blockchain technology. The tag sends out an alert if the preset temperature range is not met, also recording the time that it was out of temperature range. All smart tags have a serial number that may be scanned using smartphones, leaving behind digital trails to reduce the risk of theft or forgery. The number of orders for the tag, which used to be between 0.1~1 million, soared to billions with the outbreak of COVID-19 (Reuters, 2020e).

Developing countries are also actively employing ICT for vaccine management. India deploys ICT solutions such as eVIN/CoWIN to manage the vaccinations and supply chain. Indonesia, another densely populated country, is also applying ICT solutions through its state-owned companies PT Bio Farma and PT Telkom. They partnered to establish a digital infrastructure – the COVID-19 Vaccination One-Data System – as per the government's orders, to support the national vaccination programme and independently purchased vaccinations. The system consolidates data from various sources and is used to make vaccination plans and register the dual-track scheme for distribution. It consists of four phases: the track-and-trace technology for managing the vaccine packages; storage of vaccines at 2~8°C; a pre-ordering service for independent purchases to prevent hoarding; and an integrated reporting system including digital certification for air and rail passengers. For the elderly, the Indonesian Government analyses the regional vaccination registration records, determines the method of vaccine delivery, and informs those wishing to be inoculated of the vaccine venues. The government has also partnered with Grab, the biggest ride-sharing service in Southeast Asia, to provide drive-through vaccination services (ITU, 2021b).

Additionally, Indonesia is using the digital solution SMILE (*Sistem Monitoring Imunisasi Logistik Secara Elektronik*) to boost its immunization supply chain. SMILE digitalizes the stocks and storage temperature of the cold-chain points, offering real-time visibility of the logistics. The mobile and Internet-based application was developed by the Ministry of Health of Malaysia with support from the UNDP. There is a mobile app for cold-chain handlers, an online interface to receive the data from the app, a temperature logger to monitor the storage temperature, and a cold-chain manager to continuously oversee the products and processes. Health officials may check supply levels online, prevent vaccine stockouts, and leverage the available data to engage in governance and management from remote locations. SMILE seeks to promote operational efficiency, lower the cost for public health providers, and address inequalities in vaccine coverage (UNDP, 2018).

During COVID-19, the Indonesian Government introduced a plan for herd immunity with 370 million doses for 180 million people, the key to their pandemic response being to distribute the vaccines throughout the entire archipelago. SMILE allowed frontline health workers to get real-time information on vaccine distribution, and the Ministry of Health trained 10,000 cold-chain handlers from 34 provinces on how to use the application (UNDP, 2020c).

Endnotes

1. i.e. diagnostic tools that rapidly analyse online data (biometrics, symptoms, etc.) collected through mobile devices such as wearables (Wood et al., 2019)
2. https://www.cmu.edu/news/stories/archives/2020/april/facebook-survey-covid.html, https://delphi.cmu.edu/blog/2020/08/26/covid-19-symptom-surveys-through-facebook/
3. Republic of Korea's QR code check-in service is implemented based on public-private partnership. Users may use private company's mobile apps such as Naver, Kakaotalk to generate QR code. Korean health authorities manage entry logs.https://www.mohw.go.kr/eng/nw/nw0102vw.jsp?PAR_MENU_ID=1007&MENU_ID=100703&page=1&CONT_SEQ=355356
4. Elimination of the in-person exam requirement prior to using telehealth https://mhealthintelligence.com/news/ny-telehealth-bill-expands-coverage-supports-license-reciprocity-econsults
5. https://digital.hbs.edu/artificial-intelligence-machine-learning/ai-puts-moderna-within-striking-distance-of-beating-covid-19/
6. A wet lab is one where drugs, chemicals, and other types of biological matter can be analyzed and tested by using various liquids. (University Lab Partners, 2021), https://www.universitylabpartners.org/blog/wet-lab-vs-dry-lab-for-your-life-science-startup
7. https://blogs.worldbank.org/transport/digital-technologies-will-support-supply-chains-covid-19-vaccines-and-medical-goods

4

1

Key Insights

4 Key Insights

4.1 Preparedness and Rapid Response for Socio-Economic Resilience

Global COVID-19 cases and deaths per million demonstrate that the Asian and African countries included in our analysis were faster in responding to COVID-19 than developed countries in Europe and North America, owing to their experience with outbreaks of viral diseases such as SARS, MERS, and Ebola. They were thus able to minimize socio-economic damage without imposing stringent social distancing measures and lockdowns.

In contrast, countries in Europe and North America generally failed to contain the spread at an early phase and resorted to strong lockdown measures. Of these countries, the incurred damage was greater for those who had curtailed their investment in public health since the 2008 global financial crisis. It is also worth noting that the economies which undertook strong quarantine measures at an early stage despite the socio-economic impact suffered fewer infections, hospitalizations and deaths.

Integrated governance for epidemics also impacted the effectiveness of rapid responses. Countries with institutions dedicated to disease response were able to take prompt action and found it relatively easier to earn the trust of their people.

4.2 Growing Role of ICT in Disease Response

The examples presented in section 3 demonstrate how the appropriate use of ICT in responding to the pandemic helped to quickly control the spread of COVID-19, minimize the negative impacts of lockdowns, and reduce the development period for vaccines and medicines.

Many studies analysing the responses to COVID-19 also support this viewpoint. Whitelaw et al. (2020) point out that digital health technology helped carry out strategies and responses that would have been impossible manually and that countries including Republic of Korea had successfully flattened the incidence curve at an early stage by adopting digital technology for government-led control and response processes. The authors present five domains in pandemic preparedness and response in which digital technology played an important role: tracking, screening for infection, contact tracing, quarantine and self-isolation, and clinical management. They also emphasize that the integration of digital technology in pandemic policy and response has potentially contributed to lower death rates in certain countries. They find that countries who swiftly introduced digital technology to contain the virus were front-runners in disease management and that their comprehensive response measures could provide valuable insight for countries dealing with high levels of confirmed cases.

With its role in disease response having been highlighted due to COVID-19, ICT is likely to be integrated in future responses against other diseases as well. Ting et al. (2020) observe the application of new digital technologies (IoT, big data analysis, AI, and blockchain) in the monitoring, surveillance, detection, and prevention of COVID-19, and their role in mitigating the impact on the medical system (see Table 12). They predict that IoT and big data will have more impact on the former, with AI and blockchain greatly affecting the latter. As such, they expect that a wide range of digital technology is likely to contribute toward enhancing public health strategies, and the surge in ICT deployment from 2020 will result in widespread use at governmental levels, including to tackle chronic diseases.

Table 12: Impact of digital technology on public health strategy

Public-health measures	IoT	Big data	AI	Blockchain
	Digital technology			
1. Monitoring, surveillance, detection and prevention of COVID-19 (directly related to COVID-19)	+++	+++	++	+
Examples	1. Real-time tracking and live updates in various online databases in the USA, UK and China	1. Modeling of disease activity, potential growth and areas of spread	1. Detection of COVID-19 from chest imaging (X-ray) (Beijing Hospital)	1. Manufacturing and distribution of COVID-19 vaccines once they are available
	2. Live tracking of the at-risk vicinity in Korea (Coronamap.live; Wuhanvirus.kr)	2. Modeling of the preparedness and vulnerability of countries in fighting a disease outbreak	2. Prognostication of disease progression via clinical data, imaging and AI	2. Insurance claims from COVID-related illness and death
2. Mitigation of impact (indirectly related to COVID-19)	+++	++	+++	++
Examples	1. Virtual clinics (PingAn, China)	1. Business modeling on pharmaceutical supplies for various medications	1. AI to automatically diagnose medical conditions unrelated to COVID-19 (Zhongshan Ophthalmic Eye Center, China)	1. Distribution of patients' regular medication to the local pharmacy or patients' doorstep
	2. Public information dissemination via WhatsApp in Singapore[a]	2. Modeling of the utility of operating theaters and clinics with manpower projections	2. Medical 'chat bots' to address public inquiries on COVID-19	

Source : Ting et al. (2020)

ICT has been crucial for disease-response activities as well as our daily lives all throughout the pandemic. Yet this also carries the risk of widening the digital divide. Those who are digitally equipped are able to work, shop, and learn online, but those with poor ICT access cannot sustain their basic requirements (e.g. income, education, healthcare and daily necessities) during lockdowns. This implies that the gap between these two groups could widen even further. Moreover, transitioning public and essential services to online formats is a difficult task for LMICs due to their limited ICT resources. LMICs are struggling to sustain their disease-response policies and suffering from greater socio-economic repercussions than high-income countries. These issues should be dealt with in the near future so as not to exacerbate or entrench the current situation and to avoid a vicious cycle of deepening the digital divide and socio-economic inequality.

4.3 Importance of ICT Infrastructure and Legal System in the Disease Response

The employment of ICT in responding to COVID-19 has been more comprehensive than in any other epidemic, making digital infrastructures – the framework for all ICT services – an essential part of the socio-economic system. Above all, movement restrictions including lockdowns led to a surge in data traffic for both wired and wireless networks, with increased data usage for online education, telework, and access media. As such, building a robust, resilient, and secure ICT infrastructure has become a core strategic mission for COVID-19 and future pandemic responses.

In order to ensure the continuity of ICT services during COVID-19 and other pandemics, the ITU (2020) proposes measures to be taken by individual countries in its *Guide to develop a telecommunications / ICT contingency plan for a pandemic response*. First, in terms of legislation and regulations to improve the telecommunications/ICT capacity for emergency responses, the ITU's proposals include temporary spectrum licences to deal with increased traffic; enhanced ICT capabilities to include suburban, rural, and remote areas; information dissemination through SMS and SNS platforms to the entire population for crisis response; and online education solutions for all students. For the preparedness and response phases, the ITU recommends multi-technology solutions and the reviewing of relevant legislative and regulatory frameworks. It also suggests that the analysis of mobile phone records and social media data, as well as big data including large-scale simulations, could assist in addressing epidemics.

Meanwhile, as for telecommunications/ ICT management elements for effective preparedness and responses to pandemics such as COVID-19, the ITU proposes evaluating the network capacity and increase in traffic, securing backup measures, and identifying areas with poor connectivity.

In addition to the level of infrastructure, legislation is also a decisive factor in dealing with COVID-19 and other diseases. Because of the 2015 MERS outbreak, Republic of Korea already had a social consensus and legislative revisions in place on the use of mobile phone routes, card transactions, and other personal information. This allowed timely control of COVID-19 with rapid tracing of transmission routes at an early stage. Earning people's trust is also important for legal revisions. Some countries failed to amend their laws on personal data, such as location information, owing to concerns over privacy infringement.

Moreover, the biased use of AI may also intensify inequalities. First, AI-based image diagnosis could lead to biases since only regions equipped with the necessary imaging equipment would have data available for AI training. The lack of transparency surrounding algorithms is another issue. When using AI for vaccine development and other treatments, the impact of COVID-19 could be misrepresented due to the differences in the demographic data across regions, demanding scrutiny to ensure that the limitations of such data do not lead to biased algorithms. The private sector, which plays a key role in the pandemic response, could also aggravate biases and inequalities due to corporate opacity. The predictions made by infectious disease models could also be inaccurate since they only take into account the average value of variables for demography and social structure, as opposed to the behavioural differences between groups.

The availability of data also produces disparities because the data collection for COVID-19 usually depends on a specific technology. Google's mobility data, for example, provides valuable insights for modelling but does not fully reflect societies where such mobile technology is not readily available. Disinformation disseminated through the automated recommendation algorithms of social media platforms is an infodemic issue, with the groups most susceptible to COVID-19 also more likely to embrace the false information, and then engage in riskier behaviour. Furthermore, efforts to address such infodemics are deployed through online data and a small number of languages such as English, deepening the bias. As such, the AI bias and resulting inequality should be reviewed from the first stages of an AI project, which should use a more deliberate approach in considering the regional contexts and protection of vulnerable groups (Luengo-Oroz et al., 2021).

4.4 Heightened International Coordination in Response to Future Pandemics

Despite the efforts of the UN and other international organizations to prompt coordination between countries' health and economy sectors during the COVID-19 crisis, this was compromised in many cases due to nationalism. The global health coordination system must be reorganized to respond to not just COVID-19 but also new pandemics in the future.

This need was pointed out in a March 2020 statement by the WHO Director-General Dr Tedros and leaders from dozens of countries including President Macron of France, Chancellor Merkel of Germany, Prime Minister Sanchez of Spain, and President Moon Jae-In of Republic of Korea. Entitled "COVID-19 shows why united action is needed for more robust international health architecture", it also introduced the Access to COVID-19 Tools Accelerator (ACT-A) to ensure universal and equal access to vaccines, treatments, and test kits for COVID-19 as well as other pandemics.

The statement also emphasized the importance of countries working together towards a new international treaty for pandemic preparedness and response. Dr Tedros stressed that no country is safe until we are all safe in his speech at the Aspen Security Forum in August 2020, and that science, solutions, and solidarity are the best measures to overcome the pandemic together, and avoid vaccine nationalism (WHO, 2021e).

Nonetheless, international coordination on COVID-19 has been lacking in many ways. UN Secretary-General Guterres cautioned in an interview with the Associated Press in June 2020 that the go-it-alone policies of countries could make it difficult to defeat COVID-19 (UN News, 2020). Former Prime Minister Brown of the UK argued in his article in the Oxford Review of Economic Policy that the individual actions in response to COVID-19 – vaccine development, viral containment, and epidemiological surveillance – had the property of global public goods (GPGs), which in turn complicated their efficient supply in the absence of cooperation, thereby leading to failure in pandemic control (Brown, 2020). This highlighted the need for coordination on GPGs in response to future pandemics. To this end, vaccines, treatments and medical equipment should be fairly distributed; early warning systems for the swift detection and containment of new outbreaks should be established; and existing international agencies designed to facilitate global cooperation should be used more effectively.

In terms of national responses to COVID-19, some developing countries fared better in disease response indices (e.g. infections and fatalities) than developed countries, but suffered greater socio-economic damage from NPI measures (e.g. travel restrictions, lockdowns and school closures). The gap between developed and developing countries in vaccination indices was also evident. Moreover, countries such as India appeared to have successfully contained COVID-19 up until early 2021 but then experienced large waves of infections due to their decision to prioritize socio-economic concerns and neglect social distancing measures. Even if developed countries manage to temporarily suppress COVID-19 through vaccination, failures to contain the virus in developing countries could lead to viral mutations, resulting in further global waves. Such inequality and risk can only be tackled through the reinforcement of global coordination.

5

Considerations/ Conclusions

5 Considerations / Conclusions

5.1 Enabling Environment: Flexible Regulation, Policy to Foster ICT

The lack of relevant regulatory frameworks is a drawback for certain countries when it comes to adopting responses based on digital data (MIT Technology Review, 2020; Politico, 2020). This calls for pre-emptive amendments to legislation for the quick and efficient use of MBD and other digital data in pandemics. However, given concerns over privacy, these measures should be temporary and limited with regulations in place to protect the data, such as pseudonymization as defined in the GDPR.

Telemedicine can reduce the burden on health care systems when deployed in combination with other digital healthcare technologies. However, legislation in this area is held back in some countries due to challenges including privacy and security issues arising from the online transmission of health information, reliability issues stemming from data being measured by healthcare workers with limited telemedicine knowledge or by patients without medical expertise, and issues concerning liability in the case of malpractice (Nittari et al., 2020; Luciano et al., 2020). Nonetheless, countries should consider introducing regulations that allow for conditional (possibly targeted) application in circumstances when conventional means of service delivery are not applicable.

Meanwhile, timely amendments to legislation may be challenging during pandemics despite the demand for prompt measures. The appropriate action in such cases could include exploring strategic policies or customized guidelines and SOPs specific to pandemic responses.

The digital healthcare sector always requires digitalized medical services and has constantly undergone efforts to match consumer demand for customized care according to consumer and patient lifestyles and for new system-connected data storage devices (wearables, sensors, and social network data). Digital healthcare technologies include medical AI, wearable devices, big data, genetic testing, mobile health care, telemedicine, remote monitoring, digital treatment, personal health information, cybersecurity, biomarkers, 3D printing, home health care, and precision medicine. Of these, the technologies used during the COVID-19 pandemic that have the most scalability are telemedicine, mobile health care, and wearable devices. The deployment of telemedicine was indeed accelerated right from the outbreak of the pandemic. Telemedicine is a step closer to being an effective solution that enables safer and enhanced medical services for the control of pandemics. The WHO also mentioned telemedicine as an essential service in dealing with the emergency situation of COVID-19, and its adoption increased dramatically in the United States, according to data from medical claims in the early stages of the pandemic (January to early June of 2020). As such, the scalability of telemedicine has great potential as it facilitates and sustains patients' access to doctors. However, several technologies, rather than a single technology, need to be converged for genuine digital healthcare services to be provided. To overcome the limitations, telemedicine or mobile healthcare services should be accompanied by mutual growth in other data-based technologies including personal health information, big data, genetic testing, cybersecurity, and AI.

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5.2 ICT to Prevent Pandemics: Pre-emptive Investment

Efficiency in predicting, preventing, and responding to diseases can be further promoted by revamping the existing systems in order to use ICT for the real-time collection and analysis of multisectoral data and in various disease-response activities.

ICT can be used to quickly disseminate precise information about epidemics, including real-time incidence risks and updates on confirmed cases. It can also be linked with the national prevention framework to actively support the disease response. Quarantine measures such as test reservations, notifications of results, the management and monitoring of case data, and the collection of status updates in connection with the 3Ts (test, trace and treat) may all benefit from ICT. Functions supporting national policies will further expand the role and effectiveness of ICT in pandemics. ICT platforms may also be core frameworks for data collection and disclosure on adverse reactions to COVID-19 vaccines. Developing countries' lack of capacity to build their own platforms is leading to disparities in data collection, but this could be solved through global ICT companies meeting those demands.

The roles of the people deploying the ICT solutions should also be re-examined. Jason Bay, Senior Director of Government Digital Services at Govtech Singapore (2020) mentioned the following about the digital contact-tracing solution TraceTogether: "[it] does not replace the contact tracing process. Instead, we see it as an important tool in the toolbox of contact tracers. It is not sufficient to rely on technology alone, as we need the expertise in public health and communicable diseases to make sense of the data collected using this technology." Consequently, more people should be prompted to actively engage in disease response by offering and participating in training and support.

As countries embarked on the vaccination process for COVID-19, information on adverse reactions were shared worldwide, leading to temporary suspensions in certain countries as well as for certain age groups. Adverse reactions are usually detected during clinical trials, but Phase III for the COVID-19 vaccines was conducted for a group of 20,000 to 60,000, making it difficult to detect rare symptoms that occur in one out of 100,000 or a million cases. In Europe and the US, the cerebral venous sinus thrombosis, or thrombosis with thrombocytopenia syndrome, was discovered in five out of a million people who received the AstraZeneca vaccine and in one out of a million people who received the Janssen vaccine. The benefits from vaccines are unarguably greater if we compare the decrease in severe cases or deaths with the adverse effects from the vaccines, which is why the EMA (European Medicines Agency) and the United States's FDA/CDC recommended the AstraZeneca and Janssen vaccines. Collection and transparent disclosure of information on adverse reactions to the vaccines are essential, and digital platforms are core infrastructures that offer precise and transparent data for the analysis. Although the United States, Republic of Korea, and European countries are building digital platforms to collect information on such adverse reactions, certain countries in Asia, South America, and Africa do not own the capacity to build such platforms and therefore there is no means to check or respond to the adverse reactions in these countries. In short, there is inequality even in gathering information on adverse vaccine effects. All countries should be included, starting with registries of people who have been vaccinated to collect information on adverse reactions.

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Moreover, travel restrictions are affecting countries, businesses, and individuals alike. ICT contributes to freedom of movement by enabling fast and automatic testing and screening during the immigration procedure.

However, digital divides and insufficient national health capacity are issues to be dealt with in developing countries. As such, four missions need to be undertaken to facilitate the global distribution of innovative technologies. First, investments should be made in education and infrastructure to reduce the ICT gap between countries. Second, solutions should be developed and introduced based on the ease and sustainability of their application, according to the maturity level of each country's overall ICT environment. Third, training for the local workforce should be supported to enhance the national healthcare capacity. Fourth, a standard legislative and institutional framework should be designed to address data sharing and the security and privacy of personal information.

A century has passed since the outbreak of the Spanish flu and the world is hit once again by a global pandemic – COVID-19, highlighting the need for developing countries to employ ICT solutions that can complement their weak healthcare systems and disease response capacities. ICT solutions may be applied to contain infectious diseases in the public health response and in medical diagnosis and treatment.

The first ICT solution pertains to the surveillance and reporting system. ICT enables an effective disease response by helping to identify the transmission routes of the disease in various regions and facilitating the quick reporting of suspected symptoms and cases as well as contact tracing and epidemiological investigations. Moreover, the fast reporting of test results helps to speed up the quarantine and treatment process for contacts and suspected cases.

ICT solutions may also be utilized for the diagnosis and treatment of COVID-19 cases. In particular, information on symptoms and image diagnosis of suspected or confirmed cases may be used to identify potential infections and classify them according to their severity. Methods including AI-based machine learning may be applied for medical imaging (e.g. X-ray, CT) to check for infection. The deployment of ICT in telemedicine as well as quarantine management, mobile vaccination registration systems, and app-based vaccine certificates (vaccine passports), suggest an even wider range of potential uses in developing countries' disease responses.

However, an important aspect of ICT's applicability in such developing countries is the maturity of the ICT framework, and other elements such as digital readiness, availability and sustainability should also be accounted for. Furthermore, it is not enough to merely introduce and adopt ICT solutions. ICT's potential and sustainability will only be realized when it is adopted in conjunction with the promotion of basic disease prevention and response principles, health care services including diagnostics and treatment, and personnel with the appropriate skill sets.

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5.3 Enhancing Global Cooperation

A platform should be created to allow the exchange of data and information between countries to rapidly detect and effectively contain the risk of a global pandemic. The WHO also points out in its COVID-19 Strategy Update 2020 report that the lack of a reporting system permitting it to share information with public health institutions prevents access to data on the characteristics of infectious diseases. This demonstrates the need for a global data architecture that supports public health.

Similarly, in its February 2021 report Enhancing Global Cooperation to End the COVID-19 Pandemic, the Lancet COVID-19 Commission points out the need to enhance global real-time information systems and reinforce the multilateral system. According to the report, these systems should include data on virus mutations, disease transmission, health system demand, vaccine supply, access to digital services, as well as information on famines, poverty, unemployment, mental health issues, population displacement, numbers of children out of school, violence against women and children, and other dynamics relating to acute distress. The UN Statistics Office could offer the necessary methodologies and guidelines to this end. Moreover, since the collection, analysis, and use of MBD is carried out at the national level, the establishment of a global database would enhance the early detection and containment of epidemics. However, this would require countries to consider relaxing their data protection regulations for emergency response purposes.

> The 10 key recommendations from the *Lancet* COVID-19 Commission for 2021 are as follows: 1) strengthen the multilateral system to suppress the pandemic; 2) enhance global real-time information systems; 3) deploy NPIs; 4) ensure the rapid and equitable global deployment of vaccines; 5) respond to urgent humanitarian crises and widening inequalities; 6) ensure accessible K-12 education; 7) strengthen health systems including mental health services; 8) investigate pandemic preparedness, the One Health approach, and the origins of COVID-19; 9) promote transformative investments for an inclusive green and digital society; and 10) advocate for carbon neutrality at global sustainable development summits.
>
> *Lancet* COVID-19 Commission, Enhancing Global Cooperation to End the COVID-19 Pandemic, February 2021

A governance system to catalyse public-private partnerships is also essential for an early and efficient response to new pandemics. According to Budd et al. (2020), COVID-19 highlighted the need for government leadership on the assessment and speedy introduction of digital technology. Furthermore, cooperation is required not just between governments and regulatory bodies but also with companies, NGOs, and patient groups in order for digital technology to be implemented successfully in pandemic-response activities (see Figure 74). In addition to developing and distributing ICT-based services, the system should cover and exert influence over all response measures. These measures include the revision of legislation on issues such as data protection, public persuasion, building a standardized digital health database, and bridging the gap in ICT and health capacities within and between countries. Participation in and management of this global coalition should include not just international agencies but also private business coalitions such as the WEF and GSMA.

The inequality and structural dynamics between and within countries have changed since the outbreak of COVID-19, leading to an epochal challenge of finding the right power balance and constructive solutions. ICT for SDGs is a common strategic framework for all mankind and a tool to introduce policies to address social dilemmas such as political polarization, climate change, demographic changes, and inclusive growth. Moreover, it became clear that cooperative governance is the only way to nurture innovative capacities – agility, adaptiveness, and anticipation – which were the key capacities and values highlighted during the pandemic response.

For a new innovative society, the following five roles and functions for ICT may be considered as means of supporting our ability to cope with epidemics and the related crisis-management governance and resilience. First, ICT can enable a mission-oriented innovation strategy, in which all socio-economic operations are designed and operated digitally to enhance innovation and sustainability. To this end, the innovation of regulations and public-private partnerships should be reinforced. There should be an institutional role and accountability, not to merely build an ICT infrastructure, but to create new added value by sharing and utilizing the innovative outcomes produced within the ICT ecosystem. The second function is to foster data-driven policy-making. Policies should be made through data, not to generate data, and the process of utilizing data to monitor and evaluate policy-making should be more objective and transparent. In addition, an innovative data ecosystem should be established through collaboration and exchange between public and private entities and through data governance based on trust and ethics.

Third, there must be open government, with public values – transparency, honesty, accountability, civic participation, and trust – defining the management of changes and acting as the main engine for innovation in all governmental and social domains. As a predisposing factor and strategic leverage, ICT is the most important principle and measure to achieve this. Fourth, we need solidarity with the government as a platform. The government will gain trust, effectiveness, and sustainability by acting as a platform for participation and cooperation between nations and between the private and civil society. It is within this governance and policy-making culture that ICT will nurture innovative ideas, services, relationships, solutions, and values, and maximize the affinity and experience of all agents. Lastly, ICT has a role in anticipatory innovation governance. Governments require expertise through early detection to come up with pre-emptive and strategic measures for epidemics as well as relevant shifts to "new normal" and "next normal". Accordingly, ICT is a social institutional vessel and infrastructure for anticipatory innovation, and the most important foundation for an innovative ecosystem.

Greater socio-economic expectations and institutional accountability will be placed on ICT as the government and private sector communicate via knowledge and content platforms to detect issues through the public governance of participation and cooperation, and in the process of innovation to produce mission-oriented outcomes and shared value. To this end, we should engage in genuine discussions, develop experiential cases, and promote a governance culture and innovative ecosystem for entrepreneurs, consumers, and the civil society, to promote sustainability through ICT.

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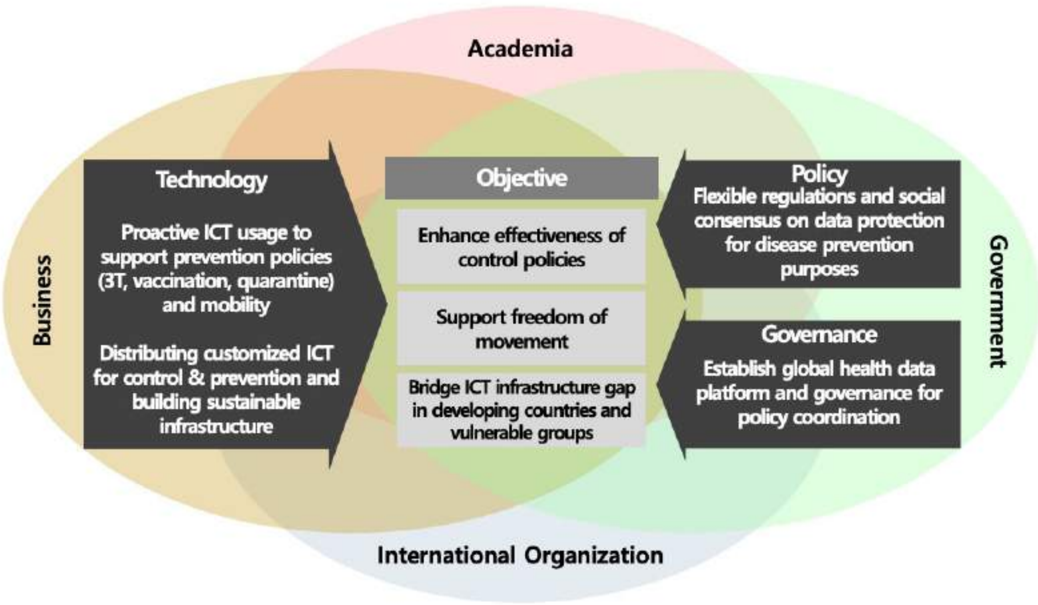
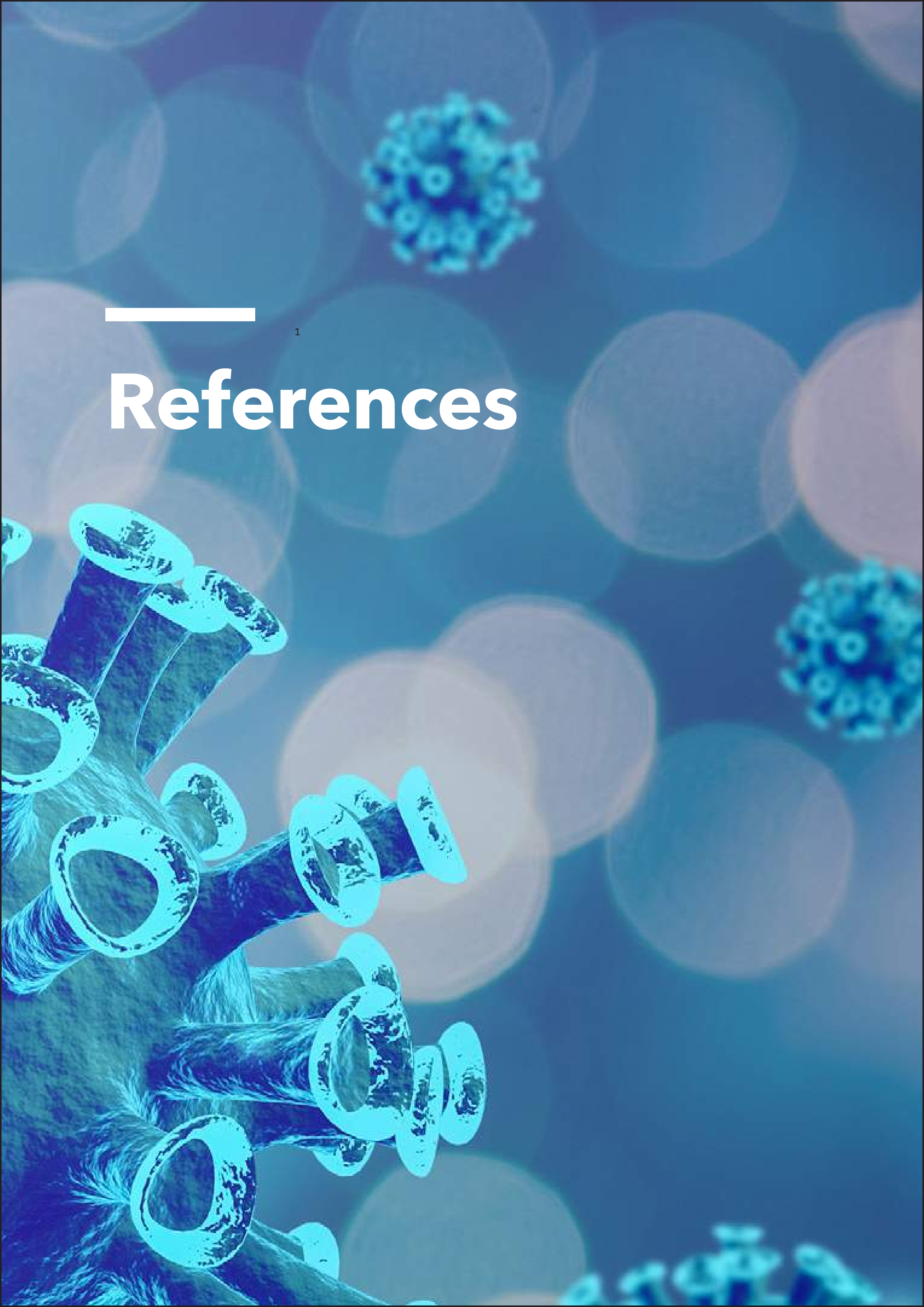
Figure 74: Considerations for a future epidemic response





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Chapter 2

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