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THE ROLE OF ICT DURING THE COVID-19 PANDEMIC



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Republic of Korea – World Bank Group Partnership
On COVID-19 Preparedness and Response

The Role of ICT During the COVID-19 Pandemic

September 2023

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ABSTRACT

The COVID-19 pandemic significantly changed people's lifestyles, as it led to school closures, cancellation of public events, work-at-home policies, and social distancing. Countries around the globe collected data to design policies that would mitigate the negative effects of COVID-19. From the past experiences of the Great Influenza (1918), SARS (2002), and MERS (2012), global leaders were aware of the importance of international cooperation and ICT (Information and Communication Technology) for coping with the new SARS-Cov-2 virus since early 2020. This note describes how ICT helped COVID-19 management from five perspectives: (1) optimal policy development, (2) contact tracing, (3) telemedicine, (4) working from home, (5) online education, and (6) SNS (social networking services).

- 1. Policy Development influenced ICT and Simulations:** ICT and simulations have been crucial in developing effective pandemic response strategies. Governments and public health organizations used data driven, as well as large-scale computational models to understand the virus's spread, predict potential outbreaks, and suggest optimal containment measures. These tools helped inform policymakers on the best course of action, enabling them to take informed decisions about social distancing policies, vaccination campaigns, and resource allocation. This approach to policy development allowed for more targeted and efficient responses to the COVID-19 pandemic and will likely be utilized in future public health crises.
- 2. Contact Tracing:** Governments worldwide have responded to COVID-19 with various policies, including contact tracing applications, wearing masks, and social distancing. Official contact tracking applications are available in over 40 countries, each with its own characteristics. The deployment of drones, closed-circuit television (CCTV), new databases, and the purchase of data from private corporations are only a few examples of various technical measures. Furthermore, an ecosystem for response has been created by integrating alternative methods, some of which are expected to continue to be used beyond the pandemic.
- 3. Telemedicine:** Countries developed telemedicine or telemedicine platforms to decrease face-to-face contact between doctors and patients. With telemedicine, health care professionals were able to transform the crisis into a safer and more interactive health care service. This has also enabled reduced transportation time and cost due to less displacement of professionals and patients.
- 4. Working from Home:** Many people worked from home during the pandemic. As a result, the demand for video conference platforms such as Zoom, Microsoft Teams, and Google Meet increased. Technological advancements have made it possible for individuals to work from home, which has changed the behavior of individuals and organizations.
- 5. Online Education:** COVID-19 necessitated the transformation of the traditional classroom education system into online education. Learning through videos, voice recognition, automatic corrections, and live exams are examples of the effectiveness of online learning. However, not all countries were able to provide high quality online education, as there are students in rural areas who don't have full access to the internet. Moreover, even many teachers were not prepared to teach their students online.
- 6. SNS:** Individuals and business organizations worked together to contribute to COVID-19 mitigation. Facebook (known as Meta) worked closely with the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and national health organizations to provide accurate information to people and prevent the spread of misinformation. In addition, governments took steps to prevent the spread of misinformation and disinformation.

Table 1: COVID-19 responses utilizing ICT technology: Summary

Country	Contact Tracing	Telemedicine	Online Education	SNS
Korea	The Ministry of the Interior and Safety (MOIS) introduced a contact tracing app for visitors entering Korea to enable monitoring of daily symptoms during self-quarantine.	The limited adoption of telemedicine due to legal constraints and stakeholder resistance indicated low acceptance	Quality of online education remains unsatisfactory for many teachers and students despite government efforts to establish it	The government's provision of a dedicated information portal increased efforts to protect news consumers from fake news. This transparency of information contributed to the development of public trust
UK	NHS COVID-19 (Users got information of infected patients)	Compliance with all applicable laws, including CQC registration, is mandatory for all healthcare providers, and individual medical practitioners, and is regulated by the GMC (General Medical Council) in the UK	Provision of high-quality online education faced challenges during the pandemic, including the digital divide, which affected students from low socio-economic backgrounds due to limited access to ICT at home	
Japan	Contact Confirming Application (COCOA) (automatically recorded any close contact)	Takeda Pharmaceutical and Kanagawa Prefecture implemented Care for One, a pilot project for remote monitoring of patients with Parkinson's disease using wearables and virtual medication guidance to reduce in-person hospital visits	The Japanese government's Global Information and Governance Academic Program (GIGA) program aims to provide every school with adequate ICT resources, allowing students to access digital devices by 2023	
Germany	Corona-Warn-App (shares data if users are two meters from each other)	Increased telemedicine use during COVID-19, with more case discussions conducted through video consultation, and financial support for doctors and psychotherapists from the NAS (National Association of Statutory Health Insurance Physicians) for video consultations	The DigitalPakt program by the German government aimed to improve internet infrastructure in schools and equip them with digital technology	
Australia	COVIDSafe (the government collects personal information)	Barriers to telehealth included lack of technology infrastructure, internet access, and reduced access for vulnerable groups	The dissatisfaction of students with the quality of online education was the biggest challenge faced by Australian universities, with 50 percent of students expressing their unhappiness	

Country	Contact Tracing	Telemedicine	Online Education	SNS
France	TousAntiCovid (provides a map of local testing centers), MesConseilsCovid (provides advice how to protect oneself)	Apizee Health provides real-time web video communication on all kinds of mobile devices. The patients can receive an invitation to a teleconsultation by SMS or email	French universities' efforts during the pandemic provided opportunities for students to continue their education and adopt new learning practices while maintaining the quality of education	
US	Care19 App (the app anonymously gets a person's location)	In the US, existing telemedicine platforms like Amwell and the UPMC's (University of Pittsburgh Medical Center) virtual urgent care services reported a rapid increase in their use	Online education needs to be improved, as many students lack access and were dissatisfied with the quality	
Russia	Social Monitoring App (monitored self-isolation)	The launch of a round-the-clock remote consultation service by the Moscow City Health Department allowed for doctors to assess people who consulted them via video and audio communication	Online learning platforms were created by the Russian Ministry of Education for each region, with some providing teachers with school computers and assistance in linking personal computers to the internet	
Saudi Arabia	Tabaud (notified if users have had contact with other confirmed patients)	Telemedicine played a critical role for diabetic patients during the pandemic, assisting them in managing their health status and maintaining reasonable glucose control through virtual consultations for COVID-19	The Ministry of Education developed Madrasati, a national learning management system, to meet the needs of teachers and students of all levels in the country	
Malaysia	MySejahtera (users can determine which areas have positive cases)	The Ministry of Health provided healthcare services to patients via telemedicine or virtual clinics through doctoroncall.com.my and bookdoc.com.my since February 2020, with a focus on COVID-19	Teachers' unpreparedness to effectively integrate technology and remote students' poor internet connection and bandwidth issues due to extensive internet usage have been significant issues	Risk communication information was disseminated through social media channels such as Facebook and Twitter, and public education campaigns were launched

Country	Contact Tracing	Telemedicine	Online Education	SNS
Brazil	Coronavirus-SUS (Patient consent required for COVID positive result sharing)	Docpass utilizes virtual channels for communication with the public and requires patients and physicians to register on the app. Physician registration evaluation includes an assessment of their medical license and experience	Supporting students in rural areas with digital devices has been a challenge for the Brazilian government due to insufficient availability	
Thailand	Department of Disease Control (DDC)-Care (monitored infected individuals and high-risk clusters with private and state support)	Orca, Thailand's top tele-mental-health platform, facilitated access to counseling and supported mental health professionals	Insufficient digital devices and internet access in rural areas posed a significant challenge for online education	
China	Health Code (tracks customer location through telecom data shared among China Mobile, China Unicom, and China Telecom)	Golden Health is a telemedicine platform that connects 1,037 medical institutions at the provincial, municipal, county, and township levels, and offers telemedicine services to medical institutions in Henan Province and other provinces of China	Chinese schools and institutions use MOOCs for online education, but teachers find it harder to interact with students and provide feedback, resulting in lower engagement	
Mongolia	COVID-19 ERSDEL (provided privacy-protected contact tracing and alerted users regularly on self-quarantine and diagnosis, making it popular worldwide)	In 2013, a teleconnection was created between NCMCH (National Center for Maternal and Child Health) and CHLA (Children's Hospital Los Angeles) to improve patient care. Pediatric surgeons used tele mentoring to treat eight patients with rare conditions from distant locations	Education shifted to distance learning via TV and online classes, with enhanced capacity of institutions and teachers. 4,210 hours of TV lessons were produced in 2019-2020, but 40% of rural children lacked internet connectivity for TV or radio lessons	The Ministry of Health's pandemic response focused on time-sensitive information delivery through daily press releases during SARS 2003, and streamlined communication via social media, town halls, online dialogue sessions, and call centers
South Africa	Covi-ID App (collects personal information and stores location and infection status using self-sovereignty identity as personal information)	The MediVic App is designed for convenient access to medical care. It supported communication between patients and doctors via live chat, video consultation, and e-consultation, including the automated transmission of prescriptions	The lack of basic ICT infrastructure presented a significant challenge for South Africa, as students in poorer areas have limited access to smartphones and internet	

Country	Contact Tracing	Telemedicine	Online Education	SNS
Fiji	CareFIJI (utilizes Bluetooth Low Energy for contact tracing)	During the mitigation phase response, teams regularly met via online platforms, while doctors and nurses reached patients at home by phone	The shift to online education in Fiji disproportionately affected low-income students and those learning English as a second language, with inadequate digital resources and internet quality hindering access for both teachers and students	Misinformation and vaccine safety doubts led to a drop in COVID-19 vaccinations, and aggressive risk communication was conducted to combat fake news
Vietnam	PC-COVID (support COVID-19 prevention, offered contact tracing and centralized access to vaccination records, travel authorizations, and health declarations)	The creation of a government scheme connecting Hanoi Medical University Hospital to several satellite hospitals, commune health stations, and patient residences expanded telemedicine in Vietnam	Vietnam faced difficulties transitioning to online education due to issues such as inadequate internet access for disadvantaged students, teachers in remote areas lacking digital devices, and children needing to help with farming	The government's COVID-19 response included warning citizens of risks via social media
Indonesia	PeduliLindungi (aided Indonesian government's COVID-19 monitoring with user-submitted data on confirmed cases, requiring participant registration)	Temenin, Indonesia's national telemedicine platform, worked with 200 hospitals and health facilities, offering teleradiology, tele-EKG, tele-USG, and teleconsultations to expand healthcare services	The Ministry of Education and Culture's policy to transform school practice into online education faced challenges due to limited access to online teaching and learning facilities	
India	Aarogya Setu (uses Bluetooth and location data to check a COVID-19 infection database for close contacts)	The eSanjeevani program helps medical practitioners use telecommunication tools like video conferencing to provide better health services at diverse locations throughout the country	Access to online education differs across India, with students in rural areas having limited access due to digital devices such as tablets and computers	

1. INTRODUCTION

For this note, 19 countries (Republic of Korea [Korea], the United Kingdom [UK], Japan, Germany, Australia, France, the United States [US], the Russian Federation [Russia], Saudi Arabia, Malaysia, Brazil, Thailand, China, Mongolia, South Africa, Fiji, Vietnam, Indonesia, and India) were selected based on their ICT Development Index (IDI) from the International Telecommunication Union (ITU) and the Bloomberg Resilience ranking (*Table 2*).

Developed countries with a population size of 50 million or more and an income level of US\$30,000 or more were selected first. Australia, with an IDI higher than 8.0, was also included despite having a population of less than 50 million, albeit with high income levels. Next, the focus was on how each country with high-level ICT infrastructure coped with COVID-19 and how each country's resilience scored increased. *Table 2* shows that countries with high IDI values recorded relatively low fatality rates.

Table 2: List of Countries That Recorded IDI (ICT Development Index) Rank in 2017, IDI Values, Bloomberg Resilience Score, Vaccine Doses Per Million, Confirmed Cases, Fatality Rate

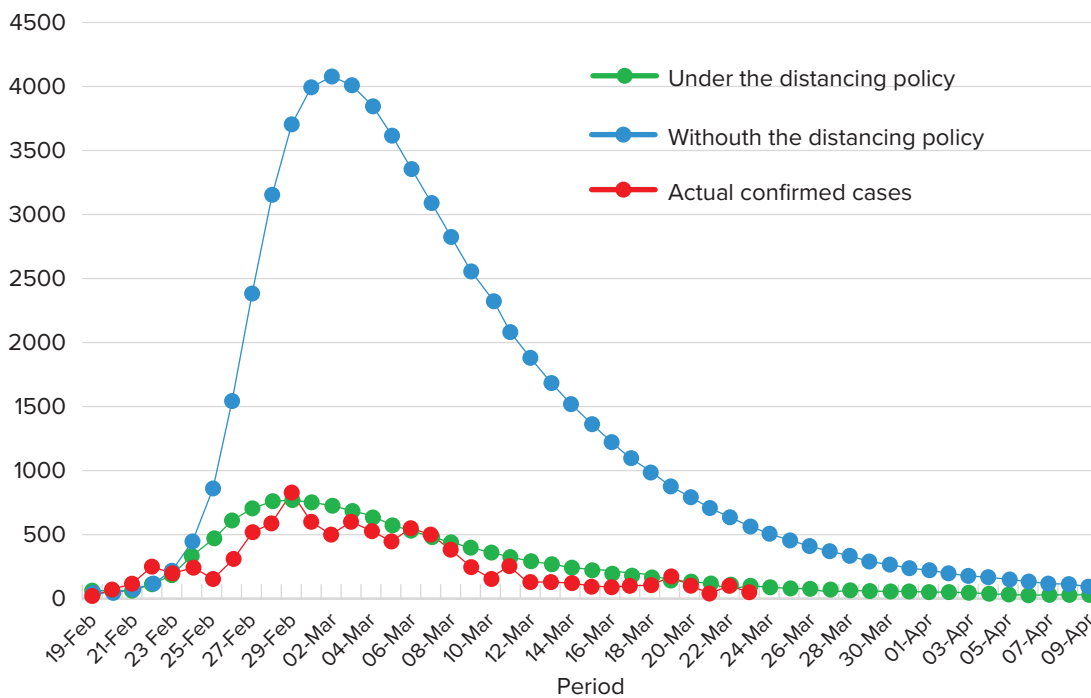
IDI Rank (ITU 2017)	Country	IDI Values (ITU 2017)	Bloomberg Resilience Score (Hong et al. 2020)	Vaccine Doses Per 100 (Hong et al. 2020)	Lockdown Severity (Hong et al. 2020)	Confirmed Cases Per Million (as of June 29, 2022) (Our World in Data 2022)	Fatality Rate (As of June 29, 2022) (Our World in Data 2022)
2	Korea	8.85	80.9	244	14	354,221	0.13%
5	UK	8.65	74.2	234.2	19	337,352	0.88%
10	Japan	8.43	71.4	227.4	38	74,702	0.34%
12	Germany	8.39	74.2	222.7	18	337,865	0.50%
14	Australia	8.24	78.1	219.6	14	313,679	0.12%
15	France	8.24	74.7	225.9	19	459,955	0.48%
16	US	8.18	69.4	199.9	27	259,749	1.16%
45	Russia	7.07	52.2	180.1	23	125,140	2.06%
54	Saudi Arabia	6.67	79.8	190.5	25	22,099	1.16%
63	Malaysia	6.38	69.3	216.2	45	134,455	0.78%
66	Brazil	6.12	69.1	213.4	33	150,270	2.08%
79	Thailand	5.67	70.2	143.1	30	63,130	0.68%
80	China	5.60	54.7	154.5	79	623	0.59%
91	Mongolia	4.96	Not provided	Not provided	Not provided	273,244	0.23%
92	South Africa	4.96	64.4	61.7	30	67,238	2.55%
107	Fiji	4.49	Not provided	Not provided	Not provided	70,509	1.32%
108	Vietnam	4.43	74.6	235.7	26	109,440	0.4%
111	Indonesia	4.33	65.2	197	34	22,232	2.58%
134	India	3.03	69	115.5	37	30,870	1.21%

2. OPTIMAL POLICY DEVELOPMENT

To effectively respond to COVID-19, it was crucial to apply quarantine policies, which incorporated social distancing measures, such as, masking, social distancing of at least two meters, and adjusting business hours and meeting size. Optimization of these policies can be achieved through the application of computational research, simulations, artificial intelligence (AI) and machine learning (ML). These are well known examples of ICT implementation.

Korean government applied a series of simulations of various scenarios as well as policy evaluation, which combined ICT to related Research and Development for field responses. Korea Institute of Science and Technology (KIST) has been leading simulation research to interpret and respond to disease transmission using its supercomputers and AI. KIST utilized an individual-based transmission simulation toolkit based on large-sized high-performance computers to perform simulations (Figure1). This contributed significantly to optimizing early quarantine policies such as social distancing (Lim et al. 2022). The efforts of Korean government to implement effective quarantine policies using computational science and AI is well evaluated as Bloomberg reported on June 29, 2022. As pointed out, Korea had ranked first in resilience against infectious diseases (Hong et al. 2020).

Figure 1: Computational results to estimate the effectiveness of a social distancing policy during the first wave of COVID-19 pandemic in Korea (used KIST’s results showing the utility of the ICT-based approaches)



3. CONTACT TRACING

ICT and ICT infrastructure can play a critical role in supporting public health, the management of medical emergencies, online education, and global economies. For example, using digital technology to battle the pandemic has been viewed as a crucial measure, and contact tracing apps are one example of such tools. Contact tracing uses techniques to trace proximity, including the Global Positioning System (GPS), triangulation of cellular operator antennas, and Bluetooth.

Contact tracing applications have been used to combat past infectious illnesses, and they have been brought into play in the present pandemic. However, although contact tracing helps locate and track down people and devices, this technology raises several privacy issues, as personal information is recorded and often made public. *Table 2* below provides a snapshot of the different applications used by the countries (see Annex for details).

Table 3: IDI Rank, With Contact Tracing Method of Each Country

Country	IDI rank	Contact Tracing
Korea	2	The Ministry of the Interior and Safety (MOIS) introduced a contact tracing app called “Safe-Quarantine Safety Protection.” All visitors entering Korea are required to install the app. Users must submit daily symptoms during self-quarantine.
UK	5	The National Health Service (NHS) rolled out NHS COVID-19. Users can be instructed to self-isolate if the app detects that they are close to someone with the infection.
Japan	10	Japan developed the Contact Confirming Application (COCOA), which automatically records close contact on Android and IOS devices using Bluetooth technology.
Germany	12	The Corona-Warn-App is based on Privacy-Preserving Contact Tracing. When two users are nearly two meters from each other for 15 minutes, their apps share data over BLE (Bluetooth Low Energy).
Australia	14	The Australian government developed the COVIDSafe App. When a person registers for the COVIDSafe App, the Australian Department of Health collects personal information with the Digital Transformation Agency as the COVIDSafe IT service provider.
France	15	TousAntiCovid enables simple access to other resources, providing a map of local testing centers, wait times, and “MesConseilsCovid,” which provides individualized advice on how to protect oneself and others.
US	16	The Care19 App anonymously catches a person’s location and asks if they want to share their location history with the state if they test positive for the coronavirus.
Russia	45	Moscow’s IT Department created the Social Monitoring App. The app monitors self-isolation and quarantine for persons being treated at home and who are limited in leaving their homes.
Saudi Arabia	54	Tabaud notifies users if they have had contact with others confirmed to be infected with COVID-19.

Country	IDI rank	Contact Tracing
Malaysia	63	MySejahtera allows users to determine which areas have positive cases, and whether they have come into contact with a person who has tested positive.
Brazil	66	The Coronavirus-Unified Health System (Coronavirus-SUS) can only work properly if the patient who tested positive for COVID agrees to share that result.
Thailand	79	The Department of Disease Control (DDC)-Care monitors and tracks individuals who have been infected or are classified as being in a “high-risk cluster,” with support from private entities and state enterprises.
China	80	China created a nationwide telecom data analysis platform called “Health Code.” All three major Chinese telecommunications companies (China Mobile, China Unicom, and China Telecom) use this system. They may share information about their customers’ mobile phone whereabouts during the last 15 or 30 days.
Mongolia	91	COVID-19 ERSDEL (One of Mongolia’s contact tracing apps) app users receive regular alerts and details regarding self-quarantine and diagnosing. Its excellent privacy protection with contact tracing makes it popular all over the world. COVID-19 ERSDEL app users receive regular alerts and details regarding self-quarantine and diagnosis.
South Africa	92	The App “Covi-ID” is a voluntary app that uses Bluetooth and geolocation to collect a data subject’s personal information. In addition, the data subject’s location and infection status will be kept on their phone, using a self-sovereignty identity as their personal information.
Fiji	107	The CareFIJI App was developed to operate on Android and iOS operating systems. It makes use of the Bluetooth Low Energy technology to register encounters between two devices that can be used for contact tracing.
Vietnam	108	The Vietnamese government stepped in with tremendous resolve to develop solutions and software for health care to support the prevention of the COVID-19 pandemic. PC-COVID enables contact tracing and offers vaccination records, travel authorizations, and health declarations all in one place.
Indonesia	111	Pedulilindungi enables users to submit data about COVID-19 in their areas to assist the Indonesian government in monitoring confirmed cases. Users must register as participants, share their travel destinations, and report any COVID-19 exposures.
India	134	Aarogya Setu scans a database of reported instances of infection to determine whether users have been close to someone with COVID-19, using Bluetooth and location data from their phone.

4. TELEMEDICINE

Telemedicine refers to health services and information delivered or enhanced by internet-related technologies. For example, when COVID-19 cases started to increase worldwide, many people went to hospitals to get tested, increasing their risk of contagion. With telemedicine, health care professionals have transformed the crisis into a safer and more interactive health care experience that has allowed them to reduce transportation time and cost due to less displacement of professionals and patients (Elhadi et al. 2021). *Table 3* summarizes the telemedicine platforms used by different countries, together with their limitations (see Annex for details).

Table 4: IDI Rank, With Telemedicine System of Each Country

Country	IDI rank	Telemedicine
Korea	2	Korea introduced telemedicine in 1988, but it has yet to be formally accepted owing to stakeholders' resistance and legal restrictions. The COVID-19 pandemic has triggered fundamental changes in every country's health care services system. However, the Korean health care system is still not being prepared to accept telehealth services. The Korean government temporarily applied patient-doctor telemedicine to the entire population of Korea in the wake of COVID-19 pandemic. However, the number of telemedicine users ceased to increase, indicating patients' stagnant interest in non-face-to-face care and doctors' continuing resistance to government policy.
UK	5	All health care providers are subject to the same restrictions as in-person providers, as they are all required to register with the CQC (Care Quality Commission) and demonstrate that they comply with all applicable laws. The General Medical Council (GMC) regulates individual medical practitioners. All doctors who practice medicine in the United Kingdom must be registered with the GMC and follow specific GMC-established standards for proper medical practice.
Japan	10	Takeda Pharmaceutical and Kanagawa Prefecture implemented Care for One, a pilot project for remote monitoring of patients having Parkinson's disease. Aiming to reduce the burden of health management and in-person hospital visits, the organizations developed an integrated platform that monitors patients with wearables, providing virtual medication guidance and prescribed drug delivery.
Germany	12	The use of telemedicine has increased due to the COVID-19 epidemic, and case conferences and case discussions are now more frequently conducted through video consultation. In addition, the National Association of Statutory Health Insurance Physicians (NAS) provides financial support for doctors and psychotherapists who perform video consultations.
Australia	14	There are barriers to telehealth uptake in Australia, including a lack of technological infrastructure and internet access and a risk that access will be reduced for vulnerable population groups. Another barrier to using telehealth is the limitations inherent in performing physical examinations remotely.
France	15	After the first lockdown in 2020, teleconsultations increased dramatically. Apizee Health provides real-time web video communication on all kinds of mobile devices. The patients can receive an invitation to the teleconsultation by SMS or email.
US	16	In the US, existing telemedicine platforms like Amwell and the University of Pittsburgh Medical Center's (UPMC) virtual urgent care services have reported a rapid increase in their use. A recent poll found that 23 percent of adults have used telehealth services in light of the COVID-19 pandemic.
Russia	45	The Moscow City Health Department launched an around-the-clock remote consultation service via video and audio communication. Doctors assess people who apply to them according to established criteria and assist patients with COVID-19.
Saudi Arabia	54	During the pandemic, COVID-19 led doctors and patients to move to virtual consultations. Telemedicine played a critical role for diabetic patients, assisting them in managing their health status and maintaining reasonable glucose control.
Malaysia	63	Since February 2020, with a focus on COVID-19, the Ministry of Health (MOH) has continued to deliver health care services to ordinary patients and health care service users via telemedicine or virtual clinics via doctoroncall.com.my and bookdoc.com.my.
Brazil	66	Docpass uses virtual channels to communicate with the public. For patients and physicians to join, they need to download the app and register. Once patients register, they can activate the app. Registration validation for physicians usually takes five days, for evaluation of their medical license, resumé, diploma, specialization, and experience as a doctor.
Thailand	79	Orca, Thailand's top tele-mental-health platform, breaks down logistical barriers to accessing counseling while helping to support the careers of dedicated mental health professionals.

Country	IDI rank	Telemedicine
China	80	Golden Health is designed to be compatible with multiple network access methods. It connects 1,037 medical institutions at the provincial, municipal, county, and township levels. In addition, it provides telemedicine services to medical institutions in Henan Province and other provinces of China.
Mongolia	91	A global teleconnection between the National Center for Maternal and Child Health (NCMCH) and Children’s Hospital Los Angeles (CHLA) was created in 2013 with assistance from the Jennifer Lopez Foundation to improve patient care. Telementoring is employed in pediatric surgery for unusual, technically demanding patients or in locations with COVID-19 and other pandemics. Pediatric surgeons telementored eight patients with intestinal intussusception, congenital duodenal atresia, anal atresia, congenital inguinal hernia, or congenital abdominal wall abnormalities from distant places. Mongolia has effectively adopted telemedicine in many health areas over the last 20 years.
South Africa	92	The MediVic App supports communication between patients and doctors via live chat, video consultation, and e-consultation features, including the automated transmission of prescriptions.
Fiji	107	The Ministry of Health and Medical Services (MoHMS) presently needs greater telehealth and telemedicine capability. As part of the mitigation phase response, teams meet and chat regularly via Zoom, Viber, and other platforms. Doctors and nurses reach patients (at home) by phone, and information networks allow them to follow patient health status remotely—the ministry’s most excellent mitigating action yet.
Vietnam	108	The government has created a scheme connecting Hanoi Medical University Hospital to several satellite hospitals, commune health stations, and patient residences. The expansion of telemedicine in Vietnam is anticipated to enhance health conditions in neglected regions and open the road for the use of telemedicine by hospitals.
Indonesia	111	Temenin is Indonesia’s national telemedicine platform, offering teleradiology, tele-electrocardiography (tele-EKG), tele-ultrasonography (tele-USG), and teleconsultations, and working with 200 hospitals and health facilities. Temenin is expected to help expand health care services, especially in remote regions without physical facilities.
India	134	eSanjeevani helps medical practitioners use telecommunication tools like video conferencing to provide better health services at diverse locations throughout the country. The program permits two types of telehealth services: doctor-to-doctor, sometimes referred to as eSanjeevani, and patient-to-doctor, also known as the eSanjeevani OPD.

5. WORKING FROM HOME

COVID-19 has affected the economies of individuals in each country. Due to aggressive social distancing COVID-19 measures, many workers were asked to work from home. Business organizations used video conferencing platforms such as Zoom, Google Meet, and Microsoft Teams to keep their employees engaged. Despite business organizations’ efforts to follow the government COVID-19 relief policies and keep their employees motivated, there are both positive and negative aspects of working from home. On the positive side, employees could save on commuting and spend more time on their work and family. The negative side of working from home is the risk to productivity, and the double-burden of both work and childcare for parents, particularly working women. Also, telecommuting has often resulted in employees working longer hours.

Despite the advantages and disadvantages of online video conferencing platforms, they effectively reduce physical contact, contributing to lower confirmed cases. *Figures 2 and 3* show Google trends of video conferencing platforms and remote work. After February 2020, the popularity of both video conferencing platforms and remote work reached its highest popularity.

Figure 2: I_t (Interest Over Time) by t (Date). The horizontal axis represents the timeline. The vertical axis represents global interest regarding remote work.

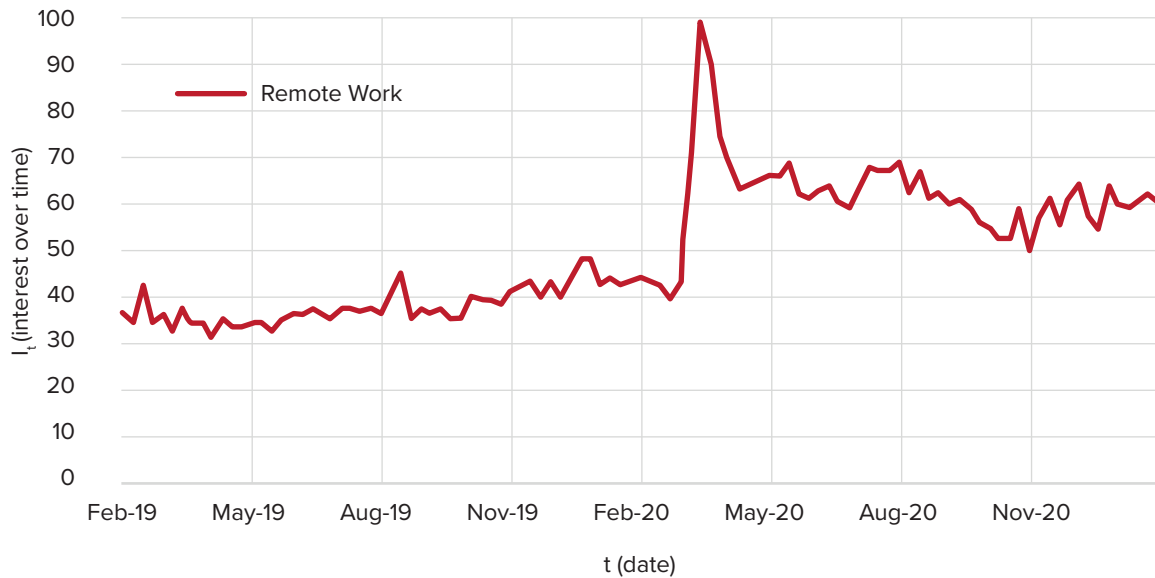
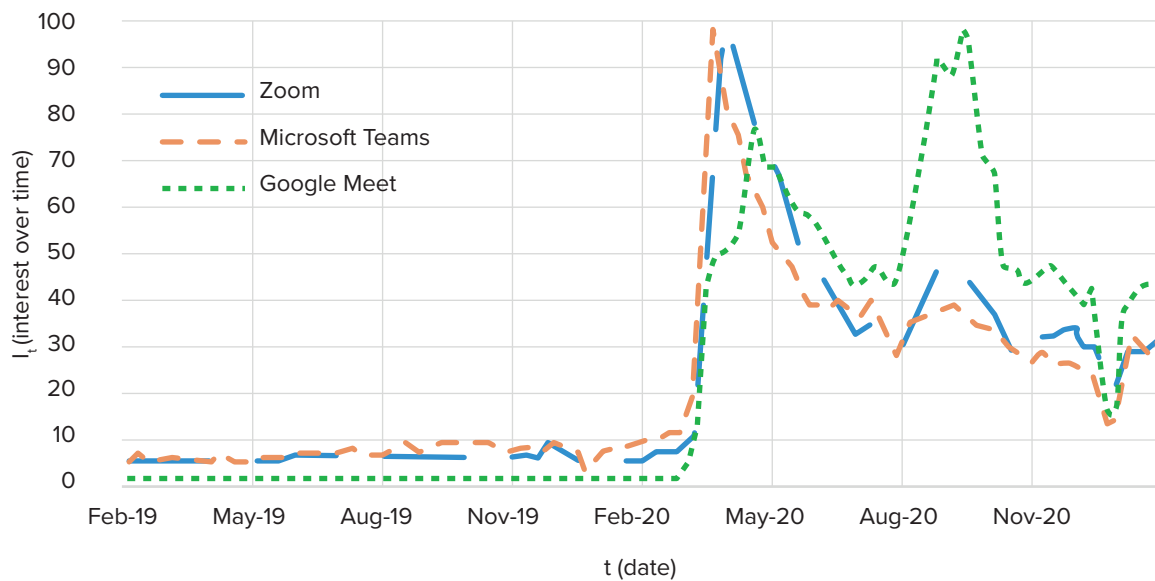


Figure 3: I_t by t . The horizontal axis represents the timeline. The vertical axis represents the global interest regarding video conferencing platforms.



As we can see, at this point, the ratio of queries for the specific search term to the total number of searches conducted in the region was the highest it had ever been during that period. Of course, these figures do not mean that people actually installed or used video conferencing platforms. Instead, it has raised people’s interest in the potential of transforming the traditional workplace culture into a remote-work one.

6. ONLINE EDUCATION

Different countries have had to resort to online education at different times during the pandemic. The use of technology in the educational field enabled its use during the pandemic. Through video conferencing platforms such as Zoom and Google Meet, students and teachers can interact during a teaching session.

Many countries have been putting extra effort into online education during the pandemic by adding more budget and supporting technologies like tablet PCs and internet infrastructure. However, not all countries succeeded. Some countries found it difficult to reach rural areas with low internet infrastructure. Furthermore, students with low socioeconomic backgrounds did not have digital devices for obtaining online education. The experience of different countries with online education is summarized below (see Annex for details).

Table 5: IDI (ICT Development Index) Rank, With Online Education Situation for Each Country

Country	IDI rank	Online Education
Korea	2	Despite the Korean government's effort to establish online education, many teachers and students are still looking for a better quality of education. Many students and teachers are not satisfied with the quality of online education.
UK	5	The UK faced the same situation as Korea did during the pandemic. The UK has difficulty providing high-quality online education compared to face-to-face teaching. The other issue was the digital divide. The digital divide means unequal access to digital technology, including tablets, laptops, and the internet. Students from low socio-economic backgrounds have less opportunity to experience online education due to limited access to ICT at home.
Japan	10	The Japanese government initiated a Global and Innovation Gateway for All (GIGA) program before the pandemic. The GIGA's primary goal is to provide every school with adequate ICT resources so all students can access digital devices by 2023. The GIGA is expected to help students in poor ICT-environment schools where four to five students, on average, share one computer. However, not many teachers are prepared to provide quality of online education.
Germany	12	The German government started a program called Digital Pakt to improve the internet infrastructure in schools. With Digital Pakt, the German government wants to ensure that schools are better equipped with digital technology. However, many schools in Germany still need digital devices to educate all students.
Australia	14	The biggest challenge in Australian universities is that most students are not satisfied with the quality of online education. According to an article in <i>The Guardian</i> , 50 percent of students were unhappy with their online education.
France	15	During the pandemic, French universities provided students with opportunities to continue their education during the pandemic. With these efforts, students can adopt new learning practices and help to maintain the quality of education.
US	16	The education system needs more than just providing every professor with a Zoom account and allowing instruction to follow its natural path for the system to work well, because not all students have access to online courses. Many students are not satisfied with the quality of online classes.
Russia	45	The Russian Ministry of Education created online learning platforms for each region. Some regions gave teachers school computers and helped them link personal computers to the internet so they could teach from home. Senior students from teaching institutions assisted teachers unfamiliar with computer technology in acquiring online learning essentials.
Saudi Arabia	54	The Ministry of Education (MoE) also developed a national learning management system (LMS) called Madrasati for all levels of students in the country. The Madrasati system is an integrated system designed to meet the needs of teachers and students. Madrasati provides synchronous and asynchronous teaching functionality to help students and teachers engage in class.

Country	IDI rank	Online Education
Malaysia	63	Since the pandemic began, teachers are not fully prepared to integrate technology effectively. Moreover, students in remote locations have poor internet connection and significant bandwidth issues owing to extensive internet usage.
Brazil	66	The Brazilian government tried to support students in rural areas, but most students still don't have digital devices and teachers are not prepared.
Thailand	79	The biggest issue is that many students in rural areas need more digital devices and internet access to study online. Low-income families have an extra financial burden in supporting their children to continue their education. Teachers also need to gain digital literacy skills to teach their students online.
China	80	The Chinese Ministry of Education requested that schools and higher education institutions teach students with high-quality online programs via online platforms such as Massive Open Online Courses (MOOCs). Teachers say the biggest drawback of online education is that it takes more work to interact with students and share feedback. Also, the level of engagement and communication could be a lot higher.
Mongolia	91	The education sector has been converted to distance learning via TV courses and online classes, and the capacity of both educational institutions and teachers has been enhanced. Four thousand, two hundred and ten (4,210) hours of TV lessons were produced for preschools, regular schools, and schools for students with special needs during the second semester of the 2019–2020 school year. However, approximately 40 percent of children in rural areas did not receive TV or radio lessons due to the lack of internet connectivity.
South Africa	92	Students in poorer areas don't have smartphones, internet, or Wi-Fi access, or the skills to use online resources. This makes it harder for them to use online learning platforms to their advantage. Given the situation, the biggest challenge for South Africa is its lack of basic ICT infrastructure.
Fiji	107	Changes in the educational system have had a disproportionate impact on low-income students and those learning English as a second language. The educational institutions in Fiji tried to change their education system to online education. Remote learning has replaced in-person instruction, and worksheets have been created for each level. However, teachers and students have difficulties accessing online education due to the low quality of the internet connection and insufficient digital devices.
Vietnam	108	Despite the Ministry of Education and Training's (MOET) efforts to ease the transition to online education, many children from disadvantaged backgrounds had difficulties accessing the internet and participating in online classes. In addition, many children had to help their parents farm in rural areas. Teachers in remote areas didn't have access to the internet and digital devices before the pandemic. Those issues indicate that the Vietnamese government was not ready to change its education system to online education.
Indonesia	111	The Ministry of Education and Culture (MoEC) developed a policy of transforming school practice into online education. However, although millions of students study at home and rely on online education, most don't have access to online teaching and learning facilities. Moreover, most students need help participating in online education due to unequal technology and internet connectivity access.
India	134	When the COVID-19 pandemic hit India, school closures led education systems to move to online education using digital devices such as tablets and computers. However, access to education technology differs across India. Students in high-income countries have more opportunities to access online education than those in low-income countries. According to the World Bank's United Nations Population Division's World Urbanization Prospects, 2021, 65 percent of the Indian population lives in rural areas where ICT infrastructure is relatively low.

7. SOCIAL NETWORKING SERVICES

During the pandemic, many countries have used social media to inform and communicate with the public. In particular, the accessibility and promptness of social media have contributed to increasing the transparency of the government and promoting social campaigns against the pandemic. On the other hand, the use of social media has also raised the concern of misinformation and has resulted in vaccine hesitancy.

Korea

The WHO has defined an infodemic as a condition of too much information, including false or misleading information, during an outbreak. There were concerns raised during the pandemic about infodemics in the Republic of Korea. The government provided a dedicated information portal and increased efforts to protect news consumers from fake news. Transparency of information has contributed to the development of public trust. The vast majority of Korean individuals were attentive to the government's daily news briefing, according to a stratified test of 1,000 adults done in April 2020 (79.3 percent). With the government's effort to spread correct information regarding COVID-19, Korean citizens have been complying with government interventions, including nonpharmaceutical interventions and restrictions on public gatherings, comparatively well. This reflects the public's perception of the government's response to the pandemic.

Malaysia

Social media channels, including Facebook and Twitter, were used extensively to disseminate risk communication information. Public education and awareness raising campaigns were implemented, and a mobile messaging service was used to deliver short messages on warnings and recommendations to mobile phone users—for instance, “let's wear masks,” “let's wash our hands,” “let's keep distance,” “let's protect together,” and other guidance. In addition, the State Emergency Commission (SEC) and the Ministry of Health (MOH) distributed information, guidelines, and recommendations on mask use, distance keeping, and hand hygiene through various media, social media, and public locations.

Mongolia

During the SARS 2003 pandemic, the MOH learned to focus on delivering time-sensitive information and involving data rapidly via daily press releases. During the COVID-19 pandemic, the MOH streamlined communication using social media to remain connected and accessible to the public. Town halls, online dialogue sessions, call centers, and hotlines were also set up and organized to disclose information to the public. In addition, the MOH improved public trust by conducting periodic public sentiment analyses and opening communication channels with the public through social media.

Fiji

As COVID-19 immunization campaigns rolled out, mainstream and social media reported on “anti-vaxxer” views and vaccine safety doubts, resulting in a drop in vaccinations. In addition, the public steadily became more hesitant about being vaccinated due to the ease of access to all information (and disinformation) online. In order to stop the spread of misinformation and disinformation regarding the vaccines, the government used social media platforms such as Viber, Facebook, and Gmail to communicate with HCWs (health care workers). During the second wave of COVID-19, aggressive risk communication was conducted to combat vaccine hesitancy using social media platforms and panel discussions.

Vietnam

The Vietnamese government warned citizens of the risks of COVID-19 even before the first case was reported, using social media and texting people directly. The government frequently communicated with the public through Zalo (a local Vietnamese app). The government also used creative measures to reduce the risk of infection, including a pop song turned into a hand-washing PSA and a mobile app to provide citizens with real-time information on COVID-19. In April 2020, Vietnam passed a decree allowing authorities to fine people who share false, untruthful, distorted, or defamatory information on social media.

8. CONCLUSION

In many countries, the use of ICT proved to be effective in preparation and response to the pandemic in every aspect; not only has it accelerated the pandemic response in areas such as testing and contact tracing, but also it has facilitated communications and the delivery of education services. The analyses show that the level of ICT development is correlated with the severity of lockdowns, confirmed cases, and resilience to COVID-19.

ICT as a tool for responding to COVID-19

The COVID-19 pandemic clearly demonstrated countries' health care capabilities and ability to respond to infectious diseases. Although responses from various developed countries, including Korea, the UK, Germany, France the US, and Japan, were different, it was common to use ICT to collect information and quickly implement quarantine policies based on it. As a representative example, the Johns Hopkins Coronavirus Resource Center in the United States has been updating and disclosing the number of coronavirus infections, related policies, and trends in coronavirus infections—every day at the start of the pandemic and later with decreasing frequency. COVID-19-related data worldwide is presented in a single dashboard, providing analysis information, the trend of infected people, and the level of social isolation policies. It was possible to collect and disclose such information because ICT was used.

Korea responded effectively and quickly to COVID-19 because it prepared for infectious diseases during the MERS and SARS outbreaks in the past, and it has a well-developed ICT system. The Epidemic Intelligence Support System (EISS) led the response to the movement of confirmed patients and close contacts, where timeliness is the most important factor, through accurate information delivery and rapid sharing. Some other countries took considerable time to introduce location-tracking apps.

ICT infrastructure and response to COVID-19 in each country

Figure 4: Ls (Lockdown Severity) by I (IDI Values). It shows degree of lockdown in countries with high ICT infrastructure.

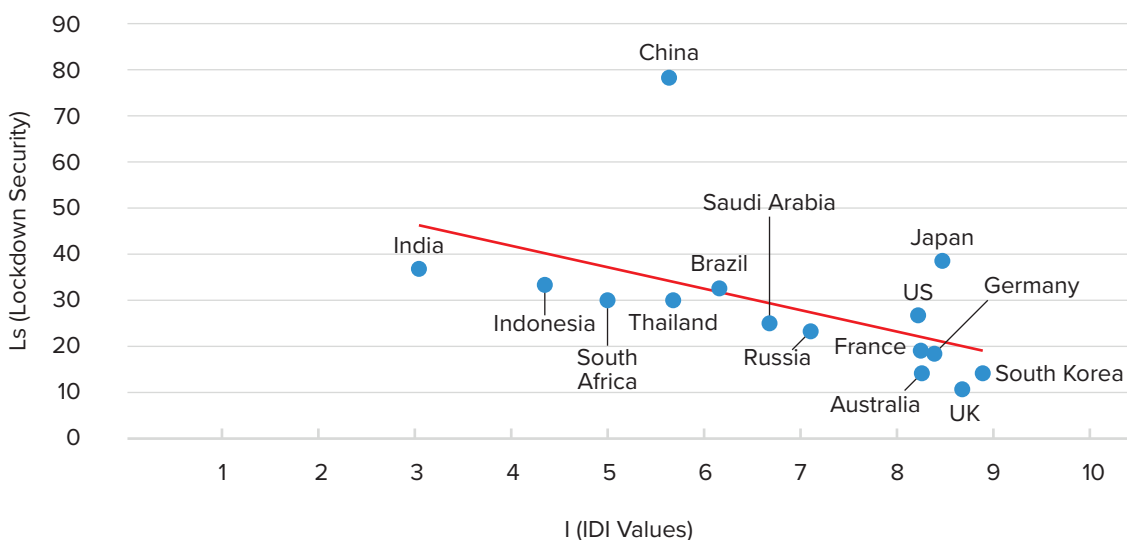
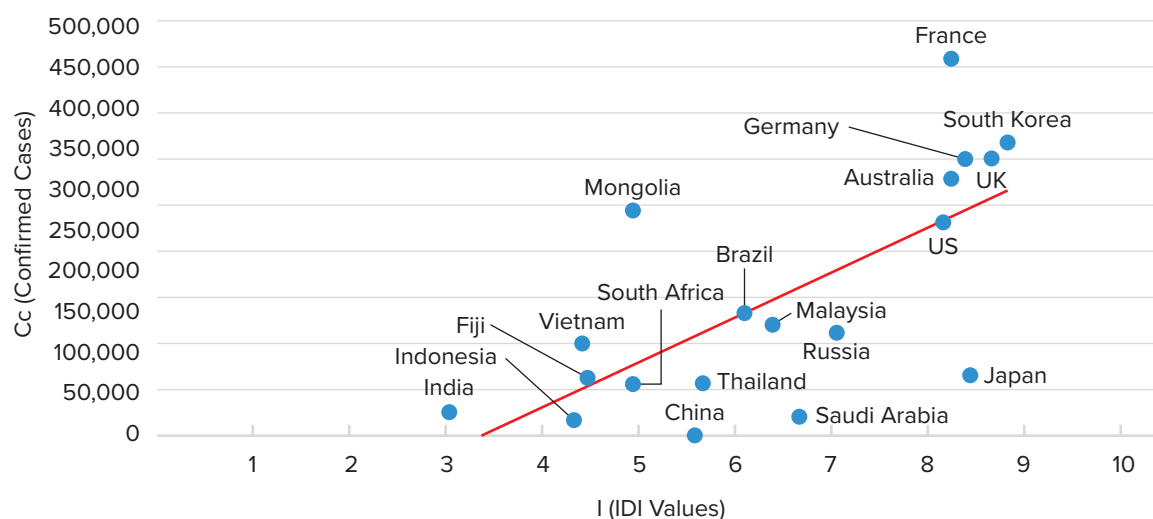


Figure 5: Cc (Confirmed Cases) by I. It shows total confirmed cases of countries with high ICT infrastructure.



During the COVID-19 pandemic, it was found that each country was in a different stage of social distancing. For example, China implemented a very high level of social quarantine (also called lockdown severity), whereas the US and Japan responded with a low level. *Figure 4* shows at a glance that the direction of policies pursued by each country is different, as is the level of ICT infrastructure. The horizontal and vertical axes represent the ICT development index and the lockdown severity, respectively. The lockdown severity is a composite measure based on nine response indicators, including school closures, workplace closures, travel bands, and other factors. As shown in *Figure 4*, the higher the IDI ranking of countries with developed ICT infrastructure, the lower the lockdown severity. Moreover, those countries in the bottom right corner have lower fatality rates and scored higher resilience scores, according to *Table 1*.

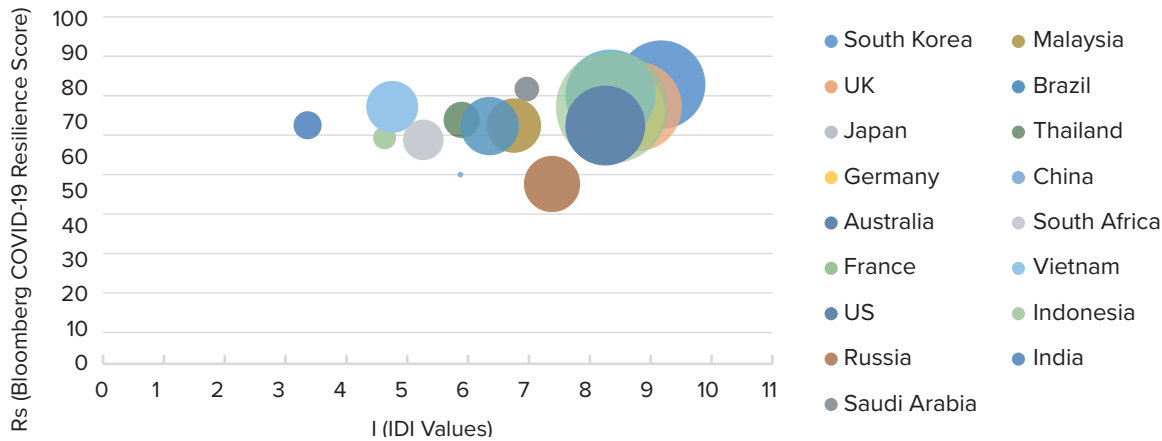
Table 6: COVID-19 Tests per 1,000 People with IDI Values and Lockdown Severity

Country	COVID-19 tests per 1,000 people (cumulative) (Our World in Data 2022)	IDI Values (ITU 2017)	Lockdown Severity (Hong et al 2020)
UK	5,566	8.65	11
Korea	823	8.85	14
Australia	1,992	8.24	14
Germany	1,093	8.39	18
France	2,708	8.24	19
Russia	1,623	7.07	23
Saudi Arabia	901	6.67	25
US	2,086	8.18	27
Thailand	241	5.67	30
South Africa	348	4.96	30
Brazil	305	6.12	33
Indonesia	147	4.33	34
India	471	3.03	37
Japan	220	8.43	38
China	Not provided	5.60	79

Note: Mongolia, Malaysia, Fiji, and Vietnam are not on the *Table 5* because they didn't provide data on COVID-19 tests.

Figure 5 shows that the higher the IDI values, the higher the confirmed cases. As shown in Figure 4, countries with high ICT values implemented low lockdown severity, while China and India, which have relatively lower ICT values, implemented high lockdown severity. Table 5 also shows that countries that implemented low lockdown severity conducted relatively many COVID-19 tests. In addition, it shows that countries with high ICT values implemented low lockdown severity and actively conducted COVID-19 tests.

Figure 6: Cc by I and Rs (Bloomberg COVID-19 Resilience Score)



Note: Mongolia and Fiji are not on the bubble charts because the Bloomberg Resilience ranking didn't provide data on them.

Figure 6 shows the IDI values and the COVID-19 resilience scores on the horizontal and vertical axes, respectively, and the confirmed cases are displayed as bubbles. There is a high number of confirmed cases in countries with high ICT values and a high COVID-19 resilience score. As shown in Table 5, this seems to be due to the fact that countries with high ICT values have conducted many COVID-19 tests. It can be seen that many developed countries have conducted more COVID-19 tests than developing countries.

9. LESSONS LEARNED

- Various methods such as contact tracing, online education, and telemedicine using ICT were implemented in many countries. However, in order to implement these government policies effectively, good user manuals are necessary.
- Countries with a high level of ICT infrastructure could rapidly transform traditional education systems into online systems and implement telemedicine, as they had the technologies and budgets to provide tablet PCs and other digital devices.
- In South Africa, India, Indonesia, Brazil, Mongolia, Fiji, Vietnam, China, and Thailand, countries with relatively low IDI values, building and improving ICT infrastructure should be a top priority to make the ICT policies effective.
- In addition to the online education and telemedicine policies using ICT, policy makers should consider how many people in rural areas with low income can obtain access to the services.
- Often most of the ICT infrastructure is concentrated in big cities. Governments should endeavor to increase the accessibility of remote areas to ICT infrastructure.
- In the case of online education, the lack of digital literacy is also a big issue. Therefore, governments should provide guidelines for teachers to use technology to deliver quality education.
- Governments in each country should ensure clarity by delivering correct information regarding COVID-19 and the proper use of PPE through the media so that people are not exposed to misinformation and disinformation.
- Data privacy was a big issue when governments implemented contact tracing apps. People in some countries put the public interests first in order to deal with COVID-19.

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