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A multi-country comparative analysis of the impact of COVID-19 and natural hazards in India, Japan, the Philippines, and USA

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\textbf{ABSTRACT}

Several countries have been affected by natural hazards during the COVID-19 pandemic. The combination of the pandemic and natural hazards has led to serious challenges that include financial losses and psychosocial stress. Additionally, this compound disaster affected evacuation decision making, where to evacuate, volunteer participation in mitigation and recovery, volunteer support acceptance, and interest in other hazard risks. This study investigated the impact of COVID-19 on disaster response and recovery from various types of hazards, with regard to preparedness, evacuation, volunteering, early recovery, awareness and knowledge of different types of hazards, and preparedness capacity development. This study targets hazards such as Cyclone Amphan in India, the Kumamoto flood in Japan, Typhoon Rolly in the Philippines, and the California wildfires in the U.S. This study made several recommendations, such as the fact that mental health support must be taken into consideration during COVID-19 recovery. It is necessary to improve the general condition of evacuation centers in order to encourage people to act immediately. A pandemic situation necessitates a strong communication strategy and campaign with particular regard to the safety of evacuation centers, the necessity of a lockdown, and the duration required for it to reduce the psychological impact. Both national and local governments are expected to strengthen their disaster risk reduction (DRR) capacity, which calls for the multi-hazard management of disaster risk at all levels and across all sectors.

1. Introduction

During the prolonged COVID-19 pandemic, 2020 marked several natural hazards in various parts of the world. India was hard-hit by Cyclone Amphan in May 2020, Japan by heavy rains in July 2020, the Philippines by typhoons Rolly and Ulysses in November 2020, and the U.S. by large and widespread wildfires from August to October 2020. COVID-19 has stopped people from taking prompt action to respond to and recover from such disasters.

As of September 15, 2020, 51.6 million people had been directly affected by floods, droughts, or storms during the time of the COVID-19 pandemic, which witnessed 92 of the 132 extreme weather-related hazards in 2020 [1]. Different types of natural hazards have occurred or have been caused by one another simultaneously in the past, but the combination of natural hazards and a pandemic is unique. Different terminologies and definitions are often employed in these unusual cases.

Wang et al. [2] adopted the term ‘cascading disaster’ to describe a disaster that leads to another. Such disasters included hurricanes Katrina and Rita in 2005 (which caused high-speed winds, heavy rainfall, waves, and storm surges), the Indian Ocean Tsunami in 2004,
and the Great East Japan Earthquake and Tsunami (GEJET) in 2011 [3].

Chain relationships, especially those that occur in technological accidents, are known to have a domino effect. Natural hazards that trigger technological disasters are called Natech events. Some examples of Natech cases include the GEJET (which led to the Fukushima nuclear accident), the Hanshin-Awaji Earthquake of 2005, and the Northridge Earthquake of 1994 [3].

Other terms, such as ‘compound disasters’, ‘multiple disasters’, or ‘concurrent disasters’, are used to describe two disaster events not related in origin but occurring simultaneously or in succession, and which often have an impact on the affected populations [2]. Such cases will only increase in the future with the increase of the intensity and frequency of natural hazards, especially those caused by climate change [4-6]. Current research trends still focus primarily on one hazard, and studies that analyze multiple risks are difficult to come by Ref. [5]. However, the experience of the COVID-19 pandemic has highlighted the challenges and the requirement for multi-hazard planning and management [4,7].

This study aimed to examine the mutual impacts of COVID-19 and a natural hazard with a focus on risk perception, preparedness, evacuation, volunteerism, early recovery, awareness and knowledge of different types of hazards, and the development of preparedness capacity. Three types of hazards (Cyclone Amphan, Typhoon Rolly, the Kumamoto flood, and the California wildfires) were chosen for comparison. At first glance, there may appear to be no relationship between a pandemic and a natural hazard; however, a pandemic can increase the vulnerability of those exposed to a natural hazard, and the two can have a certain level of influence on one another.

According to the International Disaster Database (EM-DAT) 398 natural hazards occurred across the world in 2020. The top ten hazards due to economic losses are listed in Table 1. Three of the natural hazards investigated in this study—those in India, the US, and Japan—are on this list. The cyclone that hit the Philippines did not appear on the list, but it claimed 31 lives, more than USD 503 million in economic losses, and affected more than 3.3 million people.

2. Country perspectives: COVID-19 and type of hazards

2.1. Cyclone Amphan in India

Tropical Cyclone Amphan hit the eastern part of India on May 20, 2020, and left widespread damage around Calcutta, with at least 84 people dead in India and Bangladesh [8]. The southern districts of West Bengal were most affected, with damage amounting to approximately USD 13.5 billion. More than 500,000 people were evacuated from the cyclone’s path, but the evacuation capacity was significantly reduced because of social distancing [9]. In addition, cyclone shelters and evacuation centers have limited access to food, safe drinking water, and hygiene-enhancers [10]. Storms in the Bay of Bengal have accounted for eight of the ten deadliest tropical cyclones in history [11]; however, timely evacuation and the presence of the world’s largest contiguous mangrove forest have decreased the intensity of the Amphan cyclone after landfall [12].

The co-occurrence of natural hazards and the pandemic has led to severe crises and challenges for the resilience of societies and systems. To enable the maintenance of physical distance, only 33% of the shelter capacity in Odisha and 40% in West Bengal were used by evacuees [12]. Despite the preventive measures that were put in place for the pandemic, a significant increase in confirmed COVID-19 infections was found in Odisha (a 76.2% increase from 978 to 1723 cases) and West Bengal (a 62.5% increase from 2961 to 4813) in the post-cyclone period (May 29, 2020) when compared with the pre-cyclone period (May 19, 2020) [12]. Thus, the mass evacuation and the sheltering that followed accelerated the rate of COVID-19 infections in the region [11,12].

2.2. The Kumamoto flood

On July 4, 2020, the southern Kumamoto and northern Kagoshima prefectures experienced record-breaking heavy rainfall, which led to a rainfall emergency warning and resulted in extensive flooding and sediment hazards [13]. In Kumamoto, 65 people were killed; 217 houses were destroyed, and 458 were partially destroyed. On July 12, at the peak of the flood, 2512 were accommodated at evacuation centers [14].

Before the flood, on June 22, 2020, 49 COVID-19 cases were reported in the prefecture, and the 50th case was registered on July 16, 2020. By the end of the month, there was a drastic increase of 188 cases [15].

The COVID-19 pandemic has complicated hazard evacuation and shelter management in Japan. Close physical proximity between

| Hazard type      | Country       | Economic loss (’000 USD) | Death toll | Total number affected |
|------------------|---------------|--------------------------|------------|-----------------------|
| 1 Flood          | China         | 17,000,000               | 280        | 4,200,000             |
| 2 Cyclone Amphan | India         | 13,500,000               | 90         | 18,000,000            |
| 3 Hurricane Laura| USA           | 13,000,000               | 33         | 6500                  |
| 4 Wildfire       | USA           | 11,000,000               | 32         | N/A                   |
| 5 Flood          | India         | 7,500,000                | 1922       | 1,300,000             |
| 6 Earthquake     | Croatia       | 6,800,000                | 1          | 78,942                |
| 7 Storm          | USA           | 6,800,000                | 4          | N/A                   |
| 8 Hurricane Sally| USA           | 6,300,000                | 8          | N/A                   |
| 9 Flood          | Japan (Kumamoto) | 5,800,000           | 82         | 250,114               |
| 10 Hurricane Eta | Honduras      | 5,000,000                | 110        | 4,566,584             |
people is a risk factor for COVID-19, and social distancing is an effective measure that prevents viral transmission [16]. The designated capacity of evacuation centers dropped to nearly one-fourth of the usual capacity to accommodate social distancing among evacuees [17]. The average evacuation area per person that was planned by the prefectures in the Kanto area is 2.3 m$^2$. However, the minimum area for humanitarian assistance set by the sphere standard is 3.5 m$^2$ per person [18]. Disaster prevention plans must be reconsidered to ensure that they meet at least the minimum standard.

2.3. Typhoon Rolly

On November 1, 2020, Super Typhoon Rolly (Goni) brought torrential rains, violent winds, mudslides, and storm surges to Luzon. Some of the most affected localities were Catanduanes and Albay in Bicol Region V. At the same time, Southern and Central Luzon, which include the national capital Manila, were hit by intense rainfall and violent winds [19]. The typhoon left extensive destruction and damage in its path, and killed at least 25 people, injured 39, and affected 2 million people in eight of the country’s 17 regions. This left an estimated 845,000 people in need of assistance and protection. Most families who had evacuated in early November could return to their homes by late November [20,21].

On November 3, as many as 387,161 COVID-19 cases were confirmed in the Philippines as a whole [22], many of which were in the National Capital Region, Calabarzon, Central Visayas, and Central Luzon, which were among the regions most affected by Typhoon Rolly. The Philippines had the second-highest number of confirmed COVID-19 cases in Southeast Asia; they ranked seventh in Asia, and 20-s in the world as of November 2, 2020 [20].

Even before the typhoon, the pandemic had reduced humanitarian access to the Philippines. The authorities had put stringent community quarantine and other containment measures in place to restrict the movement of affected people. It was challenging to strike a balance between ensuring the continuity and scaling up of humanitarian aid delivery and protecting affected people from exposure to the virus, as well as taking precautions/making provisions for the reduction or suspension of aid [21]. The economy of the Philippines was negatively impacted by the COVID-19 pandemic, and millions of people lost their livelihoods because of the socio-economic impacts of the pandemic.

2.4. California wildfires in the US

In 2020, California experienced its largest wildfire season in history with more than 4.2 million acres burned down, more than 9000 separate incidents of fire, and more than 10,000 structures damaged or destroyed [23]. Five of the wildfires that occurred between August and September 2020 were on the list of the 10 largest fires in California since 1932 [24].

In August 2020, a series of lightning strikes caused hundreds of fires in northern California [25]. Sparked by more than 20,000 lightning strikes and intensified by record-breaking heat, fires erupted throughout the state. Tens of thousands of Californians required evacuation [26]. However, due to the COVID-19 pandemic and the need for social distancing, evacuation management took place in an entirely different manner, and many of those who were displaced were sent to nearby hotels [27].

August saw the peak of the 2020 California wildfires. The state averaged 120 deaths per day due to COVID-19 for the entirety of August, a month that recorded more deaths than any other during the pandemic [28]. COVID-19 complicated wildfire management and public safety during the 2020 fire season. It is unclear as to whether COVID-19 has impacted the ability of residents in the wildland-urban interface to prepare for and evacuate from wildfires, and to what extent residents feel that their safety has been affected. Several areas with high wildfire risk also experienced a record number of COVID-19 cases [29].

| Table 2 | Targeted areas of survey questionnaires. |
|---------|-----------------------------------------|
| **Country** | Targeted area | **Sample size** | **%** |
| India (253 samples) | West Bengal state | 207 | 82 |
| | Orissa state | 46 | 18 |
| | Kumamoto city | 195 | 71 |
| | Yatsushiro city | 43 | 16 |
| | Hitoyoshi city | 14 | 5 |
| | Aroa city | 16 | 6 |
| | Tsunaki town | 4 | 1.4 |
| | Sagara village | 3 | 1 |
| | Kuma village | 1 | 0.4 |
| Japan (276) | Albay province | 139 | 52 |
| | Camarines province | 72 | 27 |
| | Sorsogon province | 24 | 9 |
| | Catanduanes province | 33 | 12 |
| Philippines (268) | Santa Cruz County | 25 | 10 |
| | San Mateo county | 42 | 17 |
| | Sacramento county | 50 | 20 |
| | Santa Clara county | 69 | 27 |
| | San Francisco city and county | 66 | 26 |
| USA (252) | **Sample size** | **%** |
| | 207 | 82 |
| | 46 | 18 |
| | 195 | 71 |
| | 43 | 16 |
| | 14 | 5 |
| | 16 | 6 |
| | 4 | 1.4 |
| | 3 | 1 |
| | 1 | 0.4 |
| | 139 | 52 |
| | 72 | 27 |
| | 24 | 9 |
| | 33 | 12 |
| | 25 | 10 |
| | 42 | 17 |
| | 50 | 20 |
| | 69 | 27 |
| | 66 | 26 |
3. Survey methodology

An online questionnaire survey was conducted in selected areas in India, Japan, the Philippines, and the U.S. during March 2–11, 2021, with the support of a survey company based in Japan. A further breakdown of the targeted areas where the samples were collected is presented in Table 2. These areas were selected because of the high intensity of their impact and the damage that was incurred during disasters. The responses were collected only from those respondents in each region who had stated that they had experienced the disasters in question in India, Japan, the Philippines, and the U.S.

The survey consisted of 45 questions that collected personal demographic information (gender, age, occupation, residential area, and housing type). The questionnaire was divided into seven sections: 1) the impact of COVID-19 and disasters, 2) risk perception, 3) disaster preparedness, 4) evacuation, 5) volunteering, 6) early recovery, and 7) awareness and knowledge of the types of hazards and preparedness capacity.

In total, 1049 responses were collected from India (253), Japan (276), the Philippines (268), and the US (252). The gender ratio and age distribution (Fig. 1) of the respondents are illustrated by country. In the Philippines, 80% of responses were received from younger people (in their 20s and 30s). In other countries, approximately half of the answers were obtained from respondents in their 20s and 30s. In the US, 20% of the responses were received from people in their 60s and 70s. Nearly half of the respondents from all countries were office workers or employees. In some areas, only a limited sample was collected online due to the lack of proper Internet connectivity. Moreover, it was not possible to conduct face-to-face interviews with the affected individuals because of the COVID-19 impact. Given these limitations, this survey endeavored to collect as much data as possible and as randomly as possible from affected individuals to identify and understand the preliminary challenges that stand in the way of the analysis of trends in different compound hazards. To enable the study to be used in policy or decision-making, more data need to be collected, and statistical significance should be thoroughly examined.

4. Results and analysis

4.1. Impact of COVID-19 and natural hazards

a) Impact of COVID-19

Approximately 95% of respondents in the four countries stated that COVID-19 had affected their lives. The statements “Household income was reduced,” “Impacted my mental health/experienced stress and trauma,” and “Social ties were reduced” were the most common in all four countries (Table 3). The long-term impact of COVID-19 includes damage in the form of income reduction, strain on mental health, and loss of social ties.

Income loss was most commonly cited in India and the Philippines. In the US, the most common grievance was the reduction in social ties, and in Japan, the impact on mental health was the most common. This difference seems to mark the distinction between developed and developing countries.

b) Impact of natural hazards

Approximately 80% of all respondents indicated that the disaster had affected their lives, but only 55% of those in Japan agreed with this statement. The most commonly cited item among all four countries was “Impacted my mental health/experienced trauma and stress” (Table 4). In the U.S., a similarly high impact on physical health was observed. As illustrated in the COVID-19 responses, the impact of the disasters on income was larger in India and the Philippines than in Japan and the US.

4.2. Appraisal of preparedness

As many as 84% of the respondents in India, along with 95% of the respondents in the Philippines, indicated that they had taken
some preparation measures before the disaster; this percentage was 49% in Japan and 60% in the US (Fig. 2). In the case of a cyclone, a warning is issued a few days before the event, which provides people with more time to prepare for it.

The preparedness measures “Checked information through TV, radio, social networking sites (SNSs), and the Internet to get the latest news” and “Prepared emergency items at home (e.g., flashlight, emergency food, water, and radio)” were equally commonly cited in all countries (Table 5).

The COVID-19 related preparedness measure “Prepared hygiene materials considering the infection of COVID-19” was among the top three in India, the Philippines, and the US. The level of COVID-19 related preparedness in Japan was not as high as in other countries. It must be considered that the COVID-19 pandemic was not serious in Japan in July 2020 when the flood occurred.

In India, the Philippines, and the U.S., the most commonly cited reason for individuals not preparing for a disaster was that they did not think it was necessary due to the low risk. In addition to this, 46% in Japan, 38% in India, 25% in the U.S., and 14% in the Philippines reported that they did not know how to prepare, although they did consider that it would be important. This information indicates the need for broader-based disaster preparedness education. Raising awareness and sharing information is urgently required to further strengthen preparedness capacity in all four countries.

4.3. Evacuation strategies

Among those who evacuated, 84% indicated that the risk of COVID-19 affected their decision. To the question “where did you evacuate if not to the designated evacuation center,” in the Philippines, 86% reported the house of a friend or someone else they knew (Fig. 3). Of the Japanese respondents, only 25% evacuated to someone else’s house and 67% went to a car. This may indicate their learnings from the experience of the 2016 Kumamoto earthquake.

The survey asked the respondents to select the top three of 12 concerns: 1) accessing food and water; 2) caring for their children; 3) ensuring that family members who required special attention would receive adequate care; 4) caring for pets; 5) securing privacy; 6) protecting against heat and cold; 7) using sanitary facilities; 8) my chronic disease; 9) safety and security; 10) COVID-19 infection; 11) taking preventive measures against COVID-19; and 12) ensuring sufficient social distance at the shelter.

The top three concerns were similar across the four countries (Table 6). “Accessing food and emergency items” was the highest

### Table 3
Top 3 impact of COVID-19.

| Country | 1                                    | 2                                    | 3                                    |
|---------|--------------------------------------|--------------------------------------|--------------------------------------|
| India   | Household income was reduced         | Social ties were reduced             | Impacted my mental health/experienced stress |
| Japan   | Impacted my mental health/experienced stress | Household income was reduced         | Social ties were reduced             |
| Philippines | Household income was reduced        | Impacted my mental health/experienced stress | Social ties were reduced             |
| USA     | Social ties were reduced             | Impacted my mental health/experienced stress | Household income was reduced         |

### Table 4
Top 3 impact of the natural hazard.

| Country | 1                                    | 2                                    | 3                                    |
|---------|--------------------------------------|--------------------------------------|--------------------------------------|
| India   | Impacted my mental health/experienced stress | Household income was reduced         | Social ties were reduced             |
| Japan   | Impacted my mental health/experienced stress | Household income was reduced         | Social ties were reduced             |
| Philippines | Impacted my mental health/experienced stress | Household income was reduced       | Social ties were reduced             |
| USA     | Impacted my health                   | Impacted my mental health/experienced stress | Social ties were reduced             |

Fig. 2. Whether preparedness actions had been taken before the natural hazard.
priority except in the U.S., where “Caring for children” had the most votes. “Accessing food and emergency items” and “Caring for children” were among the top three concerns of all four countries. “COVID-19 infection risk” was in the top three concerns for respondents from Japan and the Philippines. “Ensuring that family members who required special attention would receive adequate care” was among the top three concerns for India and the US. This demonstrates that many considered evacuation centers to be unfriendly to children and people who require special attention.

This survey also elicited the three most serious problems among fourteen that people encountered at the evacuation centers: 1)
insufficient food and other necessary items; 2) taking care of my children; 3) providing enough support and care to those in my family who required special attention; 4) caring for my pets adequately; 5) insufficient privacy; 6) adjusting to heat and cold; 7) using sanitary facilities; 8) I did not feel safe at times; 9) taking care of my chronic disease; 10) taking adequate preventive measures against COVID-19; 11) enforcing sufficient social distance at the center; 12) wearing a mask all day; 13) speaking with my family and people I know; and 14) finding enough mental and psychosocial support.

“Insufficient food and other necessary items” were common problems in all the four countries (Table 7). However, the most serious problem highlighted was different in each country. This implies that the conditions of evacuation centers differ between countries, and shelters amount to different settings, with different facilities, management styles, and capacities. Therefore, it is crucial to conduct a thorough search of problems at an evacuation center and develop solutions that consider cultural needs and priorities.

The three most important problems were: “Using sanitary facilities” (in Japan and the Philippines), “Providing enough support and care to those in my family who require special care and attention” (in India and the Philippines), and “Taking care of children” (in India and the US).

“Insufficient privacy” was only included among the top three responses by Japan and “Caring for my pets adequately” was reported in the top three only by the U.S. The privacy issue of an evacuation in Japan was often addressed, which may have been one of the reasons why people had a negative impression of evacuation centers and hesitated to evacuate immediately. In the U.S., it is considered crucial to be able to bring and take care of pets at a center, and this will also be an issue that should be considered when developing a management plan in an evacuation center.

Those who did not evacuate were asked why they did not do so. More than 50% of respondents stated that they thought it would be possible to remain safe without evacuation. In the U.S., nearly 10% stated that they did not know where to evacuate, but in other countries, this number was only 3–4%. In Japan, India, and the Philippines, the second most commonly cited reason was that they were afraid of being infected by COVID-19. Thus, COVID-19 was a major factor that impaired the decision to evacuate.

4.4. Effectiveness of volunteerism

The types of support received from volunteers differed on the basis of time. The primary form of support that people received within one week (Table 8) was “Cooking and food distribution,” “Cleaning rubble and houses,” and “Receiving emergency items.”

After one week (Table 9), a new type of support, “Sorting out the items and clothes provided” arrived, as did “Medical support.” After one month (Table 10), the major types of support received were “Mental health support” and “Sorting out the items and clothes provided.”

Some of the respondents provided volunteer services. The types of support they provided were similar to those they received. In Japan, the greatest obstacle to volunteering was the lack of human resources, and in other countries, it was the requirement for social distancing (Fig. 4). More than 70% of the cases in India, the Philippines, and the US reported COVID-19-related reasons. This shows that the impact of COVID-19 significantly hampered volunteer work. The most commonly cited reason for not providing volunteer support was related to COVID-19 in all countries, except in the Philippines. COVID-19 has hampered volunteer support in several ways (Fig. 5).

4.5. Evaluation of early recovery

The amount of time required for people to return to normal life was the lowest in Japan (Fig. 6). This duration depends on the scale of the damage and the intensity of the disaster. However, after the wildfires in the U.S., nearly three months were required for 15% of respondents to return to their daily routines. In other countries, this length of time was only required for 10% of respondents. This might be related to the fact that wildfires take a few months to contain, which has a serious impact on the people affected.

In the Philippines and India in particular, the lack of financial resources and materials for reconstruction was a grave matter. In the U.S., the lack of financial resources was considered to be very important. In Japan, however, the lack of labor was the largest obstacle. This might reflect the current issue of depopulation and the aging society in Japan; in the future, this problem might assume ominous proportions.

4.6. Awareness, extent of capacity and knowledge of various hazards

Knowledge about COVID-19 and other disasters was high in all four countries. In India and the Philippines, the knowledge of chemical/industrial hazards was the highest at 70%, which was significantly higher than the rates in Japan and the US.

Approximately 95% of respondents in India and the Philippines, as well as 85% in Japan and the US, reported their intent to know more about different types of hazards based on their experience of COVID-19 and other recent natural hazards. This marks a good opportunity to help them increase their knowledge of the different types of hazards once the COVID-19 situation is resolved.

The highest level of interest among the four countries was in natural and biological hazards, except in Japan, where there was a

| Table 8 |
| Top 3 volunteer support received within 1 week after the disaster occurred. |
| --- |
| **Country** | 1 | 2 | 3 |
| India | Cleaning rubble and houses | Receiving emergency items | Medical support |
| Japan | Cooking and distributing food | Receiving emergency items | Cleaning rubble and houses |
| Philippines | Cleaning rubble and houses | Receiving emergency items | Cleaning rubble and houses |
| USA | Cleaning rubble and houses | Receiving emergency items | Cooking and distributing food |
Table 9
Top 3 volunteer support received after 1 week to 1 month.

| Country | 1                                      | 2                                      | 3                                      |
|---------|----------------------------------------|----------------------------------------|----------------------------------------|
| India   | Medical support                        | Cooking and distributing food          | Sorting out the items and clothes provided |
| Japan   | Cleaning rubble and houses              | Receiving emergency items              | Cooking and distributing food/Medical support/Mental health support |
| Philippines | Sorting out the items and clothes provided | Medical support                       | Receiving emergency items              |
| USA     | Cooking and distributing food          | Sorting out the items and clothes provided | Receiving emergency items              |

Table 10
Top 3 volunteer support received after 1 month.

| Country | 1                                      | 2                                      | 3                                      |
|---------|----------------------------------------|----------------------------------------|----------------------------------------|
| India   | Sorting out the items and clothes provided | Mental health support                 | Medical support                        |
| Japan   | Sorting out the items and clothes provided/Receiving emergency items/Medical support/Cooking and distributing food | N/A (top three supports are the same scores as the highest) | N/A                                    |
| Philippines | Mental health support                  | Medical support                        | Sorting out the items and clothes provided/Cleaning rubble and houses |
| USA     | Sorting out the items and clothes provided | Mental health support                 | Medical support                        |

Fig. 4. Major difficulties in volunteer experience.
Fig. 5. Reasons that they did not do any volunteer work.
greater interest in nuclear hazards than in chemical/industrial hazards by a small extent. Interest in both chemical/industrial and nuclear hazards was higher in the Philippines than in other countries.

Television is considered the most useful information source in India, Japan, and the Philippines. SNS/YouTube/mobile applications ranked second, and printed materials ranked third. In the US, printed materials, such as pamphlets and brochures, are considered the most useful. Online webinars are rated second, and television third. There were very few radio listeners in all four countries. Of the respondents in the U.S., 44% were in their 20s or 30s; however, this value was 50%–80% in other countries. Preferences for tools and materials also differed on the basis of on age.

Finally, the survey asked the respondents about the type, level, and extent of preparedness (Fig. 7). Only Japanese respondents believed that the capacity of the national government should be enhanced. However, no significant gap was observed in the responses from the four countries. Their expectations of the local government were higher than those of the other government levels. The expectations of individuals were relatively high, especially in India, Japan, and the US. This shows that people understand the essentiality of the role that individuals play in disaster risk reduction.

5. Discussion

The COVID-19 pandemic has aggravated the complexity of the response to and recovery from natural hazards [30]. Likewise, the survey findings clearly indicated that COVID-19 had an impact on respondents’ daily lives, evacuation decision-making, reception and provision of volunteer services, future preparedness activities, and awareness of hazard risks. In this section, the mutual influence of COVID-19 and natural hazards is discussed with regard to four areas: the impacts of COVID-19 and natural hazards; evacuation; volunteerism; and the awareness, extent of capacity and knowledge of various hazards.

5.1. Impact of COVID-19 and natural hazards

The results showed that income reduction was the most significant impact of COVID-19 in India and the Philippines, while the impact on mental health and reduction of social ties were more significant than income reduction in Japan and the U.S. The types of impact in developed and developing countries differed. In terms of the impact of natural hazards, the highest impact was on mental
health in all the countries. Both COVID-19 and natural hazards have had an extensive impact, and produced outcomes such as income reduction and challenges to mental health. As these events occurred concurrently, the compounding of the two events might have caused these impacts.

In terms of the major causes of income reduction during the pandemic, Piyapromdee and Spittal [31] argued that the economic situation of developing countries prior to COVID-19 was a major factor, as lower-income households experienced the largest proportionate income reduction. However, damage to income levels in developed countries is significant. Xiong et al. [32] and Pak et al. [33] observed that decreased demand for goods and services as well as a decline in productivity, global supply chain disruptions, changes in spending behavior, and restrictions on eating out and traveling affected local businesses and industries worldwide through financial hardships in livelihood.

Such financial hardships also caused significant psychological stress. Furthermore, strictly imposed stay-home orders and mass quarantine during the pandemic were two of the major reasons for stress, which resulted in decreased quality of life and uncertainty, and put greater risk on the development of significant psychological symptoms and socioeconomic distress [32,34–37]. To reduce the psychological impact of the quarantine, Brooks et al. [34] suggested that clear messages about what was happening, why quarantine had to be implemented, and for how long it would continue, should be conveyed. It is necessary for administrators and health officials to determine the pandemic response measures, understand how serious the mental health impact that results from quarantine can be, and take every necessary measure to ensure that the lockdown does not exceed the bounds of human tolerance as far as possible [34]. Such communication requires tremendous skill and the capability to convey such crucial messages across the country in order to enable citizens to understand the risks, the preparedness measure of the government and their effectiveness, and the importance of collaboration.

Furthermore, Xiong et al. [32] noted that the impact on mental health differs by time, country, and region according to the degree of severity, type of national economy, governmental preparedness, availability of medical supplies/facilities, and suitable dissemination of COVID-related information. Therefore, support for the recovery mental health differs between countries.

5.2. Evacuation

The survey indicated that the risk of COVID-19 greatly hampered the decision to evacuate. Nearly 30% of the non-evacuees in the Philippines, 21% in India, 9% in Japan, and 8% in the U.S., stated that they were afraid of being infected by COVID-19. Collins et al. [30] also stated that 74.3% of individuals viewed the risk of being in a shelter during COVID-19 as more dangerous than the enduring natural hazards.

Salas et al. [38], Kizer [39], and Quigley et al. [40] indicated that the problem with evacuation during the COVID-19 pandemic, in combination with a natural hazard, is that these two events call for different preventive strategies. In other words, evacuation is a central strategy for the protection of people from natural hazards. In contrast, an effective approach toward slowing the spread of COVID-19 is physical distancing and stay-at-home orders. Traditional disaster risk mitigation strategies such as evacuation are insufficient responses during a pandemic due to the increase of the risk of the virus spreading among individuals who have gathered in close proximity. Measures that limit virus transmission have complicated the management of evacuation centers.

The difficulty in the maintenance of the risks imposed by both COVID-19 and natural hazards was revealed when Cyclone Amphan made landfall, which affected India and Bangladesh. Shultz et al. [11] indicated that both nations strictly enforced COVID-19 lockdowns and rapidly mobilized and evacuated more than 6.5 million people across the two countries. Timely evacuation limited Amphan-associated mortality to almost 80. However, the mass evacuation and sheltering processes appeared to have produced a spike in new COVID-19 cases.

This experience highlighted the fact that effective preventive measures are required at evacuation centers during a pandemic; otherwise, it may create the risk of a mass infection. The WHO [41] developed a guideline for evacuation centers to use during the COVID-19 pandemic and addressed key public health practices that must be considered during the establishment of disaster evacuation centers, which included the need for physical distancing, contact tracing, hand hygiene and handwashing, control of temperature, and ventilation.

In Japan, some evacuation centers have been managed and organized, and proper preventive measures have been maintained according to the guidelines. When an earthquake occurred in Fukushima, Japan in February 2021, several evacuation centers that featured preventive measures against the spread of COVID-19 were opened. Some of these features included hand disinfection, body temperature checks, zoning of people with fever, setting up of tents with open roofs at intervals of 2 m, and the grouping of single households [42]. It is crucial to coordinate in advance and disseminate information on safety and on the various preventive measures taken at evacuation centers. This strengthens the public perception of safety within shelters and deters people from deciding against evacuation in fear of COVID-19 infection, as many might consider the measures to be inadequate safeguards against COVID-19 in a public evacuation center [30]. These considerations apply to evacuations from various hazards such as wildfires, floods, and cyclones [43].

Salas et al. [38] and Sawano et al. [42] emphasized the importance of the establishment of as many evacuation shelters (such as hotels and public facilities) as possible, the limitation of the number of people at each, and the dispersal of the evacuation. Furthermore, the evacuation center management manual for pandemic times that was issued by the Japan Medical Association [44] requested the creation of parking spaces for people who had evacuated with their cars.

It was observed that the reasons for the hesitation in taking immediate evacuation action were not only COVID-19-related, but also with regard to various concerns about the general conditions of an evacuation center. This study highlighted that people had a negative image with regard to evacuation centers, which indicated that evacuation centers were unfriendly to children and people who required special attention. Various problems and concerns at evacuation centers have been addressed for many years, and COVID-19 has
attracted attention to these hitherto overlooked issues [45]. The existing means of managing evacuation centers must be reviewed thoroughly and fundamentally and then improved [46].

5.3. Volunteerism

The survey found that COVID-19 infection concerns influenced participation in volunteer activities and the attainment of volunteer support. Social distancing was identified as the greatest obstacle to volunteer work. At the time of the 2020 Kumamoto flood that claimed 65 lives, nearly 40,000 volunteers in 12 affected cities and towns in Kumamoto Prefecture provided assistance from July to October 2020 [47]. However, at the time of the West Japan flood in 2018 that caused 61 casualties before the COVID-19 pandemic started, in Okayama Prefecture, almost 90,000 volunteers participated in support activities from July to October 2018, which is more than twice as many as the case of the Kumamoto flood in 2020 [48].

Lanchance [49] emphasized that social distancing to limit COVID-19 spread and government legislation had a negative impact on traditional volunteerism. Physical distancing guidelines present challenges for volunteer response [50]. Therefore, affected individuals are unable to rely on volunteer support for response and recovery when social distancing is strongly advised. During the COVID-19 pandemic, the Japan Voluntary Organizations Active in Disaster (JVOAD) [51] developed guidelines for disaster response for volunteers and non-profit organizations (NPOs) that conduct response activities. They were strongly notified not to conduct on-site damage assessment, and that information be collected remotely, meetings be conducted online, and volunteers bring necessary equipment such as face masks, face shields, and disposable gloves [51]. Eventually, these restrictions lead to a reduction in the number of volunteers.

There was a simultaneous attempt to maximize limited human power. When the Kumamoto flood hit in July 2020, there was a shortage of volunteers, and those who were available operated under certain restrictions, such as being tested for COVID-19 and having temperature checks at regular intervals [17]. Das et al. [17] presented an example of a recovery project conducted in Kumamoto, Japan. To address the problem of the severe shortage of volunteers and maximize limited human power, a group of local organizations and associations initiated the Kuma River Project. They collected small amounts of money from contributors to support those helping with the recovery work as a side business, and also helped affected people who had temporarily lost their jobs. Such an innovative approach and initiative is becoming increasingly necessary in the era of uncertainty, in order to tackle the unprecedented scale and intensity of events.

5.4. Awareness, extent of capacity and knowledge of various hazards

The experiences of both COVID-19 and natural hazards clearly increased the respondents’ interest in different hazard risks. This will produce a window of opportunity to increase awareness and knowledge of various hazard risks for all levels and sectors, review current risk-management strategies, and understand the hazard risks that exist where they live—a priority action in the Sendai Framework for Disaster Risk Reduction.

Survey results showed that respondents in India, the Philippines, and the U.S. had higher expectations from local governments to strengthen their disaster risk reduction (DRR) capacity. Each level of the government has a different role; ideally, disaster response efforts should be federally supported, state-managed, and locally executed. In general, local authorities are expected to take the lead in dealing with natural hazards and other emergencies with the support of the national government [52]. In that sense, it makes sense that the survey demonstrated that there was a greater expectation for local governments to strengthen their DRR as compared to the national government. It is crucial for local governments to enhance their coordination and response capacities to provide timely and effective assistance.

At the same time, the national government plays a tremendous role in the development of policies and plans toward disaster relief and pandemic planning as part of a broader national preparedness and response strategy that adopts an all-hazards approach and incorporates key roles for the national, state, and local tiers of authorities [52]. In 2020, the simultaneous appearance of multiple hazards set the tone for the need to change the DRR and planning paradigm [53]. What approach should be adopted to tackle multiple hazards, and how should current strategies and plans be improved?

The all-hazards approach (AHA) is intended for all forms of emergencies or disasters [54], and is an integrated approach toward emergency preparedness, which focuses on the identification of hazards and development of emergency preparedness capacities [55]. It has been investigated for their effectiveness. There is also a need for a top-hazards approach; because while an AHA considers the commonalities in all disasters that allow for generalized preparedness and planning, a top-hazards approach is a risk-focused framework, wherein different events require different planning and mitigation tactics and, therefore, different prioritizations as per likelihood and severity in each local context [56]. One of the limitations of a top-hazards approach is that it has to rely on the credibility of risk or hazard assessments conducted for particular areas, which is the extent to which their risk and hazard analysis and identification can be accurate in terms of the ranking of the probability of hazards and prioritization planning for hazards. Penta et al. [57] argued that the world has been experiencing unexpected hazards that are presently off the radar. The question is whether it is possible to mobilize responses to unexpected events using a top hazard approach. Additionally, it is necessary to understand that traditional risk identification and analysis do not consider how all and various hazards and impacts interconnect and overlap, with multiple cascading effects that spread across social, economic, and environmental domains with potentially catastrophic outcomes [58].

Peleg et al. [53] argued that the AHA was conceived as an approach to emergency management that could identify who should be involved in those tasks, to identify present needs, and where to acquire the resources that are appropriate to meet those needs. This approach remains a useful tool for planning guidance and practice in disasters that result from a wide range of hazards, including pandemics, based on similar needs: warnings, risk communication, coordination, supply chain management, and planning toward
established objectives [53]. The AHA does not prescribe a perfect plan for every conceivable type of disaster; rather, it could propose adaptable plans that provide the basis for how to tackle various hazards including pandemics [59]. An example of the same management system that works for both health emergencies and natural hazards is the incident command system (ICS). The ICS was developed after a disorganized and chaotic response to wildfires in California in the 1970s in order to provide a proper coordination mechanism to different entities during emergencies, that could be used for crisis management in different cases. Healthcare entities have also used ICSs for COVID-19 response in the U.S. and Australia. Tribal governments and international organizations have included ICSs and related principles in their response documentation and guidance [57,60].

Furthermore, common areas of disaster and pandemic management, such as information needs and sharing, misinformation management, supply management, and health and medical service delivery, were observed in the management and response to COVID-19. The SARS Commission report [61] stated that it would be incorrect to establish different systems for public health and nonpublic-health emergencies because a public health event rapidly takes on the characteristics of other types of events. The Sendai Framework for Disaster Risk Reduction states that it is crucial for both national and local levels “to strengthen technical and scientific capacity to capitalize on and consolidate existing knowledge and to develop and apply methodologies and models to assess disaster risks, vulnerabilities, and exposure to all hazards” [62]. It also calls for the multi-hazard management of disaster risk at all levels and within and across all sectors. In such an approach, it is fundamentally necessary to pay attention to all hazard risks during the identification of the top hazard risks.

6. Conclusion

The greatest impact of COVID-19 and the natural hazards that occurred during its time may differ between developed and developing countries. If the financial situation was poor before COVID-19, the impact of COVID-19 likely worsened the situation. Beyond economic recovery, assistance to those suffering from psychological stress should not be overlooked during the COVID-19 recovery period.

COVID-19 has greatly influenced people’s decision to evacuate, regardless of their nationality or the type of hazard. In each country, 10–20% of respondents stated that they did not evacuate because they were worried about COVID-19. To avoid this in the future, it is important to share information on the safety of evacuation centers with residents before a disaster occurs, in order to encourage them to take necessary action without hesitation. However, it was found that the most serious problems identified among evacuees were not COVID-19-related. In Japan, the lack of privacy is a serious issue. This implies the existence of several issues and concerns that made people hesitant towards immediate evacuation, and this should receive attention in order to encourage evacuation beyond COVID-19 related matters.

In the comparison of cyclones, floods, and wildfire hazards, it is evident that wildfires required more time for people to return to daily routine because containment often took months. Cyclones provide more time for preparation or the adoption of necessary actions such as evacuation. Approximately 90% of the respondents in India and the Philippines had taken preparedness measures before the disasters, while around 50% had done so in Japan and the U.S.

This study made several recommendations, such as the fact that mental health support must be taken into consideration during COVID-19 recovery. It is necessary to improve the general condition of evacuation centers in order to encourage people to act immediately. During a pandemic, a variety of management and infection preventive measures are required at evacuation centers, such as the need for physical distancing, contact tracing, ventilation, the establishment and maintenance of as many evacuation centers as possible, evacuation dispersal, and extra parking space. A strong communication strategy and campaign with particular regard to the safety of evacuation centers, the reasons behind the necessity of a lockdown, and how long it will continue to reduce the psychological impact, are necessary during a pandemic. To supplement the shortage of volunteers, it is important for local stakeholders to collaborate in the development of a new support system. Such collaboration may include the collection of small amounts of money from contributors to support those helping with the recovery work as a side business. Both national and local governments are expected to strengthen their DRR capacity, which calls for the multi-hazard management of disaster risk at all levels and within and across all sectors.

This preliminary study was conducted to understand the issues, challenges, and necessary steps toward the preparation for future compound hazards. There were some limitations that constrained the performance of deeper analysis for each survey question and the provision of case-specific recommendations with regard to how things could be improved in the context of each particular country and disaster.

More climate-related disasters are likely to occur, and their intensity and frequency will increase because of the impact of climate change. The likelihood of multiple hazards and compound events has increased [4]. Additional in-depth surveys, interviews, and studies are necessary to investigate the need to develop current preparedness and DRR strategies in order to reduce future compound hazard risks and to provide prompt, effective, and safe assistance.

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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