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Implementation of evacuation measures during natural disasters under conditions of the novel coronavirus (COVID-19) pandemic based on a review of previous responses to complex disasters in Japan

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1. Background

Following the initial occurrence of COVID-19 in the city of Wuhan in Hubei Province, China in December 2019, this highly infectious disease rapidly spread throughout China and the world, prompting the World Health Organization (WHO) to declare a pandemic on March 12, 2020 [1]. As of May 31, 2020, there were 16,851 cases of COVID-19 infections and 891 deaths in Japan [2]. COVID-19 has a post-infection incubation period of 1–14 days. The main symptoms reported by many infected people are cold-like symptoms, such as fever and dry cough, excessive fatigue, and dysgeusia. Approximately 80% of COVID-19 patients experience spontaneous remission, but 20% go on to develop pneumonia/pneumonitis. Of the latter, the high-risk group comprises not only older individuals and those with certain predisposing risk factors, such as hypertension, diabetes, and/or cardiac diseases but also some young adults, who develop severe illness.

Existing antivirals and related drugs have only provided partial, if any, beneficial outcomes. Moreover, there are fears that the severe disruptions of economies and daily life caused by the pandemic will be prolonged rather than transient phenomena. Therefore, there is an urgent need to develop and establish effective drugs and vaccines to suppress and overcome the pandemic.

At the time of writing, the rainy season is approaching in Japan, leading to growing concerns about the potential occurrence of natural disasters like flooding coinciding with the COVID-19 pandemic. The Cabinet Office of Japan has therefore issued multiple notifications providing evacuation guidelines, and various organizations have issued calls for preparations for complex disasters involving a conjunction of COVID-19 and natural disasters [3].

The main concerns at the time of occurrence of such complex disasters relate to evacuation procedures. The first volume of the Preliminary Report on the Spread of Novel Coronavirus Infection [4], published in 2020 by the Disaster Reduction and Human Renovation Institution and the Novel Coronavirus Evacuation Support Book [5] both describe concrete methods for operating evacuation centers and measures to be taken for each evacuee. The option of dispersal of evacuees, with suggested evacuation points, is available online 16 October 2020.

Keywords: COVID-19, Complex disasters, Surveillance, Evacuation, Community leadership

We aimed to investigate how evacuation measures could be effectively implemented in the event of multiple disasters caused by natural hazards under conditions of the novel coronavirus infection (COVID-19) pandemic, which is rapidly spreading worldwide. We conducted a review of literature focusing on complex disasters, entailing natural disasters in combination of outbreaks or endemics of infectious diseases. Using the Google Scholar search engine, we identified and reviewed 24 papers sourced from academia, governments, and concerned organizations, and associated data on such disasters, commencing with the Great Hanshin-Awaji Earthquake, which occurred in 1995. In light of our review, we developed a summary of correspondences and problems linked to compound disasters involving conjunctions of outbreaks/endemics and natural disasters that could offer insights for developing measures to deal with natural disasters that occur in the context of the COVID-19 pandemic. We subsequently attempted to differentiate the characteristics of evacuation measures relating to COVID-19 from those relating to other infectious diseases using three sets of extracted keywords: (1) surveillance and information sharing, (2) evacuation center environment and stockpiled supplies, and (3) community disaster risk reduction and community leadership. We identified issues relating to evacuation measures that would need to be explored further to improve disaster management and preparedness in the future.
also included in the Recommendations Regarding Evacuation, issued by the Japan Society for [6].

The Great Hanshin-Awaji Earthquake, which occurred in January 1995, prompted an evaluation of countermeasures implemented during the simultaneous occurrence of large-scale disasters and infectious diseases. A group of researchers who implemented “A study on construction of health care management system for dental health care in large-scale disaster,” hereinafter referred to as the Study Group, reported that aspiration pneumonia was prevalent among evacuees, especially older evacuees, who were physically and mentally exhausted after this earthquake [7]. Subsequent natural disasters, notably the Great East Japan Earthquake (March 2011), the Kanto and Tohoku Heavy Rains (September 2015), and the Kumamoto Earthquake (April 2016) have all been associated with outbreaks of infectious diseases at evacuation centers [8]. Outside of Japan, there have been reports of acute gastroenteritis following Hurricane Katrina (August 2005) [9] and of cholera followed by the Haiti Earthquake (January 2010) [10].

2. Purpose of this study

Each of the above-mentioned studies focused either on the particular natural disaster examined or on the associated pandemic. In light of their finding that only a few studies have linked disaster risk reduction to biological hazards, such as COVID-19, Zhang and Shaw [11] have called for studies that incorporate various aspects of complex disasters (pandemic response, recovery, and long-term development). To date, there have been no attempts to compile and systematically organize information on past occurrences of complex disasters, entailing a combination of natural disasters and infectious diseases and to discuss evacuation measures that specifically relate to COVID-19, distinguished from other infectious diseases. While organizations have provided recommendations, and individual local governments have published evacuation manuals (e.g. [12]), a notable gap in the literature concerns measures relating to evacuation and the operation of evacuation centers in the case of a complex disaster in which COVID-19 and natural disasters occur simultaneously.

Therefore we aimed to conduct a systematic review of various available studies and reports on natural disasters and infectious disease epidemics. Accordingly, we compared evacuation procedures during natural disasters in Japan, which are frequent occurrences, in the context of common infectious diseases and subsequently extracted specific issues that would apply to evacuees during the COVID-19 pandemic.

3. Methodology

We conducted a search of the Google Scholar database using “disaster” and “infection” as keywords for identifying and extracting reports and papers focusing on disasters associated with infectious diseases in Japan, commencing with the Great Hanshin-Awaji Earthquake in 1995. Our search yielded a total of 24 academic and non-academic documents and papers on measures adopted to handle outbreaks of infectious diseases at evacuation centers and other places in the event of disasters. As of the end of May 2020, we have been unable to find any literature that focused on COVID-19 and evacuation during a natural disaster using the keywords “COVID-19” and “evacuation.”

4. Infectious diseases and natural disasters

The WHO recommends the adoption of systematic measures relating to the following steps: (1) rapid assessment, (2) prevention of infections, (3) surveillance, (4) disease outbreak control, (5) disaster management, and (6) evaluation aimed at controlling the spread of infectious disease during disasters [13]. However, these measures are difficult to implement in a situation where damage is so extensive that medical institutions and administrative organizations are also at risk of being affected because the medical support staff at hospitals are themselves potential victims of the disaster. Surveillance was implemented 20 days to 1 month after the 2011 Great East Japan Earthquake and 5 days after the 2018 Kumamoto Earthquake [14]. Although systematic measures and mechanisms for enabling quick responses have greatly improved, in the event of a large-scale disaster, they may not function during the initial post-disaster stage. Surveillance entails various constraints, such as the preparation time required, disruption of reporting procedures, and an excessive burden placed on staff members at the evacuation centers. In particular, many small evacuation centers do not have permanently stationed medical professionals, and in most cases, the victims’ situations are not monitored. In the event of a large-scale disaster, it is necessary to develop and strengthen human resources for implementing countermeasures to control infectious diseases because not only specialists, such as public health nurses, are required to deal with infectious diseases within evacuation centers but also other local government personnel have important roles to play [8]. Furthermore, a system should be established for disaster preparation that enables cooperation and information sharing with specialized organizations, such as local government departments, medical institutions, and universities during times of non-crisis.

There are three key factors that define the epidemiology and pathophysiology of infectious diseases: pathogens, hosts, and environments, of which environmental factors reportedly have the greatest influence on the risk of infectious disease outbreaks occurring after natural disasters [15]. The deterioration of hygiene conditions in disaster-affected areas and the forced confinement of many victims within small spaces in evacuation centers increase the risk of transmission of infectious diseases. Therefore, a countermeasure focusing on maintaining a sanitary environment within evacuation centers is critical.

Kamase and Tokita [16] have pointed out that there would be differences in the storage locations of stockpiled goods, the maintenance of records at evacuation centers, and the preparation of information for evacuees, depending on whether evacuees have previously experienced a disaster. Clearly, another countermeasure relates to appropriate response of administrators. However, in the event of a large-scale earthquake, it is likely that administrative agencies themselves will be damaged. In addition, not only the staff of the evacuation centers but also the evacuees must protect themselves against infectious diseases at small evacuation centers because of the lack of human resources. The evacuees are required to be self-reliant. Okada et al. [17] noted that community empowerment has greatly contributed to the maintenance of healthy environments at evacuation centers.

In light of the above considerations, we extracted three sets of keywords to explore the relationship between infectious diseases and natural disasters that may have been issues during previous disasters. These keywords were “surveillance and information sharing,” “evacuation center environment and stockpiled supplies,” and “community-based disaster risk reduction and community leadership.” In the following sections, focusing on these three sets of keywords, we explore the differences between COVID-19 and other infectious diseases within responses to previous natural disasters and infectious diseases described in the reviewed literature.

5. Responses to previous disasters and infectious diseases in Japan and challenges faced

5.1. Aspiration pneumonia during the great Hanshin-Awaji earthquake

The Great Hanshin-Awaji Earthquake that erupted in Japan’s Hyogo Prefecture in 1995 caused significant damage in the cities of Kobe and Osaka and left 6434 people dead. Of these deaths, 5512 were directly attributable to the earthquake, caused by collapsed buildings that led to crushing and suffocation of victims. Of the remaining victims, 922 died of pneumonia, strokes, and myocardial infarctions induced by the disaster. Approximately 60–80% of pneumonia cases in older evacuees at the time of the earthquake were thought to be or diagnosed as aspiration pneumonia. Reports on responses to the Great Hanshin-Awaji Earthquake and on aspiration pneumonia were compiled by a team of researchers [7].

Most cases of aspiration pneumonia that occurred among older, immunocompromised individuals are believed to have been caused by the aspiration of saliva rich in oral bacteria because of reduced oral care during the extensive disaster. It has been reported that immediately after the Great Hanshin-Awaji Earthquake many older individuals were unable to maintain
oral hygiene practices, such as gargling, because of an extreme shortage of drinking water or because of an increase in oral bacteria caused by poor cleaning of dentures. According to the findings of one study, oral care that is thoroughly performed, thus preventing an increase in oral bacteria while keeping the oral cavity and denture surfaces clean, can lead to a reduction in incidences of pneumonia among the elderly by 40% [18]. However, in the event of large-scale disasters, the failure of the water supply system results in difficulties in procuring water at evacuation centers. Therefore, there is a possibility that sanitation practices required for effective health management, such as hand washing, gargling, and brushing teeth, cannot be performed. As noted in the report, the issue of privacy relating to denture removal also arose at the evacuation centers. In the absence of water, churning sugarless gum containing xylitol is considered an effective alternative oral hygiene practice. In addition, mouthwashes, especially “toothpaste sheets,” are considered effective, and stockpiles of these items should be maintained at evacuation centers [18].

5.2. Influenza and infectious gastroenteritis after the great East Japan earthquake

The Great East Japan Earthquake, which occurred in March 2011, caused extensive damage over a wide area, compelling the evacuation of approximately 300,000 people. Influenza and infectious gastroenteritis spread in the disaster-affected area because the earthquake occurred during the cold weather season when there are frequent outbreaks of such infectious diseases, even in the absence of disaster-related events (e.g., [8]). As this was a large-scale earthquake, medical supplies and equipment fell short in the medical facilities as well as at the evacuation centers. Within the medical facilities, personal protective equipment, such as alcohol-based disinfectants, masks, and aprons were generally sufficient, but supplies of paper towels, liquid soap, containers for infectious medical waste, and catheters, which are used frequently on a daily basis, were inadequate. At the evacuation centers, there were concerns about the high risk of infectious disease transmission within deteriorating sanitary environments, given large numbers of people living in close proximity in spaces such as school gymnasiums and halls and the scarcity of water for washing hands, cleaning, and food sanitation caused by the suspension of water supplies. Alcohol-based disinfectants, masks, and Tamiflu stockpiled for influenza outbreaks were procured for the evacuation centers through the coordinated efforts of the prefectural government and medical institutions.

Surveillance is one of the measures applied for monitoring and controlling infectious diseases [19]. However, at the time of the Great East Japan Earthquake, information could not be transmitted because of the damage or destruction of medical institutions and power outages, making it difficult to conduct accurate assessments of trends of infectious disease occurrence. Under such circumstances, two types of surveillance were implemented for infectious diseases at evacuation centers in Miyagi Prefecture because the operation method was changed during the course of its implementation. According to reports obtained from 34 municipalities within the prefecture, the first type of surveillance was implemented from March 18 to May 13, 2011. The second type of surveillance was conducted from May 10 to November 6, 2011 within 256 shelters across 27 municipalities. The implementation of surveillance immediately after the disaster was particularly difficult because of gasoline shortages and traffic disruptions. One week after the disaster, only 4.4% of the evacuation centers were covered. Surveillance was limited for 2 weeks after the earthquake at a time when the number of occupied shelters and victims peaked [20].

In closed or semi-closed environments, such as evacuation centers, there is an increased risk of infections and their outbreaks. According to Endo et al. [21], it is important to implement basic measures, such as non-pharmacological interventions (NPIs) (e.g., hand hygiene, cough etiquette, ventilation, and isolation), early detection of symptomatic persons, rapid test performance, isolation of infected individuals, and monitoring of close contacts. Proper implementation of the NPI in the midst of infectious disease outbreaks, such as influenza and infectious gastroenteritis, in disaster-affected areas includes the conduct of appropriate and accurate educational activities, an example being the distribution of the “eight articles on infection prevention” educational posters. Posters of this type for enhancing NPI literacy are posted at evacuation centers.

According to [8], adequate communication of information was considered the most important issue when dealing with infectious diseases in the aftermath of the Great East Japan Earthquake. For several days after the disaster, all means of communication, including fixed phones, mobile phones, and the Internet, were unusable, including in the city of Sendai, which is the largest city in the Tohoku region. In rural coastal areas that were severely damaged by the accompanying tsunami, mobile phones were not usable for a month after the disaster. Under such circumstances, cooperation is necessary not only among hospitals capable of dealing with infectious diseases in large cities but also among rural communities and hospitals, social welfare facilities, and other relevant agencies. Moreover, evacuation centers and administrative organizations must respond in a unified manner. In particular, the construction of a system that enables the restoration of medical institutions and the transmission and sharing of information, right from the initial stage of recovery when information transmission is challenging, is essential [8].

5.3. Torrential rain in the Kanto and Tohoku regions

In September 2015, Typhoon No. 18 and other heavy rainfall events caused levees to collapse and flooding to occur in several areas. A heavy rainfall emergency warning was issued throughout Ibaraki Prefecture, and a total of 229 evacuation centers were set up in 35 municipalities at the peak of the crisis. In Ibaraki Prefecture, in light of lessons learned from the Great East Japan Earthquake, the surveillance of evacuation centers was incorporated into the prefectural disaster prevention plan. Immediately after the occurrence of the flood disaster, the prefectural government’s health prevention division applied its evacuation center surveillance system [22]. Information was collected and transmitted to the public health center by fax or to the Infectious Disease Information Center of the Prefectural Institute of Public Health by email. Even when there were no reports of disease, the Infectious Disease Information Center called the individuals in charge of the evacuation centers to check their status. Because the surveillance started on the day of the flooding disaster caused by torrential rain in the Kanto and Tohoku regions, information on the occurrence of infectious diseases in evacuation centers could be collected quickly and shared among the persons in charge in the municipalities and public health centers. Thus, the provision of health guidelines at an early stage contributed to effective interventions to contain outbreaks of infectious diseases. In addition to the prior incorporation of the surveillance of evacuation centers into the prefecture’s regional disaster prevention plan and disaster response manual, other important pre-disaster measures are required. These measures include formulating specific guidelines for smoother implementation and conducting drills to familiarize the concerned parties with surveillance operations at the time of the establishment of evacuation centers.

5.4. Infectious gastroenteritis during the Kumamoto earthquake

In the case of the Kumamoto Earthquake, which occurred on April 16, 2016, evacuation centers were set up on the day of the main shock and medical care was initiated the same day. Localized torrential rainfall, measured at 105.5 mm, continued unabated for 9 h on April 21, resulting in the issuance of an evacuation advisory that led to increased numbers of occupants at the evacuation centers. At that time, there were reports of increased numbers of individuals suffering from diarrhea at the evacuation centers in north-eastern Kumamoto Prefecture; testing with a Norovirus rapid diagnosis kit confirmed a positive result for infectious gastroenteritis.

According to Goto and Okamoto [23], the sanitary environment of the evacuation center was inadequate, with no partitions in the living space provided by a school gymnasium. People wore their shoes, which were covered in sediment and excrement from the rain, to pass in and out of this space through a corridor. Because of the water shortage and the lack of
disinfectants, lavatories could only be cleaned with water stored in buckets, and the wearing of gloves was the only protective measure taken to prevent infections. Thorough hand washing with water and soap was difficult to perform because of the water shortage, and some evacuees did not use soap and water at all to wash their hands.

On the same day that an evacuation order was announced, posters calling for hand washing with water and soap were displayed in the clinic. Further, the wearing of shoes was strictly prohibited throughout the gymnasium. Additional measures were implemented within 72 h of the increase of infected individuals, which included isolating patients with symptoms of acute gastroenteritis.

While many of the required environmental measures were initiated within 24 h of the disaster, surveillance could not be implemented because of the lack of staff at the medical institutions and the large numbers of evacuees. If the surveillance had been carried out, individuals with symptoms of acute gastroenteritis would have been identified from an early stage and the spread of the infection could have been prevented. Further, it would have been possible to work with administrative officials at evacuation centers from an early stage [23].

Most of the evacuation centers that the Kagoshima Prefecture Medical Association assisted were established within schools. Preparations for classes that began simultaneously made it difficult to use classrooms and health rooms because evacuees and patients were being attended to in these rooms. Thus, places where individuals with infectious diseases could be isolated were limited. In cases where it was difficult for such patients to return home, hospitalization was considered, and pre-emptive medication was administered to close contacts at the evacuation centers. If a gastroenteritis infection is suspected, regardless of whether the results of the norovirus rapid test are positive or negative, the patient is asked to return home if he or she is able to do so. While all of these measures were taken at designated evacuation centers, it cannot be confirmed from information available with the government whether sufficient measures were implemented at non-designated evacuation centers and at shelters that did not receive relief supplies, including masks and hand disinfectants.

The performance of administrative functions mostly continued because of the efforts of the staff and the clear definitions of their roles established in the regional disaster prevention plan before the disaster struck. In addition, the medical association and the local government had built up a good relationship through pre-disaster collaborative activities, such as home medical care. Consequently, whereas activities relating to surveillance and infection control at the evacuation sites began 20 days to 1 month after the occurrence of the Great East Japan Earthquake, they began as early as 5 days after the occurrence of the disaster in Kumamoto. What was critically required at that time was not only information sharing among evacuation centers and medical rescue teams but also cooperation among these organizations. In the case of the Kumamoto Earthquake, the “Surveillance in Post Extreme Emergencies and Disasters, Japan version,” known as “J-SPEED,” was introduced on a trial basis for the first time. It is expected that in future, this tool will enable the number of patients to be visualized through the inputting of information on the victims treated by medical relief teams at the emergency headquarters.

One important characteristic of the Kumamoto Earthquake was that many evacuations occurred at night and many evacuees spent the nights in their cars. Determining the symptoms of the infectious disease among evacuees who stayed in their cars was especially difficult. To address such issues, evacuees should be alerted, their self-reporting should be facilitated, and the managers of evacuation centers should devise surveillance strategies for them. In addition, because the government was not aware of non-designated evacuation centers, which were consequently omitted during the patrols, it is possible that information regarding the spread of infectious diseases would not have been reported to medical institutions [14].

6. Differences between COVID-19 and other infectious diseases during natural disasters

We applied the three previously mentioned keywords as an axis for considering evacuation issues in the context of the COVID-19 pandemic, focusing on differences between COVID-19 and other infectious diseases. Table 1 presents a comparison of evacuation status during previous complex disasters and pertinent issues under conditions of the COVID-19 pandemic.

6.1. Surveillance and information sharing

Whereas rapid diagnostic immunochromatographic kits are available for influenza and norovirus, they are only partially available for COVID-19. Evidently, rapid diagnosis of COVID-19 infected persons is essential, but the only method currently available for diagnosing COVID-19 is polymerase chain reaction (PCR) testing, which is difficult to carry out at evacuation centers at the time of a disaster. While the establishment of a surveillance system that includes the use of rapid and sensitive diagnosis kits should be a future priority, at present, this system is limited to isolating infected individuals, which is difficult to achieve given that many people are asymptomatic. In the case of infectious diseases, such as infectious gastroenteritis, contact transmission is dependent on evacuation centers’ environments, whereas in the case of COVID-19, which is regarded as an infection transmitted through both contact and droplets, the disease may spread rapidly from the infected person. There were significant delays in carrying out post-disaster surveillance at evacuations in the case of events such as the Great East Japan Earthquake. However, in the context of COVID-19, because subjective symptoms may be difficult to identify, an individual may unknowingly transmitted the infection to others leading to its rapid spread. Therefore, it is critical that surveillance is conducted immediately after the occurrence of a disaster and that the stipulated sequence of measures is promptly initiated, such as immediate isolation in the case of a symptomatic individual. To prevent the spread of infection in the event that an individual is symptomatic, evacuees should implement health management on their own, using health check sheets and other relevant tools, and they should record the names of their contacts.

Initiating early surveillance is difficult in the event of a major disaster, as medical and administrative institutions may have been extensively damaged. Nevertheless, the establishment of a pre-disaster surveillance method in collaboration with the concerned individuals at evacuation centers is necessary to detect occurrences of infectious diseases at an early phase. In particular, a strategy of dispersed evacuation is recommended under conditions of the COVID-19 pandemic, while conducting continual surveillance, even when evacuation is dispersed. To ensure efficient information sharing, non-designated evacuation centers and evacuees should be listed simultaneously. A surveillance method based on self-reporting should be designed, and check sheets should be prepared in advance to facilitate responses to surveillance at a later date. In addition, surveillance of evacuees as well as external staff and visitors entering the centers should be considered.

6.2. Evacuation center environments and stockpiled supplies

Schools were designated as evacuation centers during previous disasters, and in some cases, it was not possible to secure spaces for isolating individuals with infectious diseases. In the case of the COVID-19 pandemic, the issue of securing space for isolation is critical for preventing the spread of the infection. In general, whereas the area to be occupied by evacuees is calculated using the standard prescription of 1.57–2.93 square meters per person in Japan [24], the international “Sphere criteria” standard, which provides several guidelines on sanitation and maintenance of the living environments of evacuation centers, stipulates a minimum area of 3.5 square meters per evacuee [25]. Combined with social distancing of 2 m, the total area required per person would be 6 square meters according to the international standard. Accordingly, the number of people who could be accommodated in shelters would be reduced from one-third to a quarter of normal occupation. Evidently, the designated evacuation centers would not be sufficient to accommodate all of the evacuees. Provided that dispersed evacuation is conducted along with surveillance and information sharing, as discussed above, it
would be appropriate. Another potential issue concerns the difficulty of procuring and distributing stockpiled goods, such as masks, tents, and cardboard boxes for separating compartments allocated to each evacuee at evacuation centers in the event of a pandemic. Therefore, countermeasures such as private procurement of supplies should be considered.

6.3. Community disaster risk reduction and community leadership

According to Okada [17], there is an increased risk of outbreaks of infectious diseases at evacuation centers during disasters, and hand hygiene in excess of conventional practices is required as an infection control measure. However, judgments and responsibilities for maintaining hand hygiene lie with the evacuees, who should be self-reliant. Strong “leadership of the people” is reported to have contributed significantly to the maintenance of sanitary environments in evacuation centers in the past [17]. Therefore, raising awareness to prevent the spread of infection within communities and efforts to maintain sanitary environments are essential. The question of whether “leadership of the people” can be demonstrated in the case of dispersed evacuation remains a critical one.

7. Conclusion

In this paper, we have presented a comprehensive review of countermeasures taken during previous disasters and outbreaks of infectious diseases and have outlined issues relating to the formulation of evacuation measures required during complex disasters under conditions of the COVID-19 pandemic in preparation for complex disasters. For example, while the evacuation of residents living in high-risk areas is essential, the practice of keeping them concentrated within evacuation centers needs to be revised. Given the capacities of evacuation centers and the need to practice social distancing, a strategy of dispersed evacuation is necessary. In the case of dispersed evacuation under conditions of the COVID-19 pandemic, providing that disaster risks are not high, evacuees’ homes and cars may provide alternative shelters to evacuation centers. However, the problems of information sharing, identification of evacuees, and surveillance need to be addressed. Evacuation methods may also differ depending on the duration of the evacuation (short-term or long-term), so more specific and appropriate evacuation methods need to be developed.

In addition, asymptomatic or mildly ill patients may be treated at home or at accommodation facilities. More specific options for evacuating such individuals need to be considered. To reduce the numbers of evacuees, it is essential to develop systematic approaches and measures for evacuees that are differentiated according to the targeted hazards.

Future studies should focus on examining more concrete evacuation measures. One study could focus on the responses of India and Bangladesh concerning evacuations that were compelled by a cyclone in the Indian Ocean at the end of May 2020. Comparative studies of Japanese and foreign case studies relating to evacuation associated with natural disasters under conditions of COVID-19, ways of running evacuation centers, and various available options could yield useful insights. In addition, guidelines on evacuation methods and shelter management methods specific to COVID-19, which contribute to a reduction of the complex disaster risk, should be prepared on an urgent basis and disseminated to governments at home and abroad, local governments, and other administrative organizations.

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CRedit authorship contribution statement

Masashi Sakamoto: Investigation, Writing - original draft. Daisuke Sasaki: Writing - review & editing. Yuichi Ono: Conceptualization. Yuko Makino: Writing - review & editing. Eiichi N. Kodama: Supervision.
Declaration of competing interest

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

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