# Guest Editorial: Crisis Management—From Nuclear Accidents to Outbreaks of COVID-19 and Infectious Diseases

#### I. ANALYSIS

**I** NFECTIOUS diseases periodically appear and have variable case-fatality rates. First officially-detected from Wuhan, China, in late December 2019, the Novel Coronavirus (COVID-19) is now affecting almost all countries and territories around the world, international conveyances, and aircraft carriers. Although the mortality rate declined in April, it increased again as of July 30, 2020, when COVID-19 has infected 16.8 million people and resulted in 662 095 deaths [item 1) in the Appendix], and more cases continue to rise badly across the world.

Seventeen years ago, an outbreak of another coronavirus, SARS, infected 8436 people, resulting in 812 deaths with a case fatality rate of 9.6% [item 2) in the Appendix]. In 2009, the outbreak of H1N1 flu infected 7 to 14 million people and resulted in 18 449 deaths [item 3) in the Appendix]. In either case, there is a lack of a unified assessment and procedures in dealing with the spreading of infectious diseases.

Nuclear accidents have attracted international attention including the three major nuclear power plant accidents: the Fukushima nuclear disaster (2011), the Chernobyl disaster (1986), and the Three Mile Island accident (1979). These nuclear accidents resulted in radiation-related casualties of 1, 28 or 4000, and 0, respectively [items 4) and 5) in the Appendix]. The numbers of deaths from epidemic outbreaks, major nuclear accidents, traffic accidents, suicides, and air pollution as well as the case-fatality rate of epidemic outbreaks are plotted in Fig. 1.

Infectious pandemics/epidemics such as COVID-19 and SARS as well as nuclear accidents have caused huge impacts on society, particularly in terms of economic losses and psychological disturbances from street politics. Notably, expected seasonal flu epidemics have killed far more people but attract much less attention. Examining the economic losses from major epidemic outbreaks and nuclear accidents, we note the negative correlation between the impact on gross domestic product and the severity of these casualties for different events (see Fig. 2). People care much less about deaths caused by air pollution, car accidents, suicide, and ordinary flu, which kill a lot of people continuously and annually, underlining the psychological aspect of the problems. The indirect consequences for the economy and our ways of life are catastrophic.

A consideration of the expected loss of lives calculated by multiplying the probability of occurrence of accidents by the number of casualties will show that operating nuclear power plants incurs the minimum expected loss. On the other hand, if the expected loss is calculated based on how most people perceive the world and through street politics in recent human history, operating nuclear power plants would attract the highest attention, with the next being today's COVID-19. Meanwhile, the disproportionately huge number of casualties per annum due to traffic accidents and suicide seems to have induced far less impact than nuclear power plants and the coronavirus at societal levels. For that reason, we are forced to pay close attention to epidemic outbreaks and nuclear accidents.

Wisdom is gained after an accident. A good example is that the safe operation of nuclear power plants has been enhanced from lessons learned from major nuclear accidents [item 6) in the Appendix]. However, in addition to noticing human error, we knew little about identifying the critical element of safely operating nuclear power plants until the occurrence of the Fukushima disaster. Similarly, the observation is applicable to outbreaks of infectious diseases.

## II. ESTABLISHING EMERGENCY RESPONSE UNIT

Improving health systems following epidemic outbreaks and enhancing reliability measures following nuclear power plant accidents have to be handled with calculated safety measures, which include the potential psychological and political impact on the general public. However, so far only operating nuclear power plants has taken a high, world-accepted standard. The key is how to implement that standard.

A model for the surveillance-response system to an epidemic outbreak or a nuclear accident is suggested in Fig. 3. An Emergency Response Unit (ERU) should be established applying Command, Control, Communication and Information ( $C^{3}I$ ). The ERU is composed of appropriate experts carefully prepared to make immediate decisions about all potential adverse events such as epidemics or nuclear accidents. This executive body functions as the alert "brain" of the ERU, making rapid decisions from the moment a concern is raised, and before any adverse outcome has started. The "original data" refers to signals of possible adverse events detected by frontline medical professionals or nuclear engineers.

The biggest problem at the heart of the Fukushima nuclear disaster was poor communication, i.e., missing data and delays [items 6)–8) in the Appendix]. The nondecisions made by the Tokyo Electric Power Company at the early stage and the slow response of Japan's government were other major faults.

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Fig. 2. Losses caused by epidemic outbreaks, major nuclear accidents, traffic accidents, suicides, and air pollution. Economic impacts per death as the function of casualties of epidemic outbreaks, nuclear power plant accidents, traffic accidents, and air pollution [item 2)–4) in the Appendix], [item 14) and )–21) in the Appendix]. Numbers in brackets indicate data sources.

The same problem arose with COVID-19 in Wuhan where the middle-layers between frontline medical workers and decision-making greatly distorted information, delaying the transmission of the crucial alert signal. Similarly, such a delay in response has been seen in many other countries. For example, it took some countries over weeks from the first confirmed case to declare

a national emergency. All are due to the lack of empowered ERU. The central government started executing coordinated actions with local governments only in April. Most governments established handling units on an ad hoc basis. An ERU with a mechanism for self-improvements should be established in each government system.





Fig. 3. Diagram of the surveillance-response system for epidemic outbreaks and nuclear power plant accidents.

The "middle-layers" in Fig. 3 represent the prefectural and provincial units in the hierarchy reporting system when we assume that the ERU is located under the central government of a country. They will be useful for quick reconfirmation of the accuracy of the original data, but the original data should be transmitted to the ERU directly in parallel.

Because of the lack of sense in risk management, emergencies, and crises in different countries are often carried out sloppy and ad hoc, which is recognized today in the response to the COVID-19 pandemic. Many countries have not taken the issue seriously enough until it is too late. The ERUs should be trusted by governments and the general public to whom information should be disclosed. The way its members are chosen will be crucial to ensure they are trusted.

The ideal solution would be a global ERU, which advises at the planet level; but this idea is for a utopia. For a global pandemic, it is essential for the ERU to exercise crisis management as an umbrella framework for dealing with complex systems or living environment of potential risk throughout its life cycle, from assessment, preparedness, mitigation, rescue, to recovery.

In principle, the World Health Organization (WHO) could be the ideal body to oversee a global ERU related to pandemics. The interference of politics and nationalist considerations is a major issue. At least, a WHO-led ERU would be helpful for small or less developed countries that have fewer resources to deal with a pandemic. A global ERU could also respond more urgently to pervasive dangers such as environmental problems.

### **III. RECOMMENDATIONS**

 Shorten and simplify the transmission of the signal from the original data to the ERU, as shown by the red arrow in Fig. 3, and create a direct pathway for the original data to reach the ERU to minimize Delay 1. The simultaneous data transmission through the middle-layers is useful for earlier preparation for possible actions later on. The ERU should be invested with the authority to act, thus minimizing Delay 2. If the data have not reached the threshold set with well-defined parameters and protocols, no action is taken. New data must be closely and frequently monitored (the parameter for quantifying the frequency of updates is shown in the Model as "Interval" in Fig. 3) in preparation for a prompt response once the data reach the specified threshold.

Similar to the poor handling of the Fukushima nuclear disaster, the Chinese government's slow although decisive response to COVID-19 between the end of 2019 and the first three weeks of 2020 and the inaction of the U.S. government for over one month until March of 2020 could have been avoided. Delay and ignorance in response by many countries make the COVID-19 spreading worldwide added insult to injury.

Putting in place clear parameters for Delay 1, Delay 2, and Interval can endow the ERU with more performance indicators and responsibilities. Those parameters may facilitate the communication between the bureaucrats and the chief commander in the ERU.

2) At the outset of a crisis of any magnitude, simulated outcomes of possible scenarios should be carried out immediately, and carefully analyzed. Establish an information dissemination center at the highest level of the ERU to minimize collateral problems such as counterproductive, chaotic behavior caused by panic among the general public. Conveying timely information to the general public is a responsibility of the ERU. If the simulated outcomes of possible scenarios show no significant consequence, no action is taken. Misinformation can thus be avoided, along with the consequent confusion in affected populations. The decisive actions taken by the Singaporean government, in conjunction with timely and clear public communications, in response to COVID-19 deserve attention.

The preparedness plan has to include specific tangible elements such as reserved personal protective equipment, capabilities of rapidly building temporary shielding facilities and producing equipment to protect medical and frontline staff dealing with epidemics, and spare parts for related professionals for nuclear accidents. To minimize panic, the government should arrange evacuation plans and distribute through the ERU all protective equipment, food, medicine, and other materials, depending on necessity. 3) Ever since the first nuclear plant was built in 1954 and after each major nuclear accident, a great deal of effort has been placed on safety issues in plant design and operation [item 6) in the Appendix]. What is still badly needed is to identify the critical elements or operating processes in a given system such as operating a nuclear power plant or controlling an epidemic outbreak [item 9) in the Appendix].

It is painful to see the high number of infections among medical professionals that account for from 4.1 to 25% of confirmed cases in different countries, not to mention the cross-infection between patients in hospitals during COVID-19 [item 10) and 12) in the Appendix], which was also seen during SARS when 21% of total infections (1706/8096) worldwide were among hospital workers [item 13) in the Appendix].

Fault tree analysis (FTA) is undertaken from a top-down, deductive failure analysis where undesired states of a system are eliminated step by step using Boolean logic. FTA is useful in analyzing reliability of complex systems where failures can cause huge consequences such as operating nuclear power plants or an influenza pandemic.

Identifying the critical elements that impact the spread of dangerous infectious diseases is just as important as identifying the critical elements [item 9) in the Appendix] in the fault tree of nuclear power plants. Such an adoption could greatly reduce the infection rate in highly susceptible communities, e.g., about 21% hospital workers during SARS, most from within hospitals, to 0.1% within hospitals in the future. To achieve this target, the ERU teams and new-concept hospitals will require input from hospital architects, engineers in aerodynamics, and experts in infectious diseases, bio-informatics, behavior science, risk and reliability, and quality assurance in addition to public health.

Cross-infections between patients and hospital workers and between patients and patients within hospitals could be minimized, removing a major avenue for the spread of the disease. Such a design concept should also be implemented for a One Health (human–animals–environment) system or other living environments beyond hospitals, which could greatly reduce the number of pandemic outbreaks and the degree of panic in the community.

### IV. CONCLUSION

Lessons taken from minimizing the risk of operating nuclear power plants should be applied to minimizing the outbreaks of infectious diseases. What is needed in managing crises related to nuclear accidents and outbreaks of infectious diseases is an ERU through C<sup>3</sup>I that makes rapid and accurate decisions based on data collected, no more and no less. For the same argument, we need to manage global environmental problems such as air pollution, greenhouse gas emissions owing to excessive use of fossil fuels, water resources management, and others.

Both nuclear accidents and outbreaks of infectious diseases are global issues to be handled by the global ERU. Misuse of the data is a real challenge. After the analysis, decisive and coordinated action should be taken as data suggest; other times, a better action is no action.

#### V. SUMMARY

Since the outbreak of COVID-19 at the end of 2019, little consolidated effort has been taken to deal with the epidemic worldwide for over three months. In the editorial, we list losses from recent major pandemic outbreaks and nuclear power plant accidents. Early simulations of possible scenarios by the proposed Emergency Response Unit (ERU) can prevent the potential impacts on the general public, and hence reduce global losses. COVID-19 has been poorly handled because the world lacks ERU.

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## Appendix

# RELATED WORKS

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