COMMISSION ON SCIENCE AND TECHNOLOGY FOR DEVELOPMENT (CSTD)

Geneva, Switzerland

Contribution by

Keio University

to the CSTD call for information sharing on initiatives against COVID-19

Sharing several COVID-19 related papers from our group. Hope, these are useful. Also, we recently developed a COVID-19 risk assessment tool, please see: www.covid19risk.net

At this point, this is more suited in Indian condition, and we hope to customize it for South Asia. This tool is pre-infection risk assessment tool which uses four parameters (Health, Behaviour, Exposure and Social Policy) to identify population at risk. The backend data collected from this tool can be used by policy makers for the following:

1. Informed decision making on medical and other resource allocation for high risk zones
2. Planning awareness generation programs in areas with low compliance to good respiratory hygiene and social policy.
3. Tool itself can be used as a risk communication and information tool.
4. The risk assessment tool is easy to use on mobile, laptops and tablets can be taken for the other family members (senior citizens, children etc.) who do not have access to mobile phones.

Be A COVID-19 Champion!

About the Tool

COVID-19, the novel coronavirus has become a pandemic affecting millions of people across the world

Questions are based on published research from China, Europe & reported cases in India

Features

Multilingual survey

Know your own risk

Know the risk around you

Help the NGOs to work with you

Help the government to plan

Concept

COVID-19 risk assessment has four interlinked factors that contribute to the spread of the viral infection

Usage

Take survey for yourself and for other family members

Crowd sourced data is used to plot the risk map of the area

Personal data privacy will be maintained for all respondents

RIKA

India Japan Laboratory

PROFECIA LINKS

powered by aws

Take the survey at **www.covid19risk.net**

OR

Scan

The tool is designed by RIKA in collaboration with India Japan Laboratory, Keio Univeristy. The webpage is powerd by AWS and User Interfeace is done by Profecia links

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Invited ViewPoint

Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework

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ABSTRACT

2020 has become the year of coping with COVID-19. This year was to be the "super year" for sustainability, a year of strengthening global actions to accelerate the transformations required for achieving the 2030 agenda. We argue that 2020 can and must be a year of both. Thus we call for more utilisation of the health-emergency disaster risk management (Health-EDRM) framework to complement current responses to COVID-19 and the patent risk of similar phenomena in the future. To make our case, we examine current responses to COVID-19 and their implications for the SFDRR. We argue that current mechanisms and strategies for disaster resilience, as outlined in the SFDRR, can enhance responses to epidemics or global pandemics such as COVID-19. In this regard, we make several general and DRR-specific recommendations. These recommendations concern knowledge and science provision in understanding disaster and health-related emergency risks, the extension of disaster risk governance to manage both disaster risks and potential health-emergencies, particularly for humanitarian coordination aspects; and the strengthening of community-level preparedness and response.

Contents

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1. Introduction: SFDRR and Health Emergency and Disaster Risk Management (Health-EDRM)

COVID-19 has rapidly morphed into an unprecedented health, economic and geopolitical crisis. It surely underscores the imperative of accelerating the integration of multiple global policy frameworks, not least those at the centre of the 2030 Agenda. Prior to the emergence of COVID-19, the UN Secretary General had positioned 2020 as the "super year" for action on sustainability (UN, 2020). The Sustainable Development Goals (SDGs), Paris Agreement on Climate Change, and the New Urban Agenda, alongside the SFDRR were all adopted in 2015–2016. March 18th, 2020 marks the fifth anniversary of implementation of the 2015–2030 Sendai Framework for Disaster Risk Reduction (SFDRR). The SFDRR aims to enhance national and community capacity to cope with disaster risks. It emphasizes a comprehensive approach, to address multiple hazards (technological, biological and environmental) that impact at different scales, frequency, and intensity (UNISDR, 2015).

Human health cross-cuts all the global frameworks. The SFDRR explicitly includes epidemics and pandemics among biological hazards (UNISDR, 2015) [1–3]. Moreover, SDG 3 is devoted to "good health and well-being", with an emphasis on "early warning, risk reduction and management of national and global health risks" (UN, 2015). For its part, the Paris Agreement and the Intergovernmental Panel on Climate Change Assessment Report highlights that climate change exacerbates health risks including pandemics (see e.g. [4,5]). The recently edited book by Chan and Shaw [6] on Public Health and Disasters is timely since it highlights the progress and importance of the Health-EDRM framework adopted by the WHO in 2019. Health-EDRM refers to the "systematic analysis and management of health risks, posed by emergencies and disasters, through a combination of (1) hazard and vulnerability reduction to prevent and mitigate risks, (2) preparedness, (3) response and (4) recovery measures" (WHO 2019). Health-EDRM is thus an umbrella term, which the WHO uses to refer to the broad intersection of health and disaster risk management (DRM). It also comprises such areas as emergency and disaster medicine, bolstered health systems and resilience, disaster risk reduction, humanitarian response, and community health resilience [7].

Against the backdrop of still-worsening COVID-19 impacts, this paper discusses resilience building for pandemics and related biological hazards. We examine ongoing efforts to respond to COVID-19 and these efforts' implications for the Sendai Framework. Our analysis reveals specific areas of rapid response to COVID-19. But we find lamentably few actions by DRR-related organisations, in spite of the SFDRR's call for building resilience to biological hazards. Moreover, the current WHO-led coordinated response reveals little implementation of the WHO Thematic Platform for Health-EDRM adopted in 2019. Existing mechanisms and strategies for disaster resilience, such as those detailed in the SFDRR, offer concrete means to respond effectively to epidemics and even global pandemics such as COVID-19. We thus put forward general and DRR-specific recommendations for short and long-term resilience.

This viewpoint is structured as follows. In the introduction, we present the motivation for the paper along with brief reviews of the recent progress of SFDRR and Health-EDRM implementation. Section 2 reviews global responses to COVID-19 complemented with discussion of responses by agencies related to DRR. Section 3 elaborates our recommendations supported with examples and cases.

2. Responses to COVID-19 from global to national level

This section briefly investigates current responses to COVID-19 from the global, regional to national levels. We do not engage in an exhaustive review of approaches at any level, and instead use representative cases to demonstrate our key argument. That is, we focus our analysis on whether a given level - global, regional or national - includes significant input from DRR-related agencies. To us, the evidence suggests that COVID-19 has yet to elicit early and rapid action from the DRR-related organisations. We believe this passivity belies the SFDRR's call for building resilience against all hazards, including biological hazards.

2.1. Global level

The global level of response includes the UN's COVID-19 communications wherein the Secretary General has called for "coordinated, decisive, and innovative policy action" on COVID-19. The World Health Organization, under Director-General Dr. Tedros Adhanom Ghebreyesus, leads the coordinated response for COVID-19. On the 11th of March, the DG announced that COVID-19 is a global pandemic. As of March 20, WHO's front page focuses on the COVID-19 outbreak (https://www.who.int/emergencies/diseases/novel-coronavirus-2019) (Fig. 1). The WHO has called for at least US$675 million to fund critical response efforts in countries most in need of help through April 2020.

The above and other content indicate that the WHO (2019) framework on Health Emergency and Disaster Risk Management (Health-EDRM) has no apparent role in the current response strategies. Certainly there is no mention of disaster at all within the WHO Coronavirus disease (COVID-19) technical guidance, particularly on the COVID-19 Strategic Preparedness and Response Plan, regarding Operational Planning Guidelines to Support Country Preparedness and Response (WHO, 2020).

Also at the global level, the UN Office for DRR [8] issued a press release on the 12th of March 2020 urging disaster management agencies to prioritize biological hazards. The UNDRR asked national disaster management agencies to continue with the development of their preparedness and response capacities to include health emergencies as a top priority, alongside earthquakes, floods, storms and other natural hazards (UNDRR, 2020). It

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also highlighted the importance of silo-breaking in disaster prevention and management, notably the silos between disaster management and health workers. The UNDRR reiterates that the Sendai Framework emphasizes the need for resilient health systems and the integration of disaster risk management into health care provision at all levels. After all, Sendai turns the focus from disaster response and management to preparedness, surveillance and disaster risk management in the health context (UNDRR, 2020). Yet it is not clear whether COVID-19 is leading to collaboration between the WHO and the UNDRR.

We appraise the speed and scale by which COVID-19 response funds are made available. International funding organisations, regional government bodies and private entities have proposed major financial measures. The International Monetary Fund (IMF) made $50 billion in loans available to deal with the coronavirus, including $10 billion of zero-interest loans to the poorest IMF member countries (IMF, 2020). The EU Commission President Ursula von der Leyen announced a €25 billion coronavirus investment fund for the health care sector, labour market and SMEs (EU, 2020). The World Bank Group increases COVID-19 Response to $14 billion to help sustain economies and protect jobs. The Asian Development Bank (ADB) announces $6.5 billion initial response to COVID-19 pandemic (ADB, 2020). The UN announced $15 million dollars from the UN's Central Emergency Fund to help fund global efforts to contain the spread of the COVID-19 coronavirus, particularly vulnerable countries with weak health care systems (UN, 2020). It is important to note that in the SFDRR, investment and finance are at the core of Sendai Framework, in terms of the resilience investment needed for countries and communities.

2.2. Regional level

We separate the regional level into Europe, Asia, and Africa. Concerning the former, the European Commission (EC) leads the planning and implementation of European Union (EU) strategy, its role in setting priorities, and its implementation through EU policy. A dedicated website is https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response_en. The EU has established a common European response to the outbreak of COVID-19, focusing on public health sectors and socio-economic impact particularly mobility and economy in the **European Union** (EU, 19th March 2020). Italy is the most severely impacted country in the EU. The EC support for the Sendai Framework identifies health as one of the issues interlinked with DRR (EC Web, 2020). Yet it is unclear whether the EU response to COVID-19 features coordinated involvement by DRR-related agencies and mechanisms. The opportunity for integration may be possible through the Integrated Political Crisis Response (IPCR). The IPRC provides a flexible crisis mechanism for supporting the presidency of the Council of the European Union in dealing with major natural or man-made cross-sectorial disasters, as well as acts of terrorism. The IPCR works through common Monitoring and Information-sharing (EU, 2016).

In Asia, the response of the Association of Southeast Asian Nations, or **ASEAN**, is instructive. The ASEAN was established on 8 August 1967 in Bangkok, Thailand, with the signing of the ASEAN Declaration (Bangkok Declaration) by Indonesia, Malaysia, Philippines, Singapore and Thailand. The ASEAN now includes 10 member countries and coordinates regional action. Concerning COVID-19, ASEAN has issued ASEAN Health Sector Efforts in the Prevention, Detection and Response to Coronavirus Disease 2019 (ASEAN, 2020). Guided by the ASEAN Post-2015 Health Development Agenda (APHDA) and its Governance and Implementation Mechanism (GIM), the ASEAN Health Sector Cooperation deployed and operationalized the established and existing health mechanisms for technical exchanges, information sharing, and updates on policy-related measures in responding to COVID-19. ASEAN specialised agencies involved are the ASEAN Emergency Operations Centre Network for public health emergencies (ASEAN EOC Network), ASEAN Senior Officials for Health Development (SOMHD) of ASEAN and China, Japan and Republic of Korea (Plus Three Countries), and ASEAN BioDioaspora Regional Virtual Centre (ABVC) (ASEAN, 2020). There is no indication that the ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre) is involved in the ASEAN's response to COVID-19. AHA Centre is an inter-governmental organisation which aims to facilitate cooperation and coordination among ASEAN Member States and with the United Nations and international organisations for disaster management and emergency response in ASEAN region. Leadership is beyond the mandate of the AHA Center (see https://ahacentre.org/about-us/). But its plethora of existing mechanisms can and should be used. These mechanisms include the Emergency Operations Centre (EOC), the Standard Operating Procedure for Regional Standby Arrangements and Coordination of Joint Disaster Relief and Emergency Response Operations (SASOP), the ASEAN Joint Disaster Response Plan (AJDRP), the Disaster Emergency Logistics System for ASEAN (DELSA), the Emergency Response and Assessment Team (ERAT), the ASEAN Regional Disaster Emergency Response Simulation Exercise (ARDEX), ASEAN-ERAT (ASEAN-Emergency Response and Assessment Team) and the AHA Centre Executive (ACE) Programme (REF). Globally, the ASEAN region is one of the most vulnerable to disasters, and the AHA Center has been praised for its role in strengthening DRM in the region (e.g. [9,10]). These competencies surely ought to be deployed in addressing the rapid emergence of COVID-19 as well as building resilience against a repeat.

Another item of note is the South Asian Association for Regional Cooperation (SAARC). **SAARC** is the regional intergovernmental organisation and geopolitical union of states in South Asia. Its member states are Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka. The SAARC leaders held a video conference on 15 March 2020 to discuss measures to contain the spread of COVID-19 in the region (GoI, 2020). India's Prime Minister initiated the conference, calling upon SAARC leaders to work collectively to fight the spread of the pandemic in the region. India called for the creation of a COVID-19 Emergency Fund, with voluntary contributions from all Member States. India itself pledged US$ 10 million as an initial contribution. There is no further information available. To be sure, SAARC developed a Comprehensive Framework on Disaster Management and Disaster Prevention in 2005 and established a number of SAARC centres, chiefly the SAARC Centre for Disaster Management and Preparedness (SDMC) to implement the framework. Yet progress to build the DRM capacities of South Asian states through regional cooperation has been slow (Brookings-LSE, 2015). There have long been doubts about SAARC's effectiveness (e.g.[11]) and readiness [12], so it may not be up to the task of coordinating a regional response to COVID-19.

In Africa, WHO-African region coordinates the response, with its latest Situational Report announced as of 18 March 2020. A total of 345 confirmed COVID-19 cases have been reported across 27 countries in the region (WHO-AFRO, 2020). Financially, Melinda and Gates' foundation issued USD 115 million in aid for COVID-19 with USD 100 million pledged to Africa and South Asia.

2.3. National level

It is very clear that responses to COVID-19 centre on actions at the global and national level. We organise the review by the regions.

2.3.1. Asia

The first known case of COVID-19 emerged in the **Chinese** city of Wuhan on December 12,019 and was deemed an emergency in the third week of January 2020. WHO declared COVID-19 (the “new coronavirus”) a Public Health Emergency of International Concern (PHEIC) on 31st of January 2020, and finally a pandemic on 11th March 2020. Based on Chinese newspaper, social media and other digital platform data, Hua and Shaw [13] analyse the timeline of key actions taken by the government and people over three months in five different phases: the very early phase (up to 31st of December 2019), the investigation phase (up to 20th January 2020), the early identification phase (up to 31st of January), the criticism, agony and depression phase (up to 14th February), and lastly the positive preventive and curative control phase (up to 29th February). Their analysis details the initial delay in responding, but also highlights key factors in China's efforts to combat COVID-19. These factors include

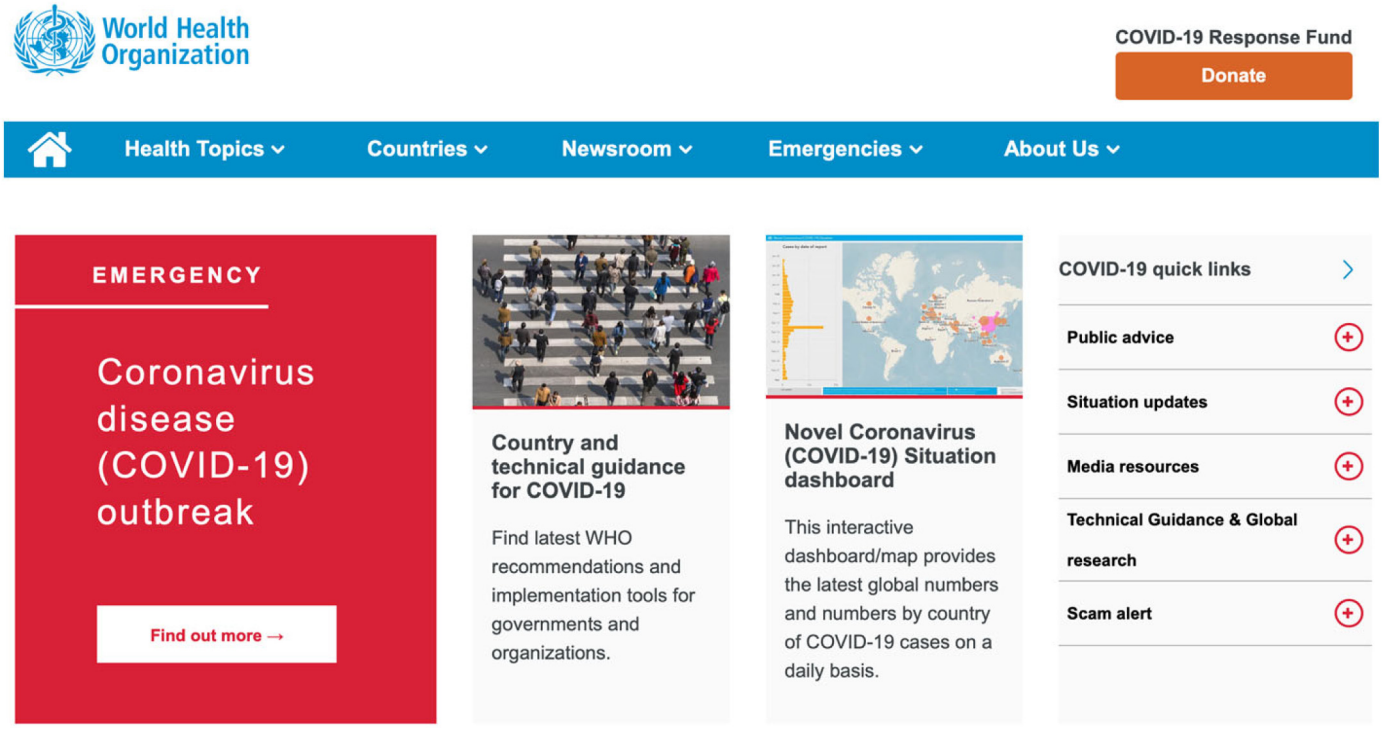

Fig. 1. Frontpage of WHO website on March 19th, 2020 (WHO, 2020).

strong governance, strict regulation, strong community vigilance and citizen participation, and wise use of big data and digital technologies.

Japan came under the spotlight in January 2020, when the luxury cruise ship Diamond Princess was docked in Yokohama, and symptoms of COVID-19 were detected in several persons. Complex issues of governance and strict regulation complicated the initial response, leading to a wide spread of the COVID-19 among the passengers and crew. Subsequently, COVID-19 began being reported in persons returning to Japan from abroad, mainly from China. The Hokkaido region is particularly affected. An epidemic cluster approach has marked the Japanese government's response, limiting testing. A strict government response followed, including school closures from early March, telework from home, flexible working time to avoid crowded trains, and an epidemic cluster approach. Communities and people followed this "request" from the government (which was not compulsory) apparently limiting the spread of COVID-19 and the number of deaths. Thus, the combination of government request and strong self-discipline within people and communities has evidently led to desirable results. The dedicated website http://japan.kantei.go.jp/index.html provides timely updates from the Prime Minister, with Japan having passed two packages of small business loans, one $4.6 billion package in February, and a $15 billion one on March 11, 2020.

In sharp contrast, **South Korea** was a surprise case of sudden high increase in affected people and high number of deaths (over 9,000 cases). Several cases of community spread, notably from religious organisations, which went out of control. However, through a strict screening and testing system, aided with advanced technology, South Korea was able to bring down the number of affected people as well as number of deaths. The country allocated more than $13 billion in emergency funds to stoke economic activity.

Taiwan, on the other hand, used 2003 SARS experience to prepare from the beginning through strict countermeasures as well as big data analysis of people's movement and thereby identifying the possible areas of spread of COVID-19.

Singapore is another case where an initial surge was observed in the number of affected people. The country took strict regulatory measures for quarantine, tracing infected people's movement. These measures succeeded in significantly limiting the number of newly infected people. Singapore has set aside 5.6 billion Singapore dollars ($4.02 billion) in the coming year to help businesses and households.

Other ASEAN countries, including **Indonesia**, provide a promising example of integrating Health-EDRM. The Indonesian COVID-19 task force (*Gugus Tugas Percepatan Penanganan COVID-19*) has been formed to coordinate the national COVID-19 response. A single coordinated source of information in Indonesia is presented through its dedicated website www.covid19.go.id. This task force is led by the chief of the National Disaster Management Agency (BNPB), General Doni Monardo. Beyond that, it remains unclear whether there is a deeper coordination of different agencies/ministries, and whether this extends to response mechanisms from the national, provincial and local governments. The Indonesian government has prepared a budget of Rp 1 trillion, or around $70 million, to be channelled through the Health Ministry to try to contain the Covid-19 outbreak and care.

India, with the second largest population in the world, has taken early precautionary measures through travel and visa bans on foreigners from certain countries, mandatory health checks and self-quarantine for 14 days. The Indian Prime Minister, in a national address, encouraged citizens to observe self-curfew and community vigilance at the initial stage. These actions appear to have limited community spread in this highly populated country. While PM Modi has announced India's contribution to SAARC, information for the national fund is not available.

Iran, on the other hand, has seen a drastic rise in the number of affected people and deaths, the largest in Asia (outside China). The Iranian outbreak has mainly been attributed to a lack of initial responses by the government, limited public awareness of the risk of contagion, and lack of mandatory self-quarantine. Public attitudes are a key issue underlying Iran's high death rate (roughly 10% of globally infected people, as compared to China's 30%).

2.3.2. Europe

In Europe, **Italy** is the worst hit with a comparatively high percentage of deaths among the infected. This outcome has been attributed to lack of regulation and testing, which prompted the community spreading. Gradually,

stricter government regulation and vigilance systems have been implemented and enforced, along with social distancing among the people. However, the open border among the EU countries has helped in spreading the disease to Spain, France, Germany and Switzerland, as well as to the UK. The European Union (EU) has been surprisingly slow in coordinating a response to the outbreak. High rates of infection and deaths eventually prompted the European Commission to coordinate a common European response to the outbreak. The response includes resolute action to reinforce the country's public health sectors and mitigate the socio-economic impact in the European Union. In terms of funding, the French announced $49 billion, Italy announced a $28 billion plan on March 11 to be divided over two separate spending packages, while the UK announced a £5 billion COVID-19 fund (UKGov, 2020).

2.3.3. North America

The impact on North America was delayed and the threat taken quite lightly. The most significant action for some time was airlift of infected passengers from the cruise ship in Japan in February 2020. However, no travel ban was imposed. This policy resulted in free travel to Europe and Asian countries, leading to a sudden increase in the number of infected people in both Canada and the USA. Once WHO declared COVID-19 a pandemic in the second week of March, the **USA** also declared a national emergency, although some of the states declared state emergency at an earlier stage. Travel bans have since been imposed and screening, testing, mandatory quarantine practices are in place. The US government's website on COVID-19 is https://www.usa.gov/coronavirus. US President Trump signed an $8.3 billion spending bill, currently called “Phase One” of stimulus efforts, and up to $50 billion in aid to states, cities, and territories (USAGov, 2020).

In **Canada**, the Prime Minister convened an Incident Response Group on coronavirus, which has been meeting since the end of January. On March 5, he created a Cabinet Committee on the federal response to the coronavirus disease (COVID-19). Chaired by the Deputy Prime Minister and vice-chaired by the President of the Treasury Board, the committee meets regularly to ensure whole-of-government leadership, coordination, and preparedness to limit the health, economic and social impacts of the virus. The Canadian federal government released $1.1 billion in emergency response, with a larger fiscal stimulus planned (Gov of Canada, 2020).

In summary, countries took dramatically different approaches in managing the pandemic. The variation is marked by prior experiences and preparation, early reinforcement of strict vigilance, testing and isolation, late law enforcement, strong vs weak public awareness, self-restraint, commitments, and other factors. Some aspects of risk perception, awareness and response is a cultural issue, and powerfully linked to the socio-economic structure of the country and community. But in a strongly interconnected world, there surely needs to be a global standard and protocol for regional and national response. It is imperative to build mechanisms that decrease risks of infection and enhance community safety and resilience.

3. Recommendations on how current strategies for disaster resilience can contribute to responses to COVID-19

In this section, we put forward some recommendations on how current strategies for disaster resilience can contribute to responses to COVID-19. These are grouped into DRR-related health emergencies and recommendations in general.

3.1. General responses and societal adjustments

3.1.1. Legal aspects

There is an urgent need for global protocols, agreed and signed by the governments, to respond to global pandemic. A global pandemic is not merely a health issue, but also demonstrates a profound influence on the global economy. The lack of science-based decisions, resort to ad-hoc travel bans, and other uninformed and uncoordinated responses, worsened this pandemic both as a health crisis and an economic crisis.

3.1.2. Health and science aspects

It is imperative to strengthen information sharing and other coordinating mechanisms for health-related humanitarian issues. This includes sharing examples and experiences of preventive and treatment systems, new vaccine and preventive medicine information, means to protect the community from spreading through breaking the line of infection, and also basic awareness on sanitation. Future complexities and uncertainties on global health, along with environmental and societal changes will only increase in the future. The scientific methodologies to deal with uncertainties are being developed and should be utilised further in decision making. As stated in a March 17 editorial in Nature, it is critical to “Follow World Health Organization advice, end secrecy in decision-making and cooperate globally” [14].

3.1.3. Lifestyle aspects

First, good hygiene and a robust immune system are key to coping with any virus, and COVID-19 is no exception. Thus healthy lifestyles are prominent in enhancing resilience. Also, telework, the use of AI and other new technologies for work which can be done remotely needs to be promoted. These measures are consistent with emergent means of collaborating and producing science. These include working from home, collaborating online, online meeting and teaching, social media engagements by scientists, and engagement of social science. This diffusion of cooperation can also help behavioural science understand societal responses, foster risk communication experts, science-policy advice.

3.1.4. Learning from prior experiences makes a difference

Some countries and regions such as Singapore, Vietnam, Taiwan learned from the bitter experience of SARS of 2003. The recent past incentivised them to act promptly and no doubt inclined their citizens to cooperate, which paid off in reducing COVID-19's spread.

3.2. DRR-specific recommendations

3.2.1. Stronger knowledge and science provision in understanding disaster and health-related emergency risks

Disaster Risk assessment is a standard approach in DRR. Core methodologies for disaster risk assessment include hazard and vulnerability assessment. These methods can be utilised for COVID-19 risk assessment. In addition, the health sciences should be more involved in the community of disaster risk management, to advance our understanding of outbreaks and pandemics, the health impacts of all hazards, and improve data collection [15]. Science is recognised especially in modelling disease spread, data on affected people, and the rush for vaccines. Open data, Open Science and Open Map are being advocated. Existing spatial and remote sensing capacity for disaster can be used for mapping pandemics. The UN-SPIDER (Space-based Information for Disaster Management and Emergency Response) knowledge portal recognises epidemics as a source of hazard. The existing regional tsunami early warning systems can also be tasked for health-related emergencies. The systems include the Pacific Tsunami Warning Center (PTWC); the Indian Ocean Tsunami Warning System (IOTWS); and the North Eastern Atlantic, the Mediterranean and connected Seas (NEAMTWS). There is strong recognition for integration on DRR and CCA and appropriate adaptation can greatly reduce the health burden resulting from climate change and disasters [16]. The Sendai Framework takes an interconnected and pluralistic approach to understanding risk (UNDRR, 2019). The nature of current risks is complex and systemic, and can also be compound, interconnected, infracting and cascading risks [17]. Natural, technological and biological hazard disasters can occur in these fashions, as shown in the triple disasters of earthquake, tsunami and nuclear power plant failure in March 11, 2011 in Japan. Countries like Japan, or Indonesia, despite having to respond to current COVID-19, they also need to be ready should an earthquake or tsunami occur.

3.2.2. Mobilise existing disaster risk governance structure to manage disaster risk and potential health-emergencies

Multi-stakeholder engagements have been established, especially in disaster vulnerable countries. The same engagements can be utilised for addressing pandemic risks. One key agency is the International Federation of Red Cross and Red Crescent Societies (IFRC). The IFRC combines a wealth of knowledge on disaster risk reduction, with expertise in fighting the spread of diseases, combat discrimination and violence, and promoting human rights and assistance for migrants. For example, the IFRC issued an Appeal for Global COVID-19 Outbreak, and the IFRC, UNICEF and WHO issued new guidance to help protect children and schools from transmission of the COVID-19 virus (IFRC, 19 March 2020).

3.2.3. Utilise existing disaster coordination mechanisms at regional level to inform epidemic response

The regional bodies like ASEAN, SAARC, European Union (EU) need to enact regional protocols, coupled with information portals on pandemic risk. Traffic is quite high within the region, especially among countries with land borders. Thus proper protocol on human movement information sharing is required. The information sharing needs to be open and transparent, which enhances safer regional, cross border as well as global movement.

3.2.4. Understand COVID-19 economic implications and resilience

COVID-19 and its effects afford ample evidence of the imperative of bringing health into DRR. The economic fall-out from COVID-19 appears to be profound, at least $20 trillion in a few short weeks, and may exceed the 2008–2009 Great Recession. The direct costs of COVID-19 travel bans, social distancing, and other responses are merely one aspect. Far more devastating is the uncertainty that has gripped capital markets. Declining economic activity and large drops in capital markets have a mutually reinforcing impact, undermining the capacity of heavily indebted businesses and households to cover their debts. Uncertainty is the primary driver of such crises, and stems in large measure from lack of close coordination and science-based decision-making. Were there more certainty, households, investors and other economic agents would be less inclined to panic. COVID-19 appears certain to become a very costly lesson that DRR does indeed save many more multiples in avoided costs than its initial investment. An additional point in this regard is that health is a critical infrastructure. The resilience of critical infrastructure is well identified in DRR literature (e.g. [18,19]). Resilience is fostered not just by science-based decisions and coordination, but also via redundancy to ensure buffer capacity when a particular system collapses [20]. Disaster-illiterate economic policy tends to see redundancy as inefficiency. But in order to cope with COVID-19 and alleviate - if not prevent - future emergencies, supply chains for at least some critical items need to be more local. In tandem, governments and private businesses will have to broaden their crisis planning to ensure timely availability of items essential to limiting pandemic risks.

3.2.5. Prepare inclusive early recovery plans

At present, the data suggest that in some countries, including China, Korea, Japan, and a couple of other Asian countries, the peak of the COVID-19 may be over. It is imperative to continue taking precautions, including screening, isolation of suspected cases and social distancing. However, it is also important to start developing early recovery planning, which needs to be gender and disability inclusive. The socio-economic fall-out from this crisis is already high, and quite literally rising by the day. Concerns about preventing a protracted global recession, if not outright depression, are leading to focused intervention in capital markets and other areas. Aviation, energy, hotels, and other concerns that appear - to their investors and to policymakers - to be too big to allow to fail seem about to be given relief. Yet pandemic risks increase when general community health and well-being weaken. Thus it is critical that measures also be taken to identify the most vulnerable and include them in recovery packages.

3.2.6. Strengthen community-level preparedness and response

Methods from Community-based DRM can be used for COVID risk assessment. Community-based disaster preparedness and management [21,22] is crucial in reducing disaster deaths and losses. The last mile approach in disaster EWS, where community networks, communication systems, can be utilised for pandemic EWS at the community level. In disaster literature, risk perception strongly influences willingness to prepare for emergencies. Social linkages in communities may play an important role in focusing risk perceptions [23], while disaster type, gender, and previously experienced disasters are good predictors of victims' attitudes toward natural disasters [24].

In summary, we have examined current and unfolding responses to COVID-19 and their implications for the Sendai Framework. Core to our argument are strategies for resilience building against biological hazards and pandemic. We reiterate our assertion that there is a lack of early and rapid actions from the DRR-related organisations, despite the SFDRR's call for building resilience including from biological hazards. The SFDRR's ultimate goal is a substantial reduction of risk and losses, coupled with laying the essential foundations for rapid and sustained recovery and sustainable development. We hope the evidence we have added shows the crisis of COVID-19 could be used to make 2020 a “super year” of great progress on these goals.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Article

Corona Virus (COVID-19) "Infodemic" and Emerging Issues through a Data Lens: The Case of China

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Abstract: Coronavirus (COVID-19) is a humanitarian emergency, which started in Wuhan in China in early December 2019, brought into the notice of the authorities in late December, early January 2020, and, after investigation, was declared as an emergency in the third week of January 2020. The WHO declared this as Public Health Emergency of International Concern (PHEIC) on 31th of January 2020, and finally a pandemic on 11th March 2020. As of March 24th, 2020, the virus has caused a casualty of over 16,600 people worldwide with more than 380,000 people confirmed as infected by it, of which more than 10,000 cases are serious. Mainly based on Chinese newspapers, social media and other digital platform data, this paper analyzes the timeline of the key actions taken by the government and people over three months in five different phases. It found that although there was an initial delay in responding, a unique combination of strong governance, strict regulation, strong community vigilance and citizen participation, and wise use of big data and digital technologies, were some of the key factors in China's efforts to combat this virus. Being inviable and non-measurable (unlike radioactive exposure), appropriate and timely information is very important to form the basic foundation of mitigation and curative measures. Infodemic, as it is termed by WHO, is a key word, where different stakeholder's participation, along with stricter regulation, is required to reduce the impact of fake news in this information age and social media. Although different countries will need different approaches, focusing on its humanitarian nature and addressing infodemic issues are the two critical factors for future global mitigation efforts.

Keywords: COVID-19; Coronavirus; infodemic; humanitarian emergency; data science; good governance; citizen participation

1. Introduction

Coronavirus (COVID-19) started spreading in December 2019 and was noticed in early January 2020. It started spreading in China in mid- to late-January. Among the different types of confusion and information challenges, we need to recognize that COVID-19 is first and foremost a humanitarian challenge [1]. As of 24 March, 2020, the virus has caused the death of over 16,600 people worldwide with more than 380,000 people are confirmed as infected by it, of which more than 10,000 are serious. As many as 184 out of 195 countries are affected. Solving the humanitarian challenge is the key priority through proper preventive measures to stop its spread, as well as curative measure to develop a vaccine. The impact of this public health emergency has affected countries and communities in terms of economic, socio-psychological issues, as well as international relations.

"We're not just fighting an epidemic; we're fighting an infodemic", said WHO Director–General Tedros Adhanom Ghebreyesus at the Munich Security Conference on 15 February 2020. WHO Information Network for Epidemics (EPI-WIN) was launched as a new information platform after WHO declared COVID-19 as a Public Health Emergency of International Concern (PHEIC). The goal

was to share customized information with specific target groups [2]. Finally, on 11th March, WHO declared it this as a pandemic.

"We know that every outbreak will be accompanied by a kind of tsunami of information, but also within this information you always have misinformation, rumors, etc. We know that even in the Middle Ages there was this phenomenon. "But the difference now with social media is that this phenomenon is amplified, it goes faster and further, like the viruses that travel with people and go faster and further. So it is a new challenge, and the challenge is the [timing] because you need to be faster if you want to fill the void...What is at stake during an outbreak is making sure people will do the right thing to control the disease or to mitigate its impact. So it is not only information to make sure people are informed; it is also making sure people are informed to act appropriately." Said Sylvie Briand, Director of Infectious Hazards Management at WHO's Health Emergencies Program and architect of WHO's strategy to counter the infodemic risk. This poses the real challenge of mitigating the risk occurring from Coronavirus.

One of the key issues of the "invisible disaster" is obtaining correct information. In 2011, Japan had a triple disaster, caused by an earthquake-induced tsunami, which caused a nuclear meltdown. A that time, there was a severe panic in and around Japan about the level of radiation, which was also an invisible disaster. However, radiation could be measured, whereas the level of penetration of the virus is not measurable. Therefore, providing the right information from a reliable source is the key issue in this type of pandemic.

Keeping this infodemic challenge in mind, this paper tries to analyze three months of happenings in China from December 2019 to February 2020, drawing and analyzing data from different Chinese websites, social media and research institutes. The value addition of this paper lies in the fact that original data were collected and analyzed in Chinese, and from Chinese social media. Although a characteristic information censorship exists in China, there were several positive and negative things that happened in the last three months. This paper is a narrative of those events and provides an original analysis.

There are three characteristics/impacts of the paper: (1) this is possibly the first analytical paper which uses firsthand social media and internet data and information from China to describe the time-series narrative in Wuhan and China with a focus on key policy decision, (2) it also uses original survey raw data to understand the types of media people used to get information, and (3) the reliance of different types of online services at different phases of the lockdown.

Of course, the paper has its own limitation, since, due to the evolving nature of the pandemic, the paper analyzes the spread in the original hotspot (although, as of late March 2020, the hotspot has shifted to Europe), which was Wuhan and the Hubei province of China. However, the key findings, which are described in Section 5, are useful to other parts of the world, which is currently suffering the impacts of COVID-19, as well as in future pandemic responses.

2. Characteristic of COVID-19

The data on Coronavirus are changing on daily basis, and it is difficult to provide current statistics for the affected, recovered and casualties. However, based on some initial studies, a few characteristics are emerging for this virus. It is reported that the case-fatality-rate (CFR) for Coronavirus was 2.3%, initially; however, the age group of 70 to 79 has an 8% CFR, and CFR is 14.6% for those more than 80 years old [3]. This means that the virus has a stronger impact on the aged population.

The other characteristic of the virus is its speed in spreading. When Dr. Zhong Nan Shan made a public announcement of this virus in CCTV on the 20th of January, the virus had already spread in different provinces in China, as well as outside China. Every day, some new countries are added to the list, which has already reached more than 100 countries and regions. It took only 30 days to spread from one city to the entire country of China. The early cases may have been spread from the Wuhan seafood market, while later cases were spread from person to person, the speed of which surprised the health workers in Wuhan city and Hubei province. The epidemic curve shown in [4] as well as

presented later in this paper, shows that the second to the third week of January was the most crucial time, when the spread was very high.

There are some similarities and differences among COVID-19, Severe Acute Respiratory Syndrome: 2002–2003 (SARS) and Middle East Respiratory Syndrome: 2012-ongoing (MARS). SARS also had a zoonotic transmission in markets in Guangdong Province, China. It is said that COVID-19 is likely to have been transmitted from bats via palm civets. Similarly, MERS was also traced to zoonotic transmission of a novel coronavirus (likely from bats via dromedary camels) in Saudi Arabia. All three viruses have similar syndromes like fever and cough, which frequently lead to lower respiratory tract disease. However, SARS has a higher CFR of 9.6%, while MARS is even higher at a rate of 34.4%. Despite much higher CFRs for SARS and MERS, COVID-19 has led to more total deaths due to the large number of cases.

Projection shows a significant recession in the global economy due to Coronavirus spread [1]. The global surge reflects a new inflection point in this epidemic. Four 'major transmission complexes' (i.e., China, East Asia, Middle East, Europe) are now active, while the US is already at a tipping point. The analysis says that continued spread within established complexes plus community transmission in new complexes drives a ~0.3%–0.7% reduction in 2020 global GDP growth. The impact on demand slows down the growth of the global economy by between 1.8%–2.2%, instead of the 2.5% growth envisioned at the start of the year. Sectors are impacted differently. Certain sectors (e.g., aviation, tourism, hospitality) see lower demand for a longer duration. For others (e.g., consumer goods), demand is initially lower but expected to rebound quickly. The report also argues that 24th of February 2020 was a turning point, when the cases outside Chine exceeded in-China cases for the first time. South Korea, Italy, Iran, Japan and Singapore are the top five countries outside China which have reported a maximum number of cases, with Iran reporting the largest number of casualties outside China.

3. Data Source and Methodology

To focus on the key word "information", which is crucial for any invisible disaster, a series of different types of data were analyzed. Primary data sources include:

(1) Sina Weibo's (Chinese social media) hot search list (in which a key word has been accessed every day for how many times as well as how many hours) [5]

(2) Corona Virus timeline data in China (which are compiled by the authors from different data sources like Sina, Tiki-Toki, Caixin, Baidu, Tencent and provincial and municipal government data) [6–21]

(3) CSM media research data on the use of different types of media to acquire information [22, 23]; and

(4) Mob-Tech Research Institute data of use of internet during the Corona virus spread [24,25].

Four specific types of analysis were made based on the above-mentioned data sources:

(a) **Timeline narrative, number of affected people and public concern**: The timeline narrative is developed based on the sequential events in the country, and important measures taken, which is also juxtaposed to the major public concerns. Weibo's data (2020) have been analyzed for the top 206 to 360 hits per topic (depends on the daily variation) over a period of three months, from 1 December 2019 to 1 March 2020 [24]. Tiki-Toki's data [9] is the Chinese government big data platform, and provides information on different government measures, news, policies, and also is linked to major global milestones in the related topic (here, Coronavirus-related topics). Sina's data was on (1) the number of affected people (confirmed cases, recovery, and death) at both the country level and in Hubei province, (2) Sina Weibo data to analyze social media information. Figure 1a,b show the growth in the number of affected and recovered people and casualties in Hubei province and the whole of China, which is referred to in a later section. Figure 2 was also prepared as an original diagram to highlight different phases of this disaster. Specific attention was made on the day to day changes in numbers, any significant policy actions taken, and any significant incidence (positive or negative) reported on social media or a website. Social

media/website information (both government official sites as well private sites) were used to draw the timeseries narrative. Word Cloud analysis was made using the key words used in social media for all the five phases mentioned in the text, and the top five most commonly used words are picked to highlight the key discussion in the social media, as well as to understand citizens' agony.

(b) **Media use during/after Coronavirus spread and information types:** This is mainly derived from the analysis of [23] on February 20–21, 2020, with more than 1500 residents from all 31 provinces in China, to understand the use of media to acquire information related to Corona virus. The analysis used the data of CSM survey to draw original graphs and diagrams with its interpretation;

(c) **Positive impact on certain online industries**: The data from [24] are based on the analysis of 2019 and 2020 analysis, but more specific intensive analysis of the use of the internet during the period of 22 January 2020 to 6 February 2020. These data were used to understand the proliferation of certain online services compared to others, which is correlated to people's interest in different topics available online.

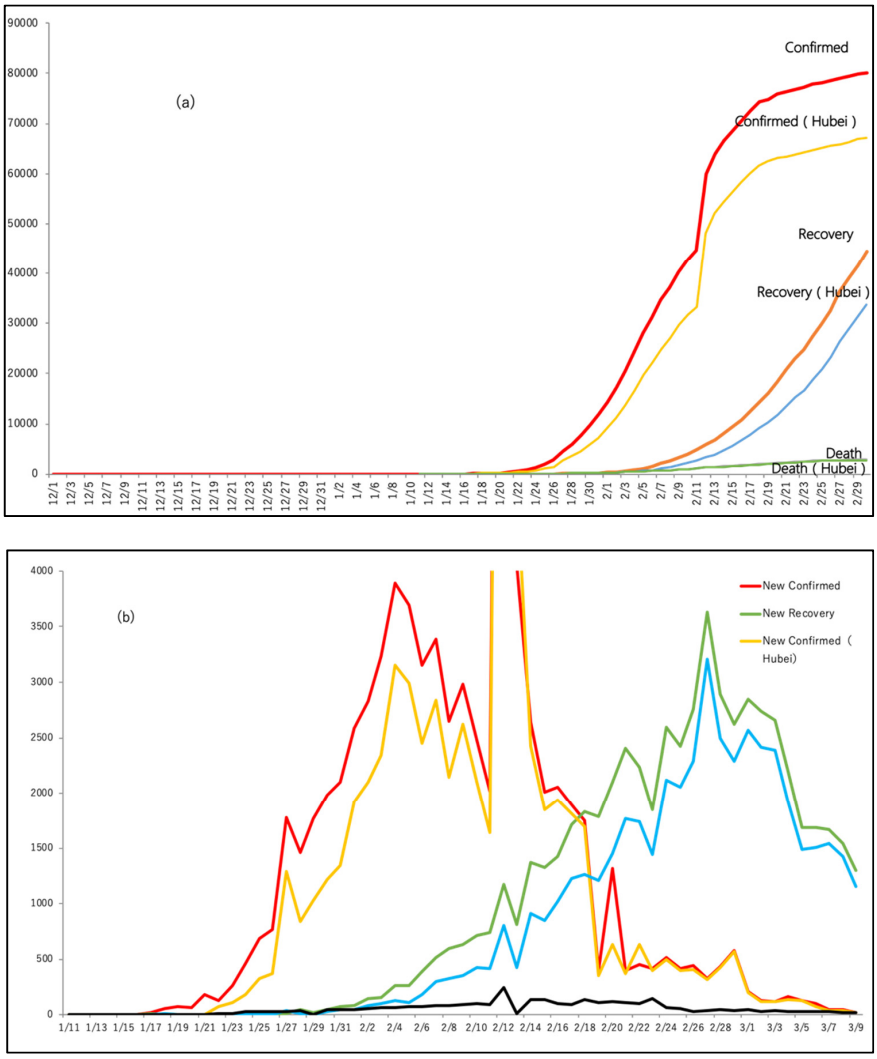

Figure 1. (**a**) Number of people affected, recovered, and dead in China and Hubei province; (**b**) New confirmed and recovered cases in China and Hubei province; (Source: these graphs were prepared by the authors using original data from: Sina News [5]).

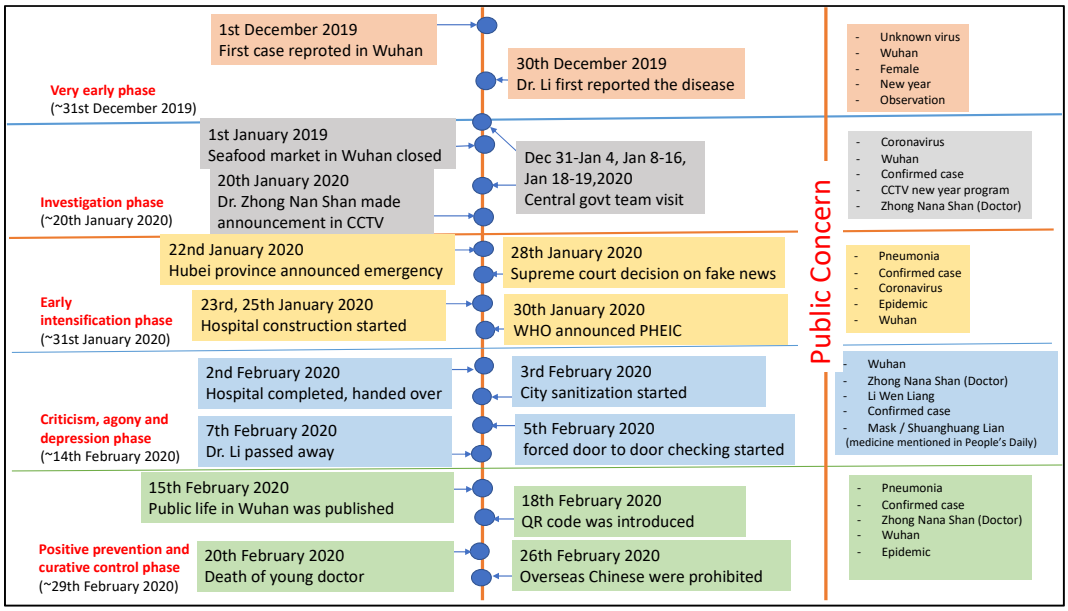

Figure 2. Timeline of key events and public concern; (Source: This figure was prepared by the authors using original data from: Sina, Tiki-Toki, Caixin, Baidu: [6–21]).

4. Data Analysis and Key Findings

4.1. Narrative on the Events and Its Response Sequence

To develop this narrative, as mentioned above, a large number of sources were consulted, reviewed and some milestones events are presented here. Needless to say, with a vast country like China, with the level of infection of Corona Virus, there are many small yet important events, which may be missed out here. However, the author tried to highlight the key developments in China based on the five following phases:

1. Very early phase: Until 31 December 2019;
2. Investigation phase: Until 20 January 2020;
3. Early intensification phase: Until 31 January 2020;
4. Criticism, agony and depression phase: Until 14 February 2020;
5. Positive prevention and curative control phase: Until 29 February 2020.

Figure 2 shows the timeline of key events in five phases. Authors extracted the key events from different news and social media reports. In each phase, five top public concerns are highlighted, which is prepared through word cloud analysis in each phase using the key social media data, as specified in the methodology section.

4.1.1. Very Early Phase: Until 31 December, 2019

As per the available statistics, the earliest case was reported on 1 December, 2019 in Wuhan, and thereafter sporadic cases have been reported all through December, especially in the later part of the month. The first case was reported in a paper [26] on 1st of December 2019. The health commission of Wuhan municipality reported the first case of Coronavirus (at the time, an unusual disease). These were unusual cases, which took the local physicians by surprise, and it was Dr. Li Wen Liang who reported the unusual case as a possible epidemic in WeChat social media on 30th of December 2019.

4.1.2. Investigation Phase: Until 20 January 2020

This phase was characterized by a crackdown by local government and detailed investigation. Huanan seafood market in Wuhan city was closed on 1st of January. The city government and its

health commission investigated the cases in December and called Dr. Li and made him apologize for spreading a rumor on the 31st of December 2019. Three teams of experts from Beijing conducted a detailed investigation from the 31st December to 4th January, 8–16 January and 18–19 January. It was revealed that the disease was a new type of epidemic, which had not been reported earlier. This was announced on 20th of January by a major and well-known doctor, Dr. Zhong Nan Shan, in a CCTV online interview.

4.1.3. Early Intensification Phase: Until 31 January 2020

This was a critical period, when the disease spread was intensified and a relatively large number of casualties was observed. Figure 1a shows the number of people affected, recovered and dead in China and Hubei province, and Figure 1b shows the new confirmed and recovered cases in China and Hubei province. At an early part of this phase, a few critical and wise decisions were made:

22nd January: Hubei province announced a Level II public emergency;

23rd of January: Wuhan city was closed and all the entries and exits to the city were restricted. The decision to construct Huoshenshan Hospital (new hospital) for Corona virus cases was announced on this day (23rd January), followed the decision to construct Leishenshan Hospital (another new hospital) decision on 25th January. Ten hospitals in Wuhan city appealed for a supply of medical and other emergency goods from all over the country;

24th January: Hubei province followed the suit, and the whole province was closed for entrance and exit. Hubei, Beijing, Shanghai and eight other provinces declared a public emergency;

25th January: The Supreme court provided instruction on "Fake news" and the negative consequences of this. Tencent, which is the parent company of WeChat, established a website called "Rumors exposed website," as a platform to reduce rumors;

26th of January: The first emergency supply arrived from Sichuan to Wuhan, along with medical and healthcare staff;

28th January: President Xi Xinping met WHO DG Dr. Tedros Adhanom Ghebreyesus and discussed the situation. China Media administration instructed all TV channels to reduce entertainment programs, and to increase broadcasting information and programs on Coronavirus and related news;

29th January: A countrywide emergency was declared;

30th January: The Emergency Committee on the novel coronavirus (2019-nCoV) under the International Health Regulations (IHR 2005) was reconvened by the World Health Organization Director–General Dr Tedros Adhanom Ghebreyesus on 30th January (Geneva time) and a Public Health Emergency of International Concern (PHEIC) was declared;

31st January: People's Daily, the major Chinese newspaper' official account, published fake news on a possible medicine (named Shuang Huang Lian, a Chinese antibiotic, of which online orders and users have drastically increased) for Coronavirus by mistake, which caused the panic-buying of the medicine by the public.

4.1.4. Criticism, Agony, Depression and Control Phase: Until 14 February 2020

The next phase was a phase of panic, criticism, agony and sad news. The following events took place that explain this phase:

31st January: Public criticism started on Chinese social media regarding the outbreak of the virus;

1st February: People's Daily corrected their mistake regarding the fake news. A major media site, Caixin data analysis, showed that public agony had increased and people were growing worried about the future spread of the virus;

2nd February: The new hospital was prepared and handed over to the Army to take control;

3rd February: Sanitization of public spaces started, school entrance examinations were cancelled, and another new hospital was ready;

4–6th February: This was a time of control, where a few major control measures were taken. like a lockdown of villages, towns and cities (earlier, this was restricted to urban areas only). A new policy of

"no one will be spared" was started (this enabled the government to enter people's house and check for virus symptoms). Dou Ban, a major media group, was shut down. Overseas news, especially the spread of Coronavirus in a cruise ship in Japan (Diamond Princess) was broadcast in China through different media;

7th February: The first whistleblower from Wuhan, Dr. Li, passed away, and this caused severe public criticism in social media. This was followed by a depression phase, where several suicides by the infected people were observed, to save their respective family members;

9th February: The Center of Disease Control (CDC) head gave an online interview with Caixin and announced that the virus is a totally new type, of which not much is known yet.

There were several incidences of sacking senior administration people; the China News head was sacked for spreading wrong information (12th February) and Wuhan's Mayor was replaced (13th February). Holidays (school as well as offices) were extended.

4.1.5. Positive Prevention and Curative Control Phase: Until 29 February 2020

The following phase was a time of positive prevention and curative planning. Several new initiatives were taken through media to address public criticism as well as to lessen public agony:

15th February: A diary of public life in Wuhan was broadcast and shared through social media;

18th February: A touching story of female nurses cutting their hair to cope with the continuous work with protective suits was broadcast in the mass media as well as on social media. Dead bodies post-mortem had started to identify the key medical factors and impacts on the body. On the 18th of February, a unique approach of using a QR code was adopted in Wuhan and then spread to other parts of Hubei province using mobility and safety of the person (in terms of effect of Corona virus). This QR code was used for public transport, entering public areas. Using big data in mobile phones, three color coding were used (Figure 3): green (safe), yellow (need to be cautious), and red (cannot enter). Printed QR codes were used for the people who did not have mobile phones (like elderly people or children). On 19th of February, the "no one will be spared" policy was ended.

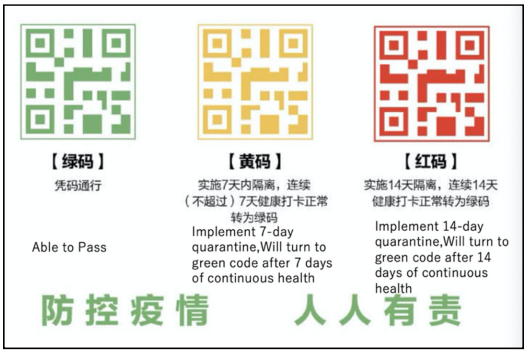

Figure 3. Three color codes used for monitoring people's movement (Source: https://www.sina.com.cn [5]).

20th February: A newlywed young doctor passed away, which also created negative sentiment in social media. The issues of vulnerable people like the aged population (11 of them died in an old people's home in Wuhan, along with the caregiver, which came out in the news on 20th February), physically and mentally challenged people, and their caregivers, received attention in the media;

21st and 22nd February: Data management and its authentication was re-ensured on (Jingzhou city), and goods distribution was re-investigated to ensure a balanced distribution (after a TikTok video which pointed out the imbalance in some areas). Punitive measures were taken for the two leaders of Hubei province for hiding information (22nd February);

23rd February: The last half of this phase was marked by mixed measures: ensuring the free flow of emergency goods and food and punishing those prohibited them (23rd February), and the death of two additional health professionals (23rd February);

26th February: New infection due to the return of overseas Chinese people in some selected provinces;

28th February: The unfortunate incidence of drinking sanitization tablet by mistake by some rural people, caused health issues, and there was another unfortunate incidence of suicide of a junior high school kid who did not have a mobile phone to undertake online classes provided by schools.

4.2. Media Use during/after Coronavirus Spread and Information Types

As mentioned above, an analysis was done by CSM Media Research with 1500 residents all over China on the mobile they use to access different sites. Figure 4 shows different media usage on four different aspects: increased usage after Coronavirus spread, same use as before, less use than before and do not use it for 6 months. Analysis shows that WeChat and TV played a strong role in acquiring information after Coronavirus spread. The amount of applications has also increased compared to other media usage, since it provides real-time information.

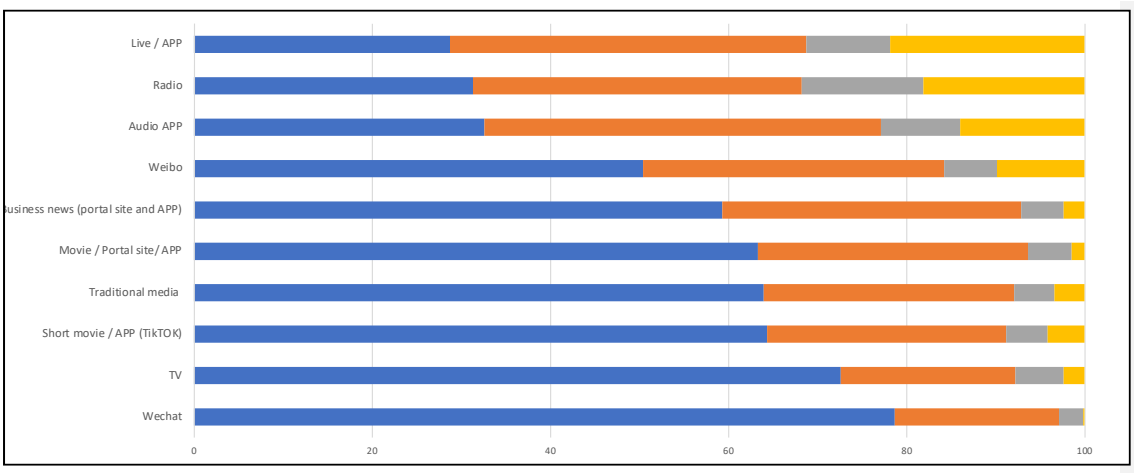

Figure 4. Use of different types of media before and after the Coronavirus spread; (Source: this figure was prepared by the authors using original data from: CSM Media Research [23]).

The survey also pointed out that 44% people sought to proactively secure information, followed the news and put in their favorites. A total of 33% viewed the information proactively, but did not put it into their favorite news items. A total of 19% people saw the information if it was in the news or media; 2% of people did not bother to take any additional actions for information gathering, while another 2% did not want to hear the negative news on Coronavirus.

Figure 5 shows the types of information accessed by different users through online platforms. It shows that the maximum access was to get information on medicines, followed by a set of other information like food/drink, online education, in-house sports, business information and entertainment and leisure goods. This shows the lifestyle requirements when people were isolated in their home for a long period of time.

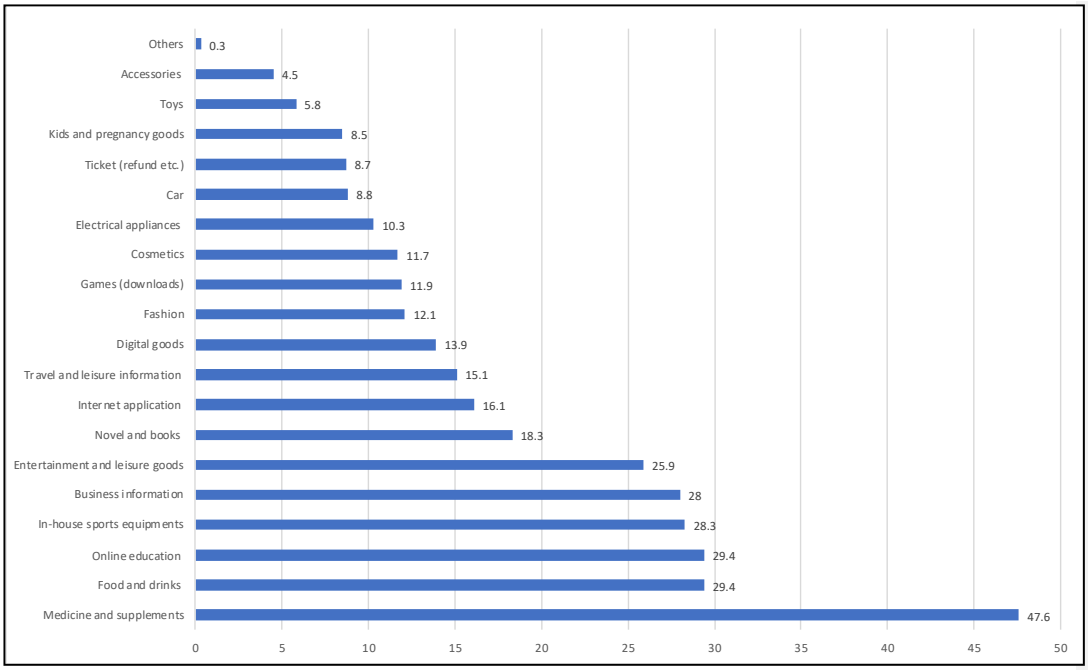

Figure 5. Types of information needed by people through online platforms; (Source: this figure was prepared by the authors using original data from: CSM Media Research [23]).

4.3. Positive Impact on Certain Online Industries

As seen in Figure 5, medicine, food supply and online education were the top searched items. Online food supply users have drastically increased by 10 million, with an increase of 10.60 million in delivery capacity (by volume) when comparing the data of online food shopping of January 2019 with that of January 2020. A significant increase is observed in users with the age group 35 to 44 years, from 27.9% (January 2019) to 45.1% (January 2020). Specific increase has been noted with households with children from 0 to 3 years old (from 7.2 % of January 2019 to 25.2 % in January 2020). The available data show that four major online food supply companies have increased their delivery capacity by a significant percentage. They are as follows: Hema Fresh (up by 50% compared to before the virus spread), Miss Fresh (up by 321% compared to January 2019), Dingdong Maicai (up by 300% from December 2019), and Jing dong Daojia (up by 470% compared to January 2019). All the companies are struggling with a lack of human resources and shared their employees to help each other, which delayed delivery in several cases.

Online education has also seen significant changes. On 27 January 2020, the Central Government Education Ministry has declared to postpone the start of classes until after the spring vacation. There was an instant rise in online education (Xueersi online internet school) after that, which saw a drastic increase by twenty-fold from 0.52 million to 11.54 million users within a period of one week (28 January to 6 February, 2020).

5. Key Learning and Postscripts

Through the Susceptible-Exposed-Infectious-Removed (SEIR) model and AI, [27] found that the epidemic of China should peak by late February, showing a gradual decline by the end of April. A five-day delay in implementation would have increased the epidemic size in mainland China three-fold. Lifting the Hubei quarantine would lead to a second epidemic peak in Hubei province in mid-March and extend the epidemic to late April, a result corroborated by the machine learning prediction.

WHO, in a recent joint study with Chinese colleagues, has summarized four specific key lessons as follows [3]:

1. China has rolled out perhaps the most ambitious, agile and aggressive disease containment effort in history. Although initially quite aggressive, gradually, a science and risk-based approach was taken to tailor its implementation;
2. Achieving China's exceptional coverage with adherence to these containment measures has only been possible due to the deep commitment of the Chinese people to collective action in the face of this common threat. At a community level, this is reflected in the remarkable solidarity of provinces and cities in support of the most vulnerable populations and communities;
3. China's bold approach to contain the rapid spread of this new respiratory pathogen has changed the course of a rapidly escalating and deadly epidemic;
4. China is already, and rightfully, working to bolster its economy, reopen its schools and return to a more normal semblance of its society, even as it works to contain the remaining chains of COVID-19 transmission.

From our own analysis, it was observed that the success of China's efforts in controlling the disease was a combination of strong governance, strict regulation and spontaneous community/citizen participation. Although it was a late response in terms of the local and provincial government at the initial stage, once the disease was confirmed as a new one, collective responses at the community, ward, city, province and national levels were significant. To keep this large a number of people confined in their homes for almost two months was not an easy decision in terms of both economic and socio-psychological aspects. China's mobile network and big data system was able to create the QR code-screening of people, which can be considered a significant achievement. As mentioned in the earlier part of this paper, WHO DG has termed this virus spread as infodemic; having the right information was key to the success of mitigation measures. At an early stage, The Supreme Court's directives on fake news were a very good step in this regard to reduce the spread of confusion and panic. The "Rumors exposed website" created by Tencent (the parent company of WeChat) helped to share information on fake news and rumors effectively. Whenever there was fake news published or some mismanagement happened with the emergency goods and food supplies, quick corrective measures were taken by the authorities. At the village level, local communities and volunteers worked hard to ensure the implementation of the mitigation measures to reduce the spread as well as to report confirmed or suspected cases. At an early stage, data management was an issue, but once the virus was confirmed and declared by the government, strict data management measures were put into place. In this case, strict corrective measures were ensured for the mismanagement of data. The current case needs a science based solutions with local action [28].

These lessons are also reflected in the WHO research roadmap [29], where eight specific research issues have been identified with a balance of medical diagnosis and community use. It also emphasized social science research in the outbreak response, where the WHO will establish a team that will be integrated within multidisciplinary research and operational platforms and will connect with existing and expanded global networks of social sciences. As per [30], governments will not be able to minimize deaths from coronavirus disease 2019 (COVID-19) and the economic impact of viral spread. Keeping mortality as low as possible will be the highest priority for individuals; hence governments must put measures in place to ameliorate the inevitable economic downturn. In our view, COVID-19 has developed into a pandemic, with small chains of transmission in many countries and large chains resulting in extensive spread in a few countries, such as Italy, Iran, South Korea, and Japan. Most countries are likely to have a spread of COVID-19, at least in the early stages, before any mitigation measures have an impact [30].

As we started the paper with two key words "humanitarian challenge" and infodemic, we would like to once again highlight that basic humanitarian principles need to be followed in this type of emergency. Of course, there are geo-political, economic and social consequences, which also need to be looked at. However, humanitarian issues need to prevail over other priorities. The second point is that Coronavirus is a non-measurable disaster, unlike other invisible disasters like radioactive emission. Therefore, having correct and timely information is crucial for stopping its spread, as well as

in the curative prevention of this disease. These two factors, along with good governance and citizen participation, will hold the key to success in combatting Coronavirus in future.

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Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia

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ABSTRACT

Corona Virus (CODID-19) was first reported in Wuhan in December 2019, then spread in different parts of China, and gradually became a global pandemic in March 2020. While the death toll is still increasing, the epicenter of casualty has shifted from Asia to Europe, and that of the affected people has shifted to USA. This paper analyzes the responses in East Asian countries, in China, Japan and South Korea, and provides some commonalities and lessons. While countries have different governance mechanism, it was found that a few governance decisions in respective countries made a difference, along with strong community solidarity and community behavior. Extensive use of emerging technologies is made along with medical/health care treatment to make the response more effective and reduce the risk of the spread of the disease. Although the pandemic was a global one, its responses were local, depending on the local governance, socio-economic and cultural context.

1. Introduction

It is now widely acknowledged that the Corona virus (COVID-19, as formally known) was first reported in Wuhan, China in December 2019, and was recognized by Chinese authorities as a new virus in January 2020. WHO (World Health Organization) declared this as a PHEIC (Public Health Emergency of International Concern) in the end of January 2020. After the initial delay in the source point (Wuhan), Chinese authorities took utmost efforts to control the spread of the disease, however, it has already started impacting other parts of China as well as other countries during mid to end of January. A term "infodemic" has been used by the WHO Director General at the initial stage of the spread of the disease (during mid-January 2020: [1] in Lancet), which seems to be still valid while writing the paper in the end of March 2020. WHO colleagues have warned the tsunami of information, especially with social media, which many times call for panic situation. We have observed this in several countries, as well as fake news spreading through social media. On 11th of March 2020, WHO has declared this as a global pandemic, and as of 23rd of March 2020, the virus has affected 172 out of 195 countries.

While the statistics of infected people, casualties changing rapidly overtime, it is very difficult to put a number. As of 29th of March, there are more than 30,000 death reported, while more than 23,000 people are in critical conditions globally. More than 650,000 people are affected. Although it is early to make any comment on the nature of its spread, a few characteristics can define this new virus as follow:

- **High rate of spread**: Within three months the virus has spread globally and is considered as a global pandemic. The rate of its spread is high, which happened due to higher mobility of people in a globally interconnected world. It can be said that people to people transmission rate of very high.
- **Aged and low immune people more vulnerable**: Data shows that the aged population [2] and people with low immunity (with diabetes or other chronic disease) are more vulnerable to this virus.
- **Differential recovery rate**: While the global average of recovery rate is relatively low (like 28 to 30%), different countries have differential recovery rate. While China, Korea, Japan has relatively high recovery rate, Europe, Iran, USA showed relatively lower recovery rate. Of course, this is constantly changing, and hopefully gets better soon.

Over last few weeks, there are several words which got significant attention like: "community spreading", "social distancing (physical distancing)", "self-isolation", "14 days quarantine", "lockdown," "break the chain" etc. All these are used for one purpose, which is to stop spreading the virus. Although there are reported use of medicines from different countries (without proper confirmation); there is no confirmed medicines used to cure this virus, or no vaccine available for COVID-19 as of March 23, 2020. Thus, the only way to stop the spread is to isolate us from social gathering or masses, and isolate confirmed people for quarantine. This process needs a combination of strong governance, use of existing and next technologies in innovative ways, and strong community participation and solidarity. Anderson et al. [3] made interesting analysis on how the country-based mitigation measures influence the course of epidemic (while they wrote the paper, the COVID-19 status was not a pandemic).

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While acknowledging that governance, citizen participation/awareness, penetration of technology varies from country to country, this paper makes a modest effort to analyze the experiences of China, Japan and Korea as East Asian cluster. Time series analysis of the key governance decision is made and its correlation with the spread of the virus within these three countries are observed. A few common lessons are drawn, which have larger implications to the society in this critical phase of COVID-19 global pandemic.

2. Global chronology of COVID-19

WHO Beijing office got the first information of an unknown virus on 31st of December 2019. From that point, three months are passed. In this section, a few global measures (mainly excluding East Asia, which will be described later), especially the role of WHO is narrated. Within two weeks from the first report in WHO Beijing office, first overseas case was reported in Thailand on 13th of January 2020. WHO Director General met Chinese President on 28th January and declared it as PHEIC (Public Health Emergency of International Concern) on 30th January. On the following day, Italy declared a national emergency with two case reported there. The virus spread continued in China as well as overseas after that, and on 11th February WHO has named the virus as COVID-19. A United Nations CMT (Crisis Management Team) was formed with WHO as the coordinating agency. WHO has appointed a few prominent persons as their COVID envoy on 21st of February to provide advices to different countries. A series of missions were organized by WHO team: one in Italy (24th February), one joint mission in China (25th February), and one in Iran (2nd March). 24th February was the time when the global epicenter has started shifting from China to other countries, with number of affected people outside China crossing that within China. Two major clusters were observed, apart from Kore and Japan: one in Iran and the other in Europe (northern Italy). Early March showed steady growth of affected people globally. WHO declared its research road map on 6th of March, and on 7th of March, it was found that the virus has affected 100 countries, and more than 100,000 people. This prompted WHO to declare COVID-19 as a global pandemic on 11th of March, and USA declared national emergency on 13th of March. Fig. 1 shows the number of affected people globally with key WHO decisions stated above.

The above description shows that within two months (from 13th of January, when first case was reported in Thailand, outside China to 13th of March, when USA declared emergency), the virus has taken a significant number of lives, affected a large number of people, and brought down many countries, including the economic hubs under lockdown. Several countries have made travel bans, lock down of cities and provinces, which has also impacted significantly the local as well as global economy.

As of 27th February 2020, a report by Mckinsey [6] has identified six global clusters as follow: Mature propagation (china complex), Early propagation (East Asia and Middle East complex), New propagation (Western Europe), and No propagation (Africa and America complex). However, one month has changed the scenario, where Western Europe complex has become the new epicenter, and America has observed a significant propagation. Based on the simulation, Mckinsey [6] proposed three global scenarios of quick recovery, global slowdown and global pandemic and recession. This would affect differentially the second and third quarter of the year. While the base scenario talks on the control of spread in East Asia in Europe in early second quarter, the early recovery predicts that it would be in late first quarter, while the recession/pandemic scenario talks about middle to late second quarter.

3. Chronology of events in East Asia and key policy decisions

Fig. 2a shows a comparative analysis of total number of confirmed, recovered and death in China, Korea and Japan. Fig. 2b shows the same on daily increase in these three countries. In both of Figures, since the numbers in China exceeds that in Korea and Japan by a significant percentage, the values are provided to show the highest numbers in China. China sees a sharp increase in number of confirmed cases from the third week of January, while a sharp increase in both recovered and death from the first week of February. Korea saw a sharp increase in number of cases from third week of February, while Japan saw an increase in the first week of March.

3.1. China

Detailed time series analysis of China is presented in Hua and Shaw [7], where the responses have been divided into five phases: 1) very early phase (up to 31st of December 2019), 2) investigation phase (up to 20th of January 2020), 3) early intensification phase (up to 31st of January 2020, 4) criticism, agony and depression phase (up to 14th of February 2020) and 5) positive prevention and curative control phase

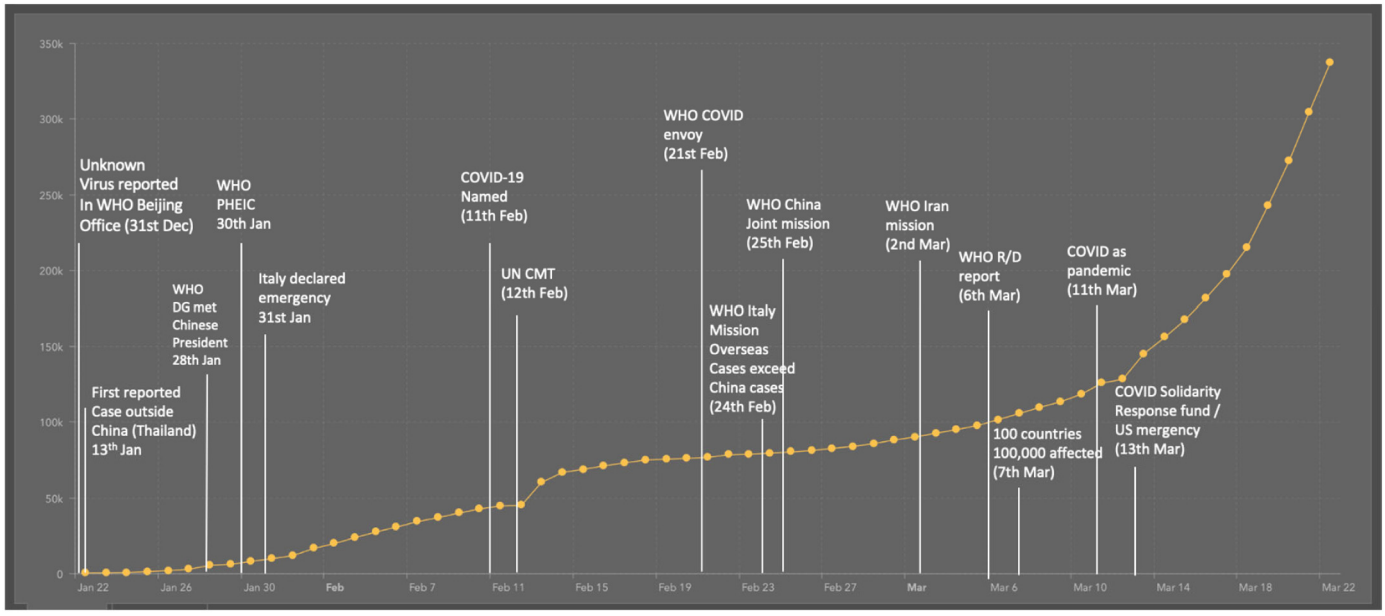

Fig. 1. Growth of globally affected COVID-19 affected people with key WHO decisions (drawn by authors with basic data from John Hopkins Corona virus Resource Center [4] with WHO rolling updates [5].

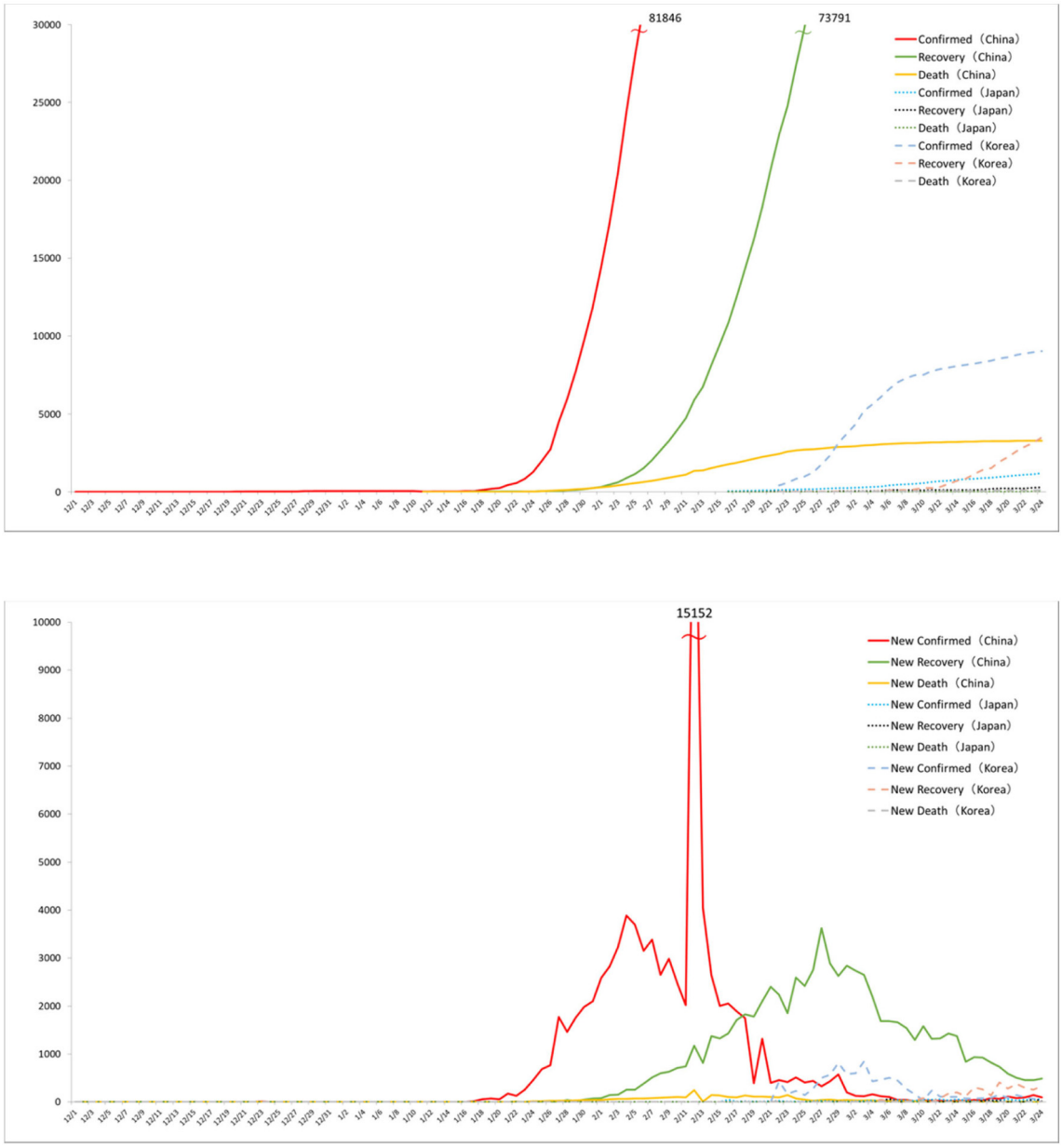

Fig. 2. a. Total number of confirmed, recovered and death in China, Korea and Japan. Panel b. Daily increase of confirmed, recovered and death in China, Korea and Japan.

(up to 29th February 2020). This paper also looks at the other events in March until 25th of March 2020. While looking at the key policy decisions taken over the course of action, a few clusters can be observed as follow (Fig. 3).

Cluster 1 (20–25 January 2020): On 20th January 2020, Dr. Zhong Nan Shan made official announcement in CCTV about the new type of virus identified in Wuhan, followed by announcement of emergency in Hubei province on 22nd of January, and decision on constructing new hospitals on 23rd and 25th of January. During this cluster the source area went under lockdown, and emergency response started officially. Based on these key decisions, emergency supplies including goods and medical teams arrived in Wuhan from different parts of the country.

Cluster 2 (2–5 February 2020): On 3rd of February 2020, city sanitization started with public spaces, parks etc. On 5th of February, a major decision was taken on "no one will be spared", which enabled the government officials to enter into people's house and check virus symptoms. This was a key turning point to identify new cases of affected people. A sharp increase in the number is also observed as a result of policy decision taken in Cluster 1 and 2 (Fig. 3). To stop spread of the disease, it was important to identify all possible sources. Thus, the strict decisions taken in cluster 1 and 2 were crucial. QR code was introduced for all residents on February 18, and this was a good check to distinguish between the affected and non-affected people. The next couple of weeks were devoted to implement the policy decisions and be vigilant for its violation.

Cluster 3 (10–13 March 2020): Visit of President Xi Xinping to Wuhan was a key turning point of the epidemic, which sent a message that the disease spread was under control. On 11th of March, WHO declared COVID-19 as a global pandemic. On 13th of March, the city of Qianjiang city in Hubei province has opened its business for the first time since the lockdown. This was also another indicator that the situation within China is under control, with appropriate preventive and curative measures are placed.

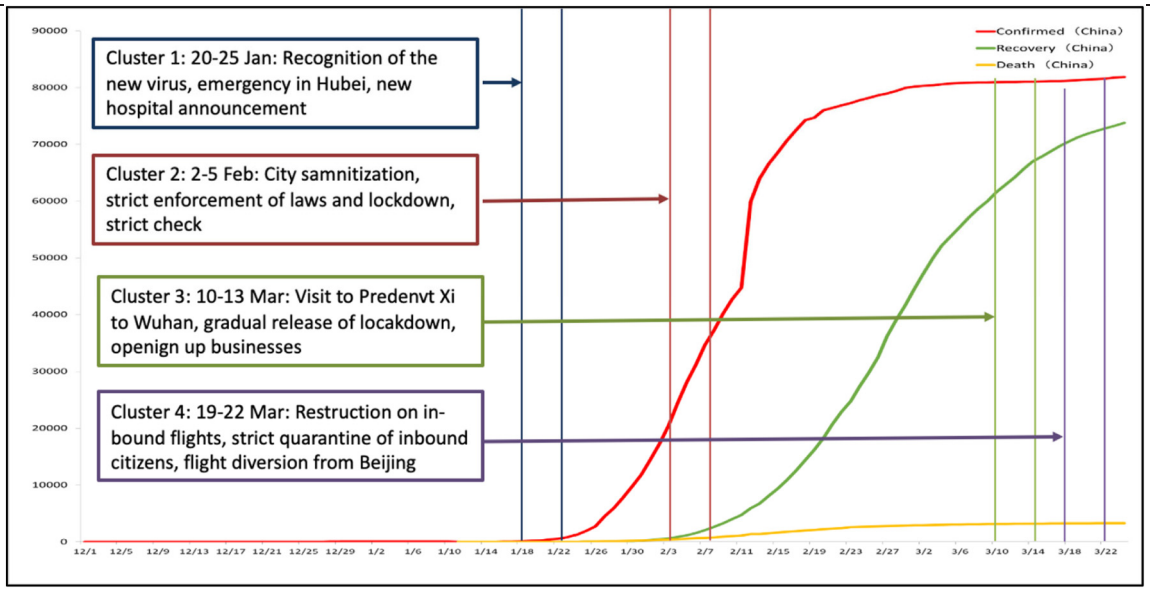

Fig. 3. Chronological changes and key policy decisions in China.
[Source: This figure was prepared by the authors using original data from: Sina, Tiki-Toki, Caixin, Baidu, see references].

Cluster 4 (19–22 March 2020): This cluster is characterized by the affected people arriving from overseas. The case of affected people entering the country from overseas was noticed on 6th of March 2020 reported in Shanghai and Shenzhen. This sent an alert to the Chinese authorities for the preparation of the returnees from overseas countries and urged stricter control on entry to the country. On 19th of March, in-bound flights to Beijing were advised to divert to other nearby airports aiming to reduce the burden to the capital city, and finally all overseas flights to Beijing was cancelled on 22nd of March. Selected hospitals were designated as specialized hospitals to treat the affected people, which other hospitals started sanitization. On 23rd of March, Wuhan lifted emergency and lockdown, however full normalization of life was aimed until 8th of April.

In case of Taiwan, the time series analysis points out an early preparation. As early as 31st of December 2019, Taiwan announced medical advisory (14 days self-vigilance, wearing mask, temperature check etc.) to inbound visitors on the Wuhan and started medical test. Specific warning was issues to all in-bound people from Wuhan on 6th of January, and was repeated four times (10th, 11th and 17th January). A team of experts was dispatched to Wuhan on 6th of January to identify the new disease spread. There was an early warning issued on restraining and legal actions on fake news spread, which was also repeated several times (11th, 17th, 21st and 23rd January). First confirmed case was reported on 21st January in Taiwan, which also prompted some other key decisions. To protect panic buying, the government bought masks, and started its own distribution system through national insurance card. Number of masks entitled per insurance card was strictly monitored, and masks were distributed free of charge in the rural areas. This system started at the early stage (3rd of February), and system was developed and customized based on the need and supply of masks, and finally the online shopping system started on 12th of March.

Other measures in Taiwan include: 1) introduction of health declaration card at entry points (airports and ports) on 11th February, 2) pre-entry electronic health declaration on 14th of February, 3) issuing travel advisory to mainland China (in January), Korea and Japan (on 22nd February), 4) provide special allowance to all medical staffs (from 23rd of February), 5) provide financial assistance to family of affected people (on 11th of March), and 6) provision of free medical treatment of the affected people not having medical insurance in Taiwan. The entry from Europe and middle east was restricted on 11th March, and total travel ban was announced on 19th of March to be effective from 24th of March to 7th of April. On 25th March, all night entertainment was banned, and gathering more than 100 people in one place was prohibited. Experience of Taiwan points out that an early level of risk identification, risk understanding and risk control and mitigation are key to prevent the spread of the disease. Prior experience of SARS may have been utilized to take early decision making, along with the inputs from the experts.

3.2. Japan

Japan reported the first case of COVID-19 between 10 and 15 January 2020 from a Chinese national who travelled from Wuhan. The second and third cases were reported on 24 and 25th January. It gradually spread through tourism industry (like bus driver, tour guide etc.). During 28th January to 17th February, Japan evacuated more than 800 Japanese national from Wuhan through five chartered flight. A detailed description of appearance of different cases in Japan can be found in Wiki [8]. Here, a few critical issues on Japan's approach is described below:

Diamond Princess Experiences: The Cruise ship “Diamond princess” arrived at the port of Yokohama on 3rd February 2020 and received world attention due to reported confirmed case in the ship. On 5th February, after a report of confirmed case, passengers were asked to stay in their rooms in the ship for quarantine and to avoid spread. At that time, there were 3711 individuals, which includes 1045 crew members. Although there was an initial delay in testing, Disaster infection Control Team (DICT) under the Japanese Society for Infection Prevention and Control started conducted test in the ship along with DMAT (Disaster Medical Assistance Team) [9]. DICT team comprised of approved infection control doctors, approved infection management nurses, as well as experts from university hospitals and other institutions. The crew members were provided with personal protective equipment (PPE) and instructed on appropriate IPC (Infection Prevention and Control) practices. The passengers were given thermometers and asked to record their body temperatures. Those passengers with lab-confirmed

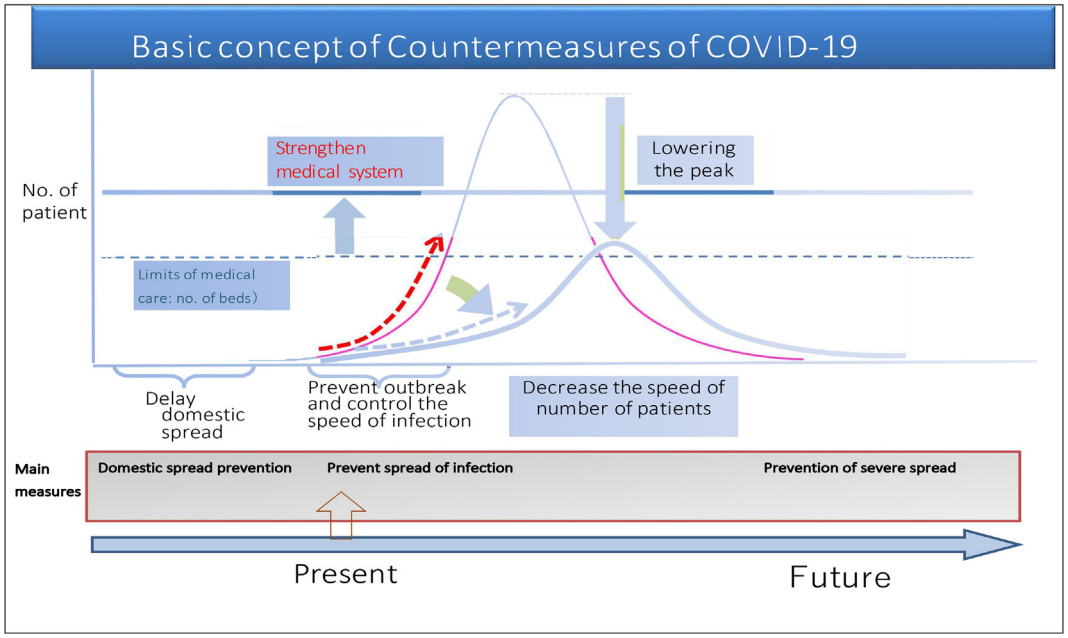

Fig. 4. Basic concept of countermeasures of COVID-19. (Translated and prepared by authors from original figure of MoHW [13]).

COVID-19 were disembarked and transferred to an isolation ward at healthcare facilities [10]. There was a zoning planned in the ship for the infected areas, as well as to store the infection prevention gears. With regards to the passengers, guidance was given through the in-cruise announcement repeatedly, and the video on the appropriate ways to remove masks and to sanitize fingers, created by the DICT, was delivered to the smart phones provided to each passenger for public awareness. As of 18th February, there have been 531 confirmed cases (14.3% of all individuals on board on 5 February), including 65 crew and 466 passengers. Based on the number of confirmed cases by onset date, there is clear evidence that substantial transmission of COVID-19 had been occurring prior to implementation of quarantine on the Diamond Princess on 5 February [10]. The disembarkation of all passenger was completed on 27th February.

Border control phase to Infection spread phase: Japan has been doing Border Control measures (*Mizugiwa Taisaku* in Japanese) to control the spread of infections in Japan. The measures in Diamond Princess is the reflection of that. Also, Japan had put specific measures to control inbound visitors from Hubei province and asking for filling up health forms, as well 14 days quarantine. However, from 15th of February, there have been reports of transmission cases for which routes could not be identified. In such situation, the focus shifted from Boarder control to infection spread control phase [11]. As of February 20, three deaths have been reported, and severe cases have started to be reported in the elderly and patients with underlying diseases. As per the experts, during the epidemic phase, the treatment of the serious patients was required. Border control measures continued with quarantine restrictions on travel of passengers from China and Korea on 5th of March, which gradually extended to other high-risk countries also. Once the disease started spreading, it was essential to identify the clusters from where it started spreading, which is stated below.

Cluster approach: The analysis by Tohoku University virology professor Hitoshi Oshitani, who is on a government panel of medical experts, comes as Japan ramps up contact tracing efforts with a focus on "active epidemiological investigation". On 25th February, MHLW prepared "Cluster Response Section," in accordance to the Basic Policies for Novel Coronavirus Disease Control. The cluster approach targeted to identify the cluster to spread the disease, and quickly take actions to stop the spread from the clusters. Japan has identified 15 coronavirus clusters nationwide in its first "cluster map", released on 16th March. Although the data changes over time, in the map, the biggest cluster, which accounts for more than 80 cases, involves four live music venues in Osaka. Another live house in Sapporo was also identified as a cluster [8]. Keeping in mind the increasing growth of affected patients, as well as identification of clusters, the Governor of Hokkaido had announced "a state of emergency" in Hokkaido on 28th of February and urged the residents to stay indoor over the weekend.

Temporary closure of schools across nation: Prime Minister Shinzo Abe had requested for the voluntary closure of school in the last week of February, and as a result, most of the schools across nations were closed from 3rd of March 2020. This apparently abrupt decision drew criticism from many schools, teachers and parents since it was announced with little preparation. However, this decision was on the crucial trigger to increase the urgency in people's understanding and actions. The only effective way at the moment to prevent the spread of this novel coronavirus is decrease personal contact among people and to increase personal hygiene, such as hand-washing [8].

Basic Policies for COVID-19: On 25 February, the Abe Administration adopted the "Basic Policies for Novel Coronavirus Disease Control" based on the advice that it received from the Expert Meeting. First, the new policies advised local medical institutions that it is better for people with lighter, cold-like symptoms to rely on bed rest at home, rather than seeking medical help from clinics or hospitals. The policy also recommends people at a higher risk of infection -including the elderly and patients with pre-existing conditions – to avoid hospital visits for such non-treatment purposes as completing prescription orders by letting them fill the forms over the telephone instead of in person. Second, the new policies allow general medical facilities in areas of a rapid

COVID-19 outbreak to accept patients suspected of infection. Before this, patients could only get tested at specialized clinics after making an appointment with consultation centers to prevent the transmission of the disease. Third, the policy asks those with any cold symptoms to take time off from work and avoid leaving their homes. Government officials urged companies to let employees work from home and commute at off-peak hours. The Japanese government also made an official request to local governments and businesses to cancel large-scale events.

Telework has been promoted very strongly with the private and public companies. However, in spite of several appeals, it was found that only 13% of are doing telework, while 38% who wish to do telework could not due to several issues, including technical problems [12]. The survey was conducted between 9 and 15 March with 21,000 company employees.

On 5 March 2020, Prime Minister Abe introduced a draft amendment to the "Special Measures Act to Counter New Types of Influenza of 2012". This would allow the Prime Minister to declare a "state of emergency" and mandate the prohibition of large-scale gatherings and the movement of people during a disease outbreak.

The basic countermeasures of COVID-19 is presented in the Fig. 4 (MoHW, [13]). There are three phases considered in this approach: 1) domestic spread prevention, 2) prevent spread of infection, and 3) Prevent severe spread. It seems that Japan is currently in the second phase, which aims at preventing spread of infection. The key target is to reduce the number of affected people by lowering the peak, and strengthening medical system. The crucial in this phase is to prevent the outbreak and control the speed of infection, so as to provide enough time to the medical facilities to get prepared. This can be done also with strengthening other countermeasures like border control, identifying key clusters, closing of school, promoting telework, and avoiding gathering of people in public places like abandoning key sports events, festivals (like cherry blossoms viewing) etc.

3.3. Republic of Korea (South Korea)

(1) The occurrence of first confirmed case and subsequent successful initial management: From the beginning of the COVID-19 situation, the Korean government, centered around the Korea Centers for Disease Control and Prevention (KCDC), has shared information with related organizations and established an effective response system.

When reports were received of pneumonic patients arising from an unknown origin in Wuhan, China, in December 2019, the KCDC strengthened the quarantine process for people entering Korea from the Wuhan region in cooperation with Chinese health authorities and the World Health Organization (WHO). After a 36-year-old woman of Chinese nationality was classified as suspected of hosting the novel disease and quarantined on January 8, 2020, the Korean government issued a Blue Alert Level (the lowest among the 4 alerts along the national crisis management system) and established a joint response system by sharing immigration information among the KCDC, the Ministry of Interior and Safety (MoIS), the Ministry of Justice (MoJ) and other related agencies.

On January 20, 2020, the KCDC confirmed the first imported case of COVID-19. The case was a 30-year-old Chinese woman living in Wuhan, China, and four days later confirmed the second imported case; a 55-year-old Korean male working in Wuhan. On the same day, the Korean government raised the alert level from Blue (Level 1) to Yellow (Level 2) and set up the Central Discharge Countermeasures Headquarters (CDCHQs) to initiate the 24-hour emergency response system [14]. In addition, the KCDC began to conduct a thorough survey of all visitors from the Wuhan region to prevent the influx of potentially infected people, and to strengthen the quarantine and public relations efforts to prevent the spread of COVID-19 during the lunar new year holiday season; a time when millions of people are on the move. Accordingly, President Moon emphasized that the government should mobilize all available resources to prevent the spread of COVID-19 and conduct a thorough investigation on all visitors from Wuhan, leading to a transparent disclosure of processes and results [15].

On January 30 and 31, 2020, the Ministry of Foreign Affairs, MoIS, and related ministries worked together to transport Koreans residing in Wuhan, China, back to Korea. MoIS formed a joint government support group to ensure the returnees were regularly monitored while adhering to a 14-day quarantine at the government facilities in Asan City and Jincheon City. Thanks to the government's transparent and proactive response, step-by-step strengthening of foreign entry procedures, and voluntary participation by citizens to self-quarantine and self-isolate, there were only 30 confirmed cases of COVID-19 by February 18. The situation seemed to gradually be turning to a stable phase.

(2) The rapid escalation of COVID-19 by members of the "Shincheonji Church of Jesus": As the number of confirmed cases surged due to the unexpected "Shincheonji" emergency, the Korean government raised the alert level to Red (Level 4) and put all available resources to tackle the crisis along with designating special management regions against infectious diseases.

On February 19, the KCDC identified the 31st confirmed case who was a 61-year-old Korean female, a member of Shincheonji. Just after that the number of confirmed cases spiked and most of them came from the Shincheonji Cluster. The COVID-19 situation in Korea took on a completely new aspect of the noble crisis situation. Consequently, the Daegu City government acquired a list of the 9336 Shincheonji members from the headquarters of the Shincheonji and cross referenced the list with the KCDC, then asked all members to be tested for symptoms and to self-isolate. The Korean government subsequently scaled up the alert level to Red (Level 4) and took extreme proactive actions in order to avoid a nation-wide transmission. As a follow up activity, Central Disaster and Safety Countermeasures Headquarters (CDSCHQs), headed by the Prime Minister, were installed [16]. The HQs focused on isolating and treating potential cases in the specially managed regions of Daegu City and Cheongdo-gun in Gyeongbuk province, and in other regions conducted epidemiological investigation and environmental disinfection to prevent a sporadic community epidemic as well as to identify Shincheonji-related cases.

(3) Protecting Daegu and Gyeongbuk and stopping a national spread: The government's transparent and democratic response, the voluntary participation of citizens, and the efforts of hidden heroes prevented the spread of Covid-19 nationwide.

On February 26, the total number of confirmed patients was 1261, and the rapid increase raised the sense of a crisis across the country. Among them, the confirmed cases in Daegu and Gyeongbuk were 75% of the cases with 945 confirmed patients. Instead of blockading the Daegu and Gyeongbuk regions, the Korean government conducted a thorough survey of the members of the Shincheonji Cluster, who triggered the community spread in Daegu and Gyeongbuk; feasibly across the country, and conducted around 10,000 diagnostic tests per day to quickly identify confirmed cases.

At the same time, measures were implemented to secure the necessary beds for the cases with the highest severity, and to solve the shortage of medical staff. In cases where life was threatened, patients were hospitalized and placed in negative pressure rooms or moved to infectious disease designated hospitals. Non-threatening cases were provided with medical support at a designated 'Life treatment Center' within each region. Moreover, Doctors and nurses from other regions voluntarily and swiftly ran to Daegu and Gyeongbuk to relieve the shortage of medical personnel. The Korean government also expedited the hiring of 724 public health doctors earlier than originally planned and deployed them to each region. On March 4, the KCDC developed and implemented standard operating guidelines for drive-through testing centers as an effective and rapid diagnostic test processing destination versus hospitals; multitudes quickly opened soon after. Additionally, 254 hospitals were designated as 'for public use;' a hospital the public could visit without fear of infection.

The Korean government continued its vocal call and support for citizenry participation in personal hygiene practices and social distancing. The MoIS, by this time, had developed and released a safety protection application for self-isolated people to self-diagnosis their health status, to be informed of self-isolation life rules, and to automatically send alerts to a dedicated official when the person leaves the self-isolation site without approval. Also by this time, as sales and usage of face masks spiked, temporary mask shortages began to be felt by everyone. To mitigate potential problems, the Ministry of Food and Drug Safety (MFDG) implemented a five-day rationing system for selling and purchasing facemasks.

On March 13, the government prepared guidelines for stronger preventative measures towards the usage of public spaces, call centers, and facilities that could accommodate many people. Religious groups cooperated with the government measures and calls by holding weekly worships online and postponing or canceling large-scale religious events.

With the government's proactive actions and citizens' participation, the number of confirmed cases decreased to 75 on March 15 and gradually began to show a stabilizing trend.

(4) Preventing overseas re-inflow and strengthening physical distancing: The Korean government applied special entry procedures to block the influx of COVID-19 from foreign countries, and shifted physical distancing policy from a voluntary participation to a strong administrative recommendation.

With the declaration of the Corona Pandemic by the WHO and the rapid expansion in the number of confirmed cases in Europe and the United States, concerns about a re-influx of COVID-19 hosts from overseas to Korea began to increase.

On March 15, the Korean government expanded the scrutiny of special entry procedures to those entering from five European countries: France, Germany, Spain, the UK and the Netherlands; on March 19, travelers from all countries received special scrutiny. In addition, the government strengthened countermeasures to block the re-introduction of foreign risk factors into Korea; including a 14-day self-isolation for all travelers from Europe and a special travel advisory for Koreans, urging the cancellation or the postponing of all overseas trips until mid-April at the very earliest. Moreover, the Korean government started to support the return of Korean citizens residing abroad; starting with those in Iran. Upon arriving at Incheon Airport, returnees were tested, and if found to be negative of the virus, they agreed to self-quarantine at home. If found to be positive, returnees were taken directly to a hospital for treatment.

The two policies of postponing the start of schools' spring semesters and forcing social distancing had been stronger measures that the Korean government took to tackle the COVID-19 spread. It was on March 18 that the special decision was taken to delay the start of the spring semester for daycare centers, kindergartens, elementary schools, junior high schools, high schools, and special schools nationwide by April 6. On March 21 and 22, the government strongly recommended to facilities with a high risk of collective contagion, such as religious facilities, indoor sports facilities, and entertainment venues, to close their doors to the public for two weeks, and asked all citizens to refrain from gathering at multi-use facilities and indoor sport arenas, or doing outdoor activities collectively for the same period.

4. Commonalities and key lessons

4.1. Governance

Different countries have different styles of governance. This section summarizes some of the key lessons on governance at different level.

4.1.1. National government's decision

Strong government control: China showed a very strong government control from the third week of January when the COVID-19 case was officially confirmed. Apart from the lockdown in Wuhan, Hubei province, and gradually to all over the country, there was strict measures not to promote fake news and panic from the initial stage. Supreme court advisory was issued on the fake news at an early stage. Also, different provincial governments helped the most affected province and city (Hubei and Wuhan) with different types of supplies and resources.

Transparency and democracy: South Korea proved to be successful in responding to COVID-19 through disclosing accurate information transparently and holding to the democracy of the whole society [17]. Since January 20, 2020, when the first COVID-19 case was confirmed, the Korean government, centered around the KCDC, shared relevant information among the WHO, Chinese authorities and other related agencies, and transparently disclosed the government's responses; leading to voluntary participation of citizens without protest.

The national and local governments of Korea quickly identified the movement path of the confirmed cases through big data analysis; data obtained through credit card usage history, CCTV analysis, etc., and disclosed them transparently through the Cell Broadcasting System's (CBS) mobile service and government's website [18]. The citizens who received the information were able to determine whether or not they had contact with the confirmed case. If so, most citizens voluntarily reported to a public health center. If they showed any signs of having the virus, a diagnostic test was requested. Due to the fact that the Korean government is well prepared for testing and conducting diagnostic analyses, all potentially infected citizens were able to be promptly analyzed, resulting in preventing the spread of infectious diseases.

Clear roles & responsibilities and Unified efforts: An effective response against a novel infectious disease like COVID-19 requires a very specialized knowledge and expertise, thus it is essential to develop and implement a holistic response plan by an expert group. From the beginning of the COVID-19 response, the Korean government set up a decision-making process centered around the quarantine countermeasure headquarters operated by the KCDC. On top of that, as the government-wide response became more vital due to the rapid increase in the number of confirmed cases, MoIS took charge of the monitoring and management of people self-isolating, finding and surveying those who had visited the Wuhan region and may be contagious, locating and securing temporary living facilities and lifetime treatment centers through Countermeasures Support Headquarters (CSHQs). This delineation of roles and responsibilities between the responsible agency (KCDC) and the coordination agency (MoIS) made it possible for the KCDC and the Ministry of Health and Welfare (MoHW) to focus on epidemiological investigations and responses to the infectious disease.

This effective response system was developed based on the double-loop learning process during the MERS experience in 2015, the novel swine-origin influenza A(H1N1) in 2009, and severe acute respiratory syndrome (SARS) in 2003. Consequently, the successful COVID-19 response can be directly attributed to the leadership of the President to accurately understand the fluctuating situation and emerging risk factors, and make accurate decisions based on the advice of expert groups, and the dedication of the Prime Minister who stayed in the Daegu and Gyeongbuk regions for three weeks to concentrate the capabilities of all ministries to cope with the crisis situation.

Expert based advices: Japan took a different cautious approach not to call for a national emergency and lockdown. The legislation in Japan does not permit a forced lockdown, but a request/advisory for the lockdown. Japan's decision was based on close interaction with the expert group, which comprised of a diverse experts from the medical side, as well as economic, political and social side. Based on the expert advices, regular government briefings and press meet by the Prime Minister,

minister or senior officials were arranged. Japan's governance approach was to flatten the growth curve, so that the health response mechanism has enough time and resources to respond to the situation, and that would possibly provide enough time to develop the vaccine and preventive measures.

4.1.2. Provincial/local government's decision

Proactive prevention activities: The Seoul and Gyeonggi-do governments; with the highest populations in Korea, took proactive measures from the initial outbreak. The Seoul City government promptly produced and distributed guidelines on special entry procedures detailing the diagnosis and preventive tips for a corona virus, and temporarily restricted the use of large public squares. In addition, after a mass infection occurred at the Guro Call Center, the Seoul city government urgently conducted a survey of 417 private call centers and feasibly prevented a spread of COVID-19 by improving the environment for telecommuters [19]. The government of Gyeonggi-do, where the headquarters of the Sincheonji Church of Jesus is located, conducted a thorough investigation of all Sincheonji churches in the region and ordered the temporary closure. Also, it ordered the members of the Shincheonji to report to local public health centers and to self-isolate.

In Daegu City and Gyeongbuk Province, where the largest number of confirmed cases were identified, the governments established a system for investigating all members of the Shincheonji and monitoring them exclusively by public officials. In addition, when hospital capacities became overwhelmed by the influx of patients, the government ordered the use of negative-pressure beds for the treatment of cases of highest severity only, and moved the cases with less severity out of the hospitals and into life treatment centers equipped with makeshift facilities where people could recover. Business sectors, religious group and other regional governments assisted Daegu and Gyeongbuk during the crisis. For example, companies such as Samsung and LG, and the religious community provided their training centers and facilities as life treatment centers. Other local authorities including Gwangju Metropolitan City persuaded its citizens to open its hospitals and facilities for patients from Daegu and Gyeongbuk so that the regions could recover more rapidly.

In case of China, Hubei province showed a strong leadership in implementing stricter measures within the province. In Japan, Hokkaido announced an emergency in early March, and restricted gathering in public spaces. Also, several other prefectures in Japan (like Osaka, Hyogo) advised not to travel between the prefectures. Tokyo Metropolitan Government also communicated with neighboring prefectures to advise travel limitations.

Prompt dissemination of the movement path of the confirmed cases: Local governments, in cooperation with the KCDC, quickly identified the movement path of the confirmed cases and informed the residents of the areas in real-time via mobile text message using the CBS. In addition, they promoted safety rules through 24-h broadcasts, and posted on the governmental homepages COVID-19 prevention tips and the movements of confirmed cases so that any citizen could find the information at any time.

4.1.3. Community governance

Community-based activism, such as aggressively finding suspected cases and supporting vulnerable groups, was another advantage of Korea to overcome the crisis. For example, in Chungcheongbuk-do, a safety group organized from community units; such as a grassroots women's group and safety guards, actively participated in finding the people suspected of carrying the virus, and in sympathetically and humanly reported them to the Community Service Center. In Chungju city and Boryeong city, local autonomous disaster prevention groups and women's associations voluntarily disinfected multi-use facilities and vulnerable facilities. Furthermore, as the phenomenon of mask shortages across the country became serious, members of non-profit organizations such as the Jeju Women's Association of Seogwipo city and the Cheonan city Happiness Support Group started to produce face masks for those incapable of easily securing supplies far from home such as the elderly and the disabled.

China also showed strong community governance with people making their community watch to strictly maintain the entry or exit from the community. This was not only implemented in the urban areas but also in the rural areas.

4.2. Innovative technologies

Several innovative technologies were used in different countries to identify affected people, to check their mobility, to reduce the risk of contamination, as well as to develop proactive recovery strategies and actions. Artificial Intelligence (AI), Big data, 5G technologies were used in combination with other emerging technologies like drones, automated vehicles, robotics etc.

In case of China, on 14th of February, the Ministry of Transport of People's Republic of China [20] issued a circular to use new technologies for addressing COVID-19 risk as well as to develop recovery strategy. Highlights of China's use of technologies are described as follow:

AI: Fudan University and Shanghai city government, along with the CDC (Center for Disease Control) develop a unique AI based medical screening and check-up for respiratory blockage, which enhanced the speed of decision making of the scan system. The system was used with more than 93% of Shanghai residents to make quick scan of the respiratory system [21].

Big data: Baidu big data was used to identify clusters of infected people. People's mobility data was used to identify movement of people from one place to another during an early stage of spread of the disease, which helped to take critical decisions on lockdown certain high-risk areas. This was also used in the recovery process, when the shops or factories are reopened to identify potential future risk areas as well [22,23].

5G: 5G data was used extensively in combination with different other technologies. Primarily, it was used in transport system to identify the mobility of vehicles and related information (like number plates, driver etc.). Combination of drones and 5G was used in the transport system to identify violation of laws in the emergency time. Thermal camera was used with helmet of police and other public officials for quick thermal screening of people in Guangdong, and the date was sent using 5G. Combination of robotics and 5G was used for city sanitization in the peak period in Wuhan when public services were also at risk. Similarly, combination of automated vehicle and 5G was used for goods delivery in certain highly contaminated areas. 5G was also used for telemedical care and advices in the newly built hospital in Wuhan. [21,24].

Health barcode: A unique health barcode system was developed to identify the affected people, as described in Hua and Shaw [7]. Hangzhou city was first to use this system on 11th of February 2020, which gradually used in 200 other cities in China [25] For developing the health barcode, user sign up for the “close contact detector” app by registering their phone number, name and ID, and then scanning a QR code on their smartphones [26]. The app will tell them whether they have been in proximity to someone who has been infected. The barcode system has three color coding: green (good health), yellow (caution required), and red (infected people), which enable or disable them to entering from different public buildings as well as public transport. With the health barcode, online mapping of affected people could be done, and people could avoid the clusters where affected people are concentrated. If a user is found to have in close contact with the affected

person, the app recommends self-quarantine and also send an alert to health officials. Career's big data was used in combination with Baidu's location (GPS) data to develop the health barcode. This was also used in Wuhan on 18th February onward, and eventually to all Hubei province from 10th March onward. On 21st March, the government announced to develop health information platform for the whole country using the same system. Chen [26] argued positive and negative consequence of the system on the ground that tools like surveillance and epidemic maps need to be combined with a view of how people react under pressure.

Rapid diagnostic test kit and an innovative test method: In Korea, the development of a kit for rapidly diagnosing the potentially infected and innovative test methods such as drive-through screening centers, enabled thousands of people to be tested every day. This large-scale diagnosis for COVID-19 was able to detect and confirm cases in their early stages, thus lowering the fatality rate and preventing the wide spread of the infectious disease. The new diagnostic kit using Real-time reverse Transcription Polymerase Chain Reaction (RT-PCR) reduced test time from 24 h to 6 h. This kit was able to be used thanks to the efforts of a small business company that has been working on development irrespective of deficits and the rapid approval by the KCDC and MFDG. The KCDC and the MFDG reduced the administrative process, which normally takes one year from development to approval, to one month, so that it could be applied quickly in the field [27].

In addition, the drive-through screening method made it possible for suspected cases to receive the result of the COVID-19 diagnostic test from their vehicle within 10 min, reducing the risk of cross-infection. While the general screening center took 2 samples per hour or 20 possible cases per day, the drive-through method was able survey 6 people per hour and 60 possible cases per day [28]. The United States and Germany already adopted this driving-thru method as a way to reduce the possibility of cross-infection and increase the efficiency. In Korea, the 'Walk-Thru Test Booth' and 'Open Walk-Thru Booth' evolved from the drive-through screening method. For this method, a potential patient enters a booth, and then a medical staff securely outside the booth checks their condition verbally via an intercom and take on-the-spot samples from patients outside the booth by using a stethoscope. This method takes only 6–7 min per person and results in a much smaller chance of contagion thanks to a complete separation between patient and doctor. On March 16, the Yangji Hospital, located in Seoul, started to implement this method for the first time; on March 25 the Korean government installed the Open Walk-through Booth at Incheon Airport in order to deal with the thousands of travelers from overseas countries.

Enhancing self-responsibility and improving administrative efficiency using ICT: The KCDC developed a self-diagnosis mobile application to strengthen monitoring by allowing domestic and foreign travelers entering Korea to self-diagnose fever and health conditions related to COVID-19, and report it to their local health center or the KCDC. As users typed quarantine-related information such as passport information, nationality, and names in the app, the KCDC was able to monitor their status during their stay in Korea [13,29].

In addition, the MoIS developed a self-quarantine safety protection mobile application to reduce the enormous administrative costs used to monitor self-isolators by public officials for local governments. In general, public officials check the status of self-isolators by daily phone or irregular visit, but they cannot prevent people from leaving home without approval. This app helped to overcome previous shortcomings by including a GPS function, so if a self-isolating person left their home without approval, a warning message is automatically sent and a dedicated official is notified and sent to the scene to prevent the patient from violating the self-isolation if necessary. This app allows self-isolating people to complete self-isolation under their own responsibility, and frees-up vital officials by allowing many administrative personnel not to have to visit the self-isolators' home or check their status by phone regularly [30].

4.3. Citizen behavior

Compliance with citizens' voluntary codes of conduct and refrain from large-scale gatherings of religious groups: A group outbreak occurred in Daegu and Gyeongbuk after the 31st confirmed case was announced; a Shincheonji believer in Daegu, but the national government did not take any mandatory blockade measures in this regions, instead provided all financial and administrative support so that Daegu and Gyeongbuk could overcome difficulties. The citizens in Daegu and Gyeongbuk also voluntarily participated in refraining from leaving their homes, self-reported 1339 cases of suspicion, and complied with stricter hygiene rules. The phenomenon of stockpiling daily necessities did not appear. Citizens from other regions faithfully fulfilled the government's request to refrain from visiting Daegu and Gyeongbuk.

All over the country, citizens made washing their hands a daily life habit. In business offices, public facilities, and facilities where large numbers of people come and go, hand sanitizers had been prepared so that people could use them freely and frequently. Citizens wore face masks when going out in order to prevent the spread of the infection. For example, the third confirmed person in Incheon on February 25, 2020, voluntarily stopped working and began self-isolating at home as soon as a suspected symptom occurred. He even wore a face mask inside the house and refrained from going out. Thanks to his efforts, all the 23 people who were in contact with him; including his mother whom he lived together with, proved to be negative.

Most religious groups also refrained from large-scale gatherings by conducting online worship services and delaying Buddha's Day celebrations, and actively participated in the "Social Distancing" campaign.

Nation-wide volunteer and donation: By the end of February 2020, the number of confirmed patients had rapidly increased in Daegu and Gyeongbuk, making medical examination and treatment of all confirmed and suspected cases in the regions impossible. Upon hearing their desperate circumstances, medical doctors, nurses, and clinical pathologists from all over the country moved in to provide medical treatment, assistances, and relief. According to the CDSCHQs, from February 24 to February 27, a total of 853 people (58 doctors, 257 nurses, 201 nursing assistants, and 110 clinical clinicians) participated in volunteer services [13]. In particular, more than 3000 people applied to volunteer as a nurse, and Korea was able to find hidden heroes such as nurse Kim who gave up her immigration to the United States in the process of applying for this volunteer service, or nurse Oh who sent a sincere letter saying, "If I am not selected as a volunteer, I would suffer the fact that I can't help others in trouble. [31]". They stayed in Daegu and Gyeongbuk for more than a month, devoting themselves to the treatment and prevention of the infection. Additionally, the president of a hotel in Changwon City provided hotel rooms free-of-charge for the volunteering medical doctors and nurses who had a hard time finding adequate accommodations. Efforts were also made to overcome COVID-19 on the basis of community consciousness, such as donations from all around the country.

Good landlord movement: With the prolongation of COVID-19, consumption contracted significantly and the domestic economy was starting to stagnate. As the economic crisis for small business owners or self-employed people with a large rent burden increased, the "good landlord movement" that temporarily lowers rent spreads across the country. For example, more than 5000 stores in Dongdaemun Market,

Gwangjang Market, and Tongin Market in Seoul City participated in the 'good landlord' campaign and cut the rent by 20–30%. In addition, a variety of "Good Landlord Movements", such as the exemption of franchise commissions from the food brand Chaeseondang, and a subsidy of 1 million Korean won for affiliates of mega coffees, gave hope to the small-business owners facing difficulties.

Community support and solidarity: Chinese people showed a strong level of community solidarity for the affected people in Wuhan. Not only they provided resources, including financial, human resources, they also helped in boosting morals of the frontline health workers, and shared different positive stories and experiences through the social media.

5. Way forward

While the world is still struggling with the pandemic, the number of confirmed cases and casualty is growing higher, the East Asian examples and analysis draw a few important lessons as follow:

Pandemic is global, but its response is local: In the growing interconnected world, our movement is quite high and fast, and that possibly enhanced the spread of the virus globally very quickly, making it a global pandemic. However, different country showed differences in approaches in responses. Thus, although the medical treatment is universal, we need to keep in mind that the healthy emergency response measures are not universal. It is a combination of country's regulation, governance mechanism, link to science-based decision making, local governance as well as community behavior. Thus, learning from each other's experience is very important.

Use of technology: In the advanced stage of technological intervention, a pandemic response is not just a medical response anymore. It needs to link different types of technologies in an appropriate way. COVID-19 response in East Asia showed extensive use of emerging technologies (like big data, AI, drone, 5G, robotics, automated vehicle, block chain etc.) linked to medical technologies.

Risk assessment: Djlante et al. [32] in a quick analysis has pointed out the need of converging the health response, emergency response and disaster risk reduction in the viewpoint of the Sendai Framework. They analyzed and concluded that current mechanisms and strategies for disaster resilience, as outlined in the SFDRR, can enhance responses to epidemics or global pandemics such as COVID-19. Some of the recommendations are as follow: recommendations concern knowledge and science provision in understanding disaster and health-related emergency risks, the extension of disaster risk governance to manage both disaster risks and potential health-emergencies, particularly for humanitarian coordination aspects; and the strengthening of community-level preparedness and response. A proper risk assessment is required taking into consideration of health risk, exposures, behaviors and policy framework.

Use of social media and sensitization on fake news: In different countries, with different level of social media penetration, the importance of distinction of proper news and fake news becomes more relevant. Importance of negative consequences of fake news is well understood in longer run, not only to fight this pandemic, but also for the longer-term recovery process.

Economic implications: The global economic impacts of the pandemic are yet to be understood, but there is a unanimous agreement of a global recession due to the pandemic. However, in different countries, sectorial impacts are already prominent, especially in tourism and hospitality sectors. MSMEs (Micro, small and medium enterprises) are possibly the hardest hit in all the countries need special economic revitalization package.

Socio-psychological impacts and lifestyle changes: Country wide or partial local down in cities have initiated a different work culture in East Asian countries, as well as in most of the other countries. Tele-work is becoming popular, online meetings, online classes in the universities are getting common, online education for school children becoming obvious. Thus, there has been a life-style change in many countries and communities, which may have relatively longer socio-psychological and behavioral implications.

CRediT authorship contribution statement

Rajib Shaw: Conceptualization, Methodology, Formal analysis, Writing - original draft.**Yong-kyun Kim:**Formal analysis, Writing - original draft. **Jinling Hua:**Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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