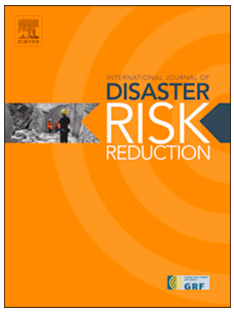

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Designing the Building Space of a Shopping Street to Use as a Disaster Evacuation Shelter During the COVID-19 Pandemic: A Case Study in Kobe, Japan

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Abstract

This study considers the risk of a natural hazard-induced disaster occurring during a pandemic, such as the novel coronavirus (COVID-19) pandemic, and develops the idea of utilizing a shopping street with disaster-proof buildings as a temporary evacuation shelter by incorporating countermeasures against the spread of infectious diseases. Using a case study of a shopping street in Kobe, Japan, we estimate shelter capacity by considering the requirement of 6 m^2 of space allotted for each person. The shelter can accommodate 1,194 evacuees and provide them with food and drinks for one day, even in the worst case of lifeline disruption. This study proposes a method of designing shelter space, and demonstrates how non-homogeneous and noncontinuous spaces within shopping street buildings can be applied to prevent the spread of infection, through the classification of evacuee types and use of space and facilities designated for each type. The study further examines the liability issue of secondary infection at the shelter with reference to civic law and the roles of government in developing a distributed evacuation framework.

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Natural hazard, novel coronavirus, evacuation shelters, shopping streets, infection prevention measures, Kobe, Japan

1. Introduction

The novel coronavirus (hereafter COVID-19) has rapidly spread worldwide since the initial outbreak in China in December 2019. The World Health Organization (WHO) declared a pandemic on March 12, 2020, and presented the guiding principle of "Avoid the Three Cs" [1], indicating that COVID-19 spreads more easily in certain places: "crowded spaces with many people nearby," "close-contact settings especially where people have close-range conversations," and "confined and enclosed spaces with poor ventilation," and thus that built spaces should avoid these characteristics. As other slogans and catchphrases, such as "social distance," "stay home," and "new normal," infiltrated society, disaster management experts and authorities were faced with the urgent need to modify evacuation strategies, including expanding the shelter area required per person, from 3 m^2 to 6 m^2. This was followed by a heavy rainy season in Japan in 2020, during which designated evacuation shelters, such as school gymnasiums and community centers, could only accommodate 30−50 % of the evacuees they had before COVID-19 [2,3]. Accordingly, shelters could not admit almost half of the evacuees, many of whom had to stay overnight in their cars or other places that were not organized disaster shelters. This situation enhanced the Japanese government's awareness to the fact that the total area of available shelter space needed to be increased to provide safe havens for all potential evacuees. To address this issue, the national government recommended that local governments encourage their residents to carry out "distributed evacuation" [4,5], which is based on the principle that people should be asked to evacuate not only to designated evacuation shelters but also to other, undesignated shelters available in local communities or ad hoc for individual evacuees, such as hotels, welfare centers, homes of relatives or friends, and religious buildings. It was even indicated that staying at home was also an option, should it be safer than evacuating to another location [4,6−8].

Under the distributed evacuation policy, residents have a greater chance of securing temporary shelters; nonetheless, they may face other challenges, such as finding an appropriate shelter, managing such a shelter, and preparing emergency and relief supplies, by themselves or in cooperation with others. As for the management and operation of evacuation shelters during a pandemic, some international and domestic organizations have published guidelines for preventing the spread of COVID-19 in shelters [1,4], which share several basic strategies such as classifying evacuees based on health status and providing separate spaces and facilities based on those classifications (see Appendix A). Moreover, the Japanese government requested each designated evacuation shelter to arrange for the distribution of hygiene products, such as masks, alcohol-based hand sanitizers, and cleaning supplies (see Appendix B), and recommended that evacuees, especially those in undesignated

shelters, prepare and take such hygiene products to shelters themselves.

Regarding the problems of insufficient space in designated shelters and difficulties in providing disaster relief supplies to evacuees in undesignated shelters, the authors have proposed the idea of using buildings on a shopping street as undesignated evacuation shelters, and examined the potential to do so in the context of Japan and in particular the case-study area, Taisho-Suji shopping street in Kobe [9]. The study estimated accommodation capacity and available supply of food and drinks based on the available stockpiles of restaurants and grocery stores. It was concluded that the shopping street could provide shelter to approximately 2,300 persons, drinks for 1,700 person-days, and food for 1,200 person-days in the case of lifeline disruption, and for 2,800 person-days if substitute facilities are available. Despite the idea's novelty, the risk of the spread of infectious diseases was not considered in this estimation [9].

The purpose of the present study is to develop the idea of using shopping-street evacuation shelters during a pandemic such as COVID-19 from viewpoints of disaster management and planning. Concretely, this study aims to: (i) update the estimation of a shelter's capacity to accommodate evacuees and supply food and drink using the shopping street's inventory considering the risk of the COVID-19 spread; (ii) investigate the possibility of providing hygiene products from the inventory and the quantities required to accommodate all evacuees; (iii) present example spatial designs for shelters as well as operational processes; and, (iv) investigate implementation and governance issues, especially regarding liability related to secondary infection and government attitudes. While the first aim above can be achieved by applying the same method as was used in Kotani et al. [9], the other aims require completely new foci and discussions, where essential advantages of the shopping-street buildings are found.

While some studies focused on the availability of facilities and buildings with large spaces as temporary evacuation shelters [10-20], only a few studies have investigated commercial facilities [21-23] among which our previous study [9] is unique due to its focus on the use of shopping streets as evacuation shelters with stockpile warehouses where evacuees can receive food and drinks on site. In this study, we again target the same street in Nagata, Kobe, Japan, that we have investigated from various points of view [24-26].

Since before the COVID-19 outbreak, problems related to infectious diseases during a time of natural hazard-induced disaster (hereafter "natural disaster" or "disaster") have been studied mainly in the fields of medical science and public health [27-31]. Since the outbreak, considerable attention has been paid to issues in the management of natural-and-pandemic complex disasters [32,33]. Among various problems brought up, this study discusses evacuation shelter design [34,35] with consideration of vulnerable people [36], and argues that our idea of using shopping-street buildings as evacuation shelters has the further merit

of preventing virus spread, owing to these buildings' non-homogeneous spaces composed of multiple floors and partitioned subspaces.

The remainder of this paper is structured as follows: Section 2 explains the background, target area, and approach of the study; Section 3 provides the results of the case study; Section 4 discusses the applicability and implementability of the shelter plan; and, Section 5 summarizes the findings and discusses the potential of future studies.

2. Background, focus, and methods

2.1 Shelter space shortages before and after the COVID-19 pandemic

The shortage of designated evacuation shelters is not a problem that first emerged after the outbreak of COVID-19, but one that Japanese society had already faced prior to 2019. For example, when the Tohoku earthquake and tsunami occurred on March 11, 2011, an elementary school in Otsuchi, Iwate prefecture, served as a designated shelter expected to accommodate approximately 120 evacuees in the event of a disaster. However, immediately after the earthquake, over 1,000 people rushed to the shelter [37]. Consequently, some evacuees who could not enter the building had to stay in their cars instead. During the 2016 Kumamoto earthquake, 183,882 people evacuated to the designated evacuation shelter on the day after the main earthquake [38], a number much higher than the local government had expected. Prior to the earthquake, the city had set up designated shelters to accommodate 58,000 people [39], resulting in a shortage of shelter space during the emergency.

In May 2020, following the initial COVID-19 outbreak, the Japanese government issued new guidelines for evacuation shelter management [40] to prepare for potential floods in the coming rain and typhoon season as well as for potential earthquakes, which could occur at any time. These guidelines are intended to prevent COVID-19 from spreading in designated shelters during disasters by taking precautions such as allowing evacuees to maintain a social distance of 2 m. Consequently, shelters refused to accept evacuees in several prefectures. For example, during heavy rainfall in July 2020, more than 500 shelters in 116 municipalities in the Kyushu region and Yamaguchi prefecture rejected evacuees [41]. Based on this experience, when Typhoon No. 10 was approaching Japan in September 2020, each local government in Nagasaki prefecture, Kyushu region, added evacuation shelters, for 742 shelters in total. When the typhoon arrived, more than 50,000 people evacuated, far exceeding the 1,670 people who had evacuated during Typhoon No. 9 the previous month. However, only 18 % of the 742 shelters actually went into operation, with 82 % of them unable to be used due to disaster damage or lack of measures in place to protect against COVID-19. At least 133 shelters in 12 cities and towns reached their capacity limit [42].

2.2 Target area

In this study, we revisit the case study of the Taisho-Suji Shopping Street in the Nagata Ward of Kobe, Japan (Figure 1),[1] which was proposed for use as an undesignated evacuation shelter in Kotani et al. [9]. The shopping street was damaged by the 1995 Kobe earthquake (the Great Hanshin-Awaji Earthquake). Before the earthquake, this street had the typical features of downtown areas of the time, with its small space busy and crowded with people, goods for sale, and so on (Figure 2a). The shopping street suffered catastrophic damage during the earthquake, and a large fire that occurred immediately after the earthquake caused further extensive damage (Figure 2b); the narrow streets were densely packed with wooden houses, preventing fire engines from entering the area. Approximately two months after the disaster, to construct fire- and earthquake-proof buildings, Kobe proposed a recovery plan to redevelop an area south of the Japan Railway Shin-Nagata Station [43]. In this project, the street was transformed into a modern shopping arcade, with skyscrapers, high ceilings, and wide streets (Figure 2c). The buildings also have basements (Figure 3a) and several floors above ground. However, after the transfiguration effected by this redevelopment, the street's lively scene was drastically damaged; vacant stores increased, and visitors decreased. Then, with efforts such as those made by local companies and shop owners to organize new events and develop traditional festivals, the street has gradually been regaining visitors [25], although the number of vacant stores has not declined (Figure 3b) [9,43].

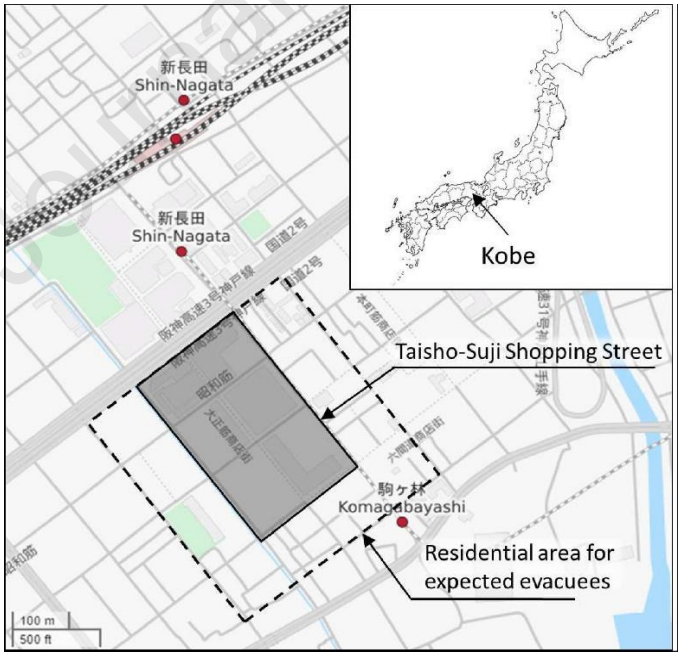
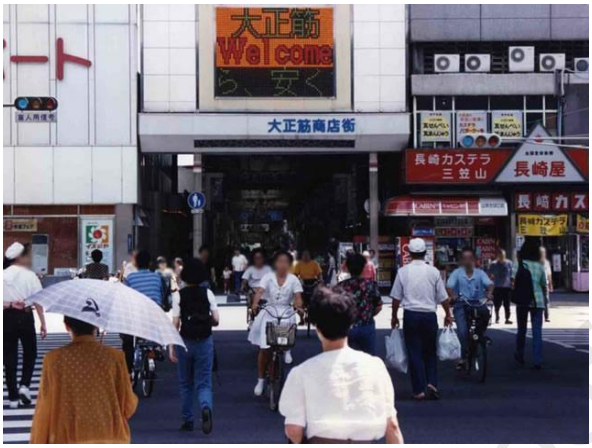


Figure 1. Target area and shopping street in the Nagata Ward, Kobe, Japan; the shaded

[1] We targeted the shops and restaurants in six buildings constructed as part of the recovery project. The Taisho-Suji Shopping Street does not include all the shops and restaurants in the buildings, but only those that belong to the Shopping Street Association. For simplicity, this study refers to all shops and restaurants in the relevant buildings as the "Taisho-Suji Shopping Street." Member shops of the association comprises approximately 60 % of those in the buildings. The association could be one of the factors of implementability; however, generally, which element plays a crucial role in driving community-based activity of disaster management varies from community to community.

area represents the Taisho-Suji Shopping Street; expected evacuees live in the area marked by the dashed line [9].

158



(a) The shopping street in 1994

(b) The shopping street damaged by the earthquake

(c) Reconstructed shopping street

(Source: http://shinsai-ar.kobe-shashinkan.jp/map_shinnagata_s.html)

Figure 2. Taisho-Suji Shopping Street before and after the 1995 Kobe earthquake and reconstruction.

159

160 Figure 1 illustrates the target area, consisting of the Taisho-Suji Shopping Street and a
161 residential area of 5,219 residents [44], some of whom would potentially evacuate to this
162 shopping-street shelter. As mentioned above, the buildings currently on the street are fire-
163 and earthquake-proof, the central passage is wide, and the arcade ceiling is high enough so
164 that fire engines can pass the street. Therefore, the buildings are suitable for use as
165 earthquake evacuation shelters. Further, this area is not subject to tsunamis or landslides,
166 and has been classified as inundation-free against floods on the scale of a one-hundred-year
167 return period. However, in 2020, updated flood simulation results indicated that the area
168 could be inundated by floodwaters of “less than 0.5 meters high” in the case of floods on the
169 scale of a one-thousand-year return period [45]. Since a flood’s scale is predictable to some
170 extent before it reaches an area, in the case of huge-scale events such as those of the one-
171 thousand-year return period, the floor plan is arranged so that the basement and first floor

are not used, while floors above the second floor will become more significant, owing to the scarcity of tall buildings that can serve as evacuation shelters in the district. Considering such needs for a flexible arrangement, in this study, we explore hazard scenarios except for a flood of one-thousand-year-return-period scale, meaning that we include the basement and first floor in shelter planning to ascertain the potential of the buildings to cover most disasters.

As previously mentioned, in Kotani et al. [9], we developed the idea of a shopping-street shelter plan and estimated its capacity not during a pandemic: results indicated that it could be used as an accommodation space for 2,300 evacuees, provide drinks for 1,700 person-days, and proper meals for 1,200 and 2,800 person-days in the case of power, gas, or water outages and in the case of an alternative lifeline being available, respectively.

2.3 Procedures

In this study, we focus on a case of a natural disaster that could occur during the COVID-19 pandemic. Quantitative examinations are performed to determine the following three matters:

1. Capacity to accommodate evacuees with safe physical distancing maintained and supply adequate food and drinks from the inventory;
2. Possibility of providing hygiene products from the inventory and the quantities required to cover accommodated evacuees;
3. Examples of typical designs to allocate evacuees to vacant spaces depending on their health status.

The procedures to demonstrate these aspects are described below.

2.3.1 Capacity to accommodate evacuees with safe physical distancing and supply food and drinks

Following the method proposed in Kotani et al. [9], we calculate the area (unit: m^2) of "available spaces" for evacuees (i.e., shared space [Figure 3a] and empty lots [Figure 3b]), which are used as shelter spaces in disasters in the shopping street. The building's floor plans and information on the empty lots as of 2020 are obtained from the management company. In the calculation of the total area of shared spaces, we exclude stairs, walls, and toilets, and only focus on spaces where people could lie down; in calculating that of empty lots, we assume that there is no furniture (e.g., shelving) there. Based on the area of available spaces, we estimate the number of evacuees that can be accommodated in the buildings. In this estimation, we assume that each evacuee would need 6 m^2 of space to avoid COVID-19 infection [33], instead of 3 m^2/person, as is often used in non-pandemic situations. We also illustrate what percentage of expected evacuees would be accommodated.

To estimate the quantities of food and drink supplied from the shopping street, we calculate the average quantity of inventory from restaurants and shops, following the method and inventory data in Kotani et al. [9]. The shops include convenience stores, supermarkets,

bakeries, and meat and fish shops. The calories (unit: kcal) and liter (unit: L) of supplied food and drink, respectively, are calculated. Based on the recommended daily intake of calories and water (2,000 kcal and 3 L per person for a day, respectively [9]), we estimate the number of person-days that could be supplied with available food and drinks. In this estimation, as the quantity of available food depends on the situation after the disaster, we consider the following two cases: (1) the case of power and water outage (hereafter "the case without utilities") and (2) the case of a substitute power and water supply (hereafter "the case with substitute utilities").

2.3.2 Possibility of providing hygiene products from the inventory and the quantities required to cover accommodated evacuees

The installation and use of hygiene products, as shown in Table A1(b), are important in evacuation shelters during a pandemic. Therefore, we examine the availability of these products from the shopping street's inventory. We visit stores that are likely to sell these products (e.g., supermarkets, convenience stores, and pharmacies) on the shopping street, check whether they exist in the inventory, and determine the possibility of their being supplied from the shopping street itself.

It is also recommended that citizens bring some hygiene products to the shelter themselves (Appendix B); however, citizens may not do so, and thus, it is important to stockpile essential hygiene supplies in shelters. We estimate the required quantities of four specific hygiene supplies, which almost everyone needs—(1) masks, (2) alcohol-based sanitizer, (3) plastic bags used for storing reusable materials, garbage etc. (i.e., "three types of polybags" in Table A1(b)), and (4) wet wipes (i.e., "alcohol wipes for cleaning" in Table A1(b))—to cover the number of evacuees accommodated in the shopping street. As a benchmark, we assume that each evacuee would wear one mask a day. Hand sanitizer requires at least 3 mL of liquid on each use [46]. We assume that a person would use hand sanitizer 10 times a day, and thus approximately 30 mL (3 mL X 10 times) would be used per person per day. We also assume that a person would use one plastic bag for trash (20 L) and one pack of wet wipes (50 sheets) a week. Evacuees would be expected to stay in the shopping street for one week.

In 2020, we could not estimate the average quantity of these hygiene products in the inventory of each shop because the inventory had changed dramatically. For example, the mask inventory decreased at the beginning of 2020, but later was overstocked, due to the increased use of reusable masks and production expansion. Future studies should calculate the exact numbers of hygiene products to be supplied from the shopping street; however, clarifying the necessary numbers will contribute to the discussion on measures to increase hygiene product stockpiles.

2.3.3 Example shelter space design and space allotment depending on evacuee health status

While Kotani et al. [9] only examined the total area of the available spaces to discuss accommodation capacity, in a non-pandemic situation, the current COVID-19 pandemic

necessitates the inclusion of another dimension—the geographical distribution of evacuees to prevent the spread of infection. We begin by discussing the spatial arrangement by obtaining floor maps of the building and information on the vacant stores and available common spaces. The number of available floors, rooms, toilets, taps with running water, stairs, and elevators is surveyed on the maps and clarified. Additionally, the necessary functions that should be provided in a shelter, such as reception areas and health check locations, are determined by referring to relevant articles and reports [47,48].

Potentially, there could be a large number of combinations for evacuee classification, the criteria for which could include COVID-19 infection status, contact with an infected individual, related symptoms, age, other underlying conditions, and support needs. The classification framework in the present study was designed to meet the necessary conditions for preventing the infection spread and supporting evacuees who need help for other reasons, while also considering the physical configuration of the building space. While several classification criteria have been proposed [9,48], in this study we formulate a meaningful framework to reflect needs and conditions at the site.

(a) Shared space in the basement (b) Vacant spaces

Figure 3. Available spaces for evacuation shelters in Taisho-Suji Shopping Street [9] .

3. Results

3.1 Capacity to accommodate evacuees with safe physical distancing and supply food and drinks

Based on the buildings' floor plans and information on the empty lots as of 2020,[2] we determine that the total area of the vacant spaces is 7,164 m^2. From the total area, we estimate that the shopping street could accommodate 1,194 evacuees (7,164 m^2 ÷ 6 m^2/person; Table 1). This is half of the 2,388 evacuees (7,164 m^2 ÷ 3 m^2/person) that could

[2] Three restaurants which opened in 2017, when the survey in Kotani et al. [9] was conducted, closed for business, and no new restaurants opened on their lots. Accordingly, the empty lots were increased compared with Kotani et al. [9].

be accommodated in a non-pandemic situation; however, the shopping street still has the capacity to accommodate 23 % (1,194 people ÷ 5,219 people) of the expected evacuees.

Table 1. Number of accommodatable evacuees and percentage among expected evacuees during pandemic and non-pandemic situations

	Pandemic	Non-pandemic
Number of evacuees to be accommodated	1,194	2,388
Percentage of evacuees to be accommodated among expected evacuees	23 %	46 %

As of 2020, 56 shops located in the shopping street are identified as being likely to be able to supply food and drinks.[3] Based on the inventory data and methods illustrated by Kotani et al. [9], we estimate the total calories (unit: kcal) of food and the total quantity (unit: L) of drinks supplied from the shops to be 2,404,820 kcal and 5,389,607 kcal of food in the case without utilities and with substitute utilities, respectively, and 4,816 L of drinks regardless of the utilities situation (the second row of Table 2). These supplies are equivalent to 1,202 and 2,695 person-days of food in the cases without utilities and with substitute utilities, respectively, and 1,605 person-days of drinks (the last row of Table 2). If we were to provide the available food and drinks to the number of evacuees who could be accommodated (i.e., 1,194 evacuees), these results indicate that we could provide meals on the first day of the disaster, even in the case without utilities. The remaining food and drinks—8 person-days (1,202 person-days – 1,194 evacuees) of food and 411 (1,605 person-days – 1,194 evacuees) of drink, could be distributed to people who stayed in their homes or were in neighboring shelters. If the food were cooked using power generators, gas cylinders, and well water, we would be able to cover two days' worth of meals for the evacuees accommodated on the shopping street.

Table 2. Estimated quantity of food and drinks supplied from the shopping street

	Food (kcal)		Drink (L)
	Case without utilities	Case with substitute utilities	
Total supply from 56 shops in 2020	2,404,820	5,389,607	4,816
Equivalent person-days	1,202	2,695	1,605

[3] In comparison with Kotani et al. [9], the following three changes were observed in the shops associated with the estimation: (1) as mentioned in the previous footnote, three restaurants which opened in 2017 closed for business and no new restaurants opened in their lots; (2) another restaurant that opened in 2017 closed, and then a company that did not sell food and drinks opened a business on the lot; and, (3) one fish shop that opened in 2017 was changed to a restaurant. We accounted for the above changes in the estimation.

293

294 **3.2 Possibility of providing hygiene products from the inventory and the quantities required**
295 **to cover accommodated evacuees**

296 We visited stores that were likely to sell hygiene products (i.e., two supermarkets, one
297 convenience store, one drug store, and one electronics retail store) and checked their
298 inventory. As shown in Table 3, we determine that most of the hygiene products, such as
299 masks, alcohol-based sanitizers, and thermometers, can be supplied from the shopping
300 street's inventory (In the table, ◎ denotes at least one store has the inventory; △ denotes
301 that the store visited do not stock them in their inventory.).

302 Following this, we estimate the required number of four specific hygiene supplies—(1) masks,
303 (2) alcohol-based sanitizer, (3) plastic bags, and (4) wet wipes—to cover a one-week stay for
304 evacuees accommodated in the shopping street (i.e., 1,194 evacuees), based on the
305 assumptions described in Section 2. It is found that 8,358 masks (1,194 people X 1 mask/day
306 X 7 days), 35,820 mL of hand sanitizer (1,194 people X 30 mL/1 day X 7 days), 1,194 plastic
307 bags, and 1,194 packs of wet wipes would be required (Table 4). These quantities of hygiene
308 products should be supplied from the shopping street's inventory and/or stockpiled as relief
309 supplies in the shopping street.

310 Table 3. Hygiene products likely to be supplied from the shopping street's inventory

Items	Possibility of being provided from the inventory
Masks	◎
Alcohol-based sanitizer	◎
Thermometers	◎
Non-contact thermometers	◎
Alcohol wipes for cleaning	◎
Disposable towels	◎
Paper towels	◎
Paper bags (for vomiting)	◎
Hand soap	◎
Household detergent for cleaning	◎
Sodium hypochlorite for sanitization	◎
Face shields	△
Raincoats	◎
Poly gloves	◎
Wraps	◎
Three types of polybags	◎
Zipper bags	◎

Multipurpose baskets	△
Spray containers	◎
Trash cans with foot pedals	△
Portable toilets	◎
Cardboard beds	△
Partition walls	△

311 ◎: Highly likely to be supplied △: less likely to be supplied

312

313 Table 4. Required hygiene products for evacuees to be accommodated in the shopping street

Items	The required quantity for a week stays
Masks	8,358 masks
Hand sanitizer	35,820 mL
Plastic bags	1,194 bags
Wet wipes	1,194 packs

314

315 **3.3 Example shelter space design and space allotment depending on evacuee health status**

316 **3.3.1 Classification of evacuees**

317 Here, we illustrate example designs for allocating evacuees to available spaces depending on
318 their health status. Assuming the shelter reception is set up outside the first floor of the
319 building, we classified evacuees into the following types according to their health status and
320 support needs:

321 ● Type I (infected) evacuees: People who have undergone a COVID-19 infection test before
322 the evacuation, have tested positive, and have neither yet fully recovered nor received a
323 negative test.

324 ● Type CS (close contact with infected others and symptomatic) evacuees: People who
325 came in close contact with an infected person. They have not been tested yet, but have
326 some symptoms related to COVID-19, such as a fever or cough.

327 ● Type C (close contact with infected others) evacuees: People who have been in close
328 contact with an infected person but are not showing symptoms.

329 ● Type S (symptomatic) evacuees: People who have neither made close contact with an
330 infected person nor have been diagnosed as positive for COVID-19, but have some related
331 symptoms.

332 ● Type H (healthy) evacuees: People who do not meet any of the criteria above.

333 In addition, some people are more vulnerable in disaster contexts due to physical causes

other than COVID-19 infection, such as other illnesses, injuries, disabilities, and old age; thus, they would have support needs. They are classified into the following types with the additional letter "V" (vulnerable): Type IV, Type CSV, Type CV, Type SV, and Type HV evacuees. Evacuees who are not vulnerable are classified as Type IN, Type CSN, Type CN, Type SN, and Type HN evacuees, with the letter "N" (not vulnerable) added.

The shelter space should be designed such that it meets three conditions. First, the entrance needs to include a space to conduct health checks and determine each evacuee's type. Second, spaces for occupancy should be completely divided between Type IV, IN, CSV, CSN, CV, CN, SV, and SN evacuees (Group I-CS-C-S) and Type HV and HN evacuees (Group H). Accordingly, the spaces where each evacuee group stays should be divided, either on separate floors or in rooms separated by walls. Shared facilities, such as toilets and the water supply, should also be divided, as should the traffic (flow) lines for accessing them. If possible, Group I-CS-C-S should be further divided, with Type IV and IN evacuees (Group I) and Type CSV, CSN, CV, CN, SV, and SN evacuees (Group CS-C-S) in separate spaces. The queue for toilets and the water supply can get congested at certain times of the day. In order to keep distance between two individuals in a queue, tapes can be put on the floors to indicate where users should be standing. Third, regarding the traffic line design, vulnerable people should be given priority in elevator use. If there is more than one elevator, they should be separately allotted to Group I, Group CS-C-S, and Group H, to reduce their possible contact. If there is only one elevator, it should be arranged so that the space for one group—for example, Group H—is set up on the first floor, or hygiene practices, such as disinfecting one's hands before and after touching the elevator buttons, should be more strictly requested.

Figure 4 shows an example shelter space design that satisfies the above three conditions, targeting the basement, first floor, and second floor of Building No. 5 on the shopping street, which has relatively large available spaces. Almost all the empty lots in the available spaces have air conditioning facilities; therefore, air circulation is significantly ensured in each lot. In the figure, the red areas indicate available spaces, blue areas indicate stairs, yellow areas indicate elevators, and green areas indicate facilities such as toilets and the water supply. The gray areas indicate unavailable spaces, which are occupied by stores and used for purposes other than disasters, and are therefore not expected to be used as shelter spaces during a disaster.

3.3.2 Procedures to classify evacuees at reception

Figure 5 illustrates the detailed procedures for classifying evacuees who come to the building. At the reception, evacuees who are already known to be infected with COVID-19 are sent to "the desk for evacuees with a confirmed infection" and classified as Type I. After checking their support, evacuees would be identified as either Type IV or Type IN.

Evacuees who have been in close contact with people infected with COVID-19 would be sent to "the desk for evacuees with close contact with the infected" and categorized as Type CS if they report symptoms during their health status check, and Type C otherwise. Next, depending on their support needs, Type CS evacuees would be categorized as either Type CSV

or Type CSN. The same procedure would be applied to Type C evacuees, who would then be classified as either Type CV or Type CN.

Evacuees who have neither tested positive for COVID-19 nor made close contact with people infected with COVID-19, but perceive some related symptoms, would be sent to "the desk for evacuees with noticeable symptoms" and categorized as Type S. Then, their support needs would be checked, and they would be classified as either Type SV or Type SN.

Evacuees who do not fit any of the above categories would be sent to the "desk for evacuees without noticeable symptoms." If some symptoms are detected in the health status check, those evacuees would be categorized as Type S; otherwise, they would be categorized as Type H. Type H evacuees would then be classified as either Type HV or Type HN, depending on their support needs.

3.3.3 Space and traffic lines for each evacuee type

After evacuees are classified as one of the above types, they would be requested to follow a specific traffic line to access a specific space (Figure 4). The details of the assigned available spaces on each floor and traffic lines with access to the spaces for each type are shown below.

Basement (Figure 4a)

To reduce their contact with other evacuee groups as much as possible, we decided that only Group I would use the basement. Group I would follow the purple route to go to the basement, using only *Gate 1* to avoid contact with other groups. Type IV evacuees would be prioritized to use *Elevator 1* (E1) to move to the basement. They would be allocated to one of the partitioned *Available Spaces 1*, *2*, and *3* (AS-B1, 2, and 3), which can accommodate six, two, and seven people, respectively. Type IN evacuees would be asked to use *Stairs 1* (S1) to reach *Available Space 4* (AS-B4), which can accommodate 264 people. *Toilet BF1* (T-BF1) would be used by Group I only.

In this example, we expect that the stay of Group I would be short, since they should be moved to other appropriate facilities as soon as possible to receive medical treatment. Thus, we allocated Group I to the basement, where they cannot see the outside and are likely to get stressed to some degree. Thus, if significant space is available on the upper floors and Group I could be kept separate from the other groups, it would be desirable to allocate them there.

First floor (Figure 4b)

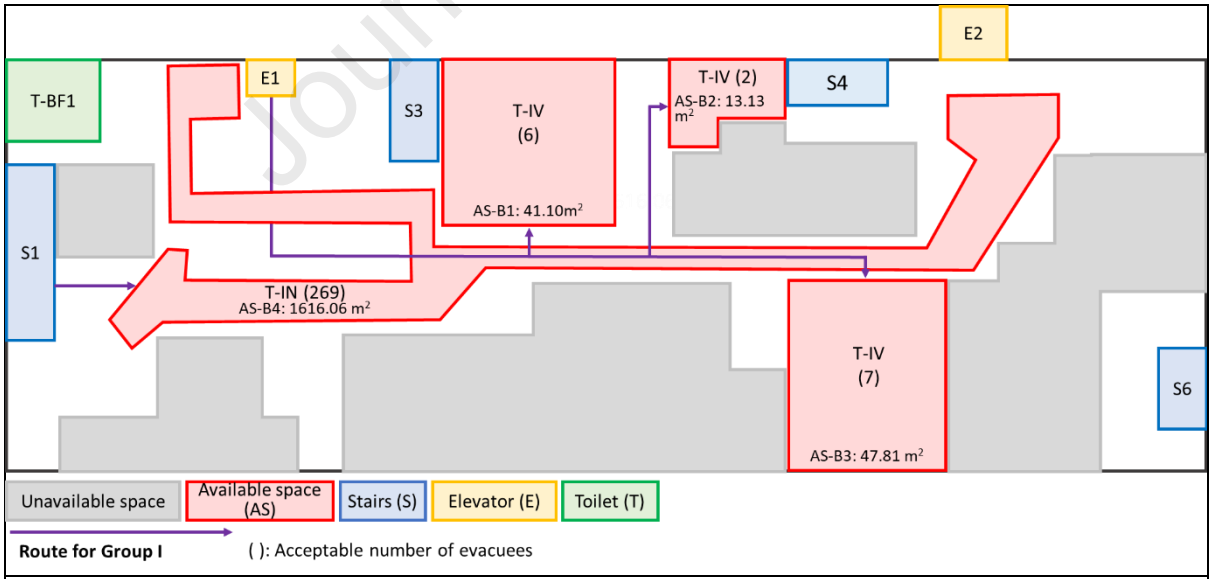
The first floor would only be used by Group H. They would exclusively use *Gate 2* to avoid contact with other groups and would follow the green route to available spaces on the first floor. Type HV evacuees would be accommodated in *Available Spaces 1* (AS-1F1) and *2* (AS-1F2), which are partitioned and can accommodate one and two people, respectively. Type HN evacuees would be allotted *Available Spaces 3* (AS-1F3) to *5* (AS-1F5) near the entrance, which can accommodate 216 people. *Toilet 1F1* (T-1F1) would be used only by Group H. *Available Space 6* (AS-1F6) could be used for hygiene product storage.

Second floor (Figure 4c)

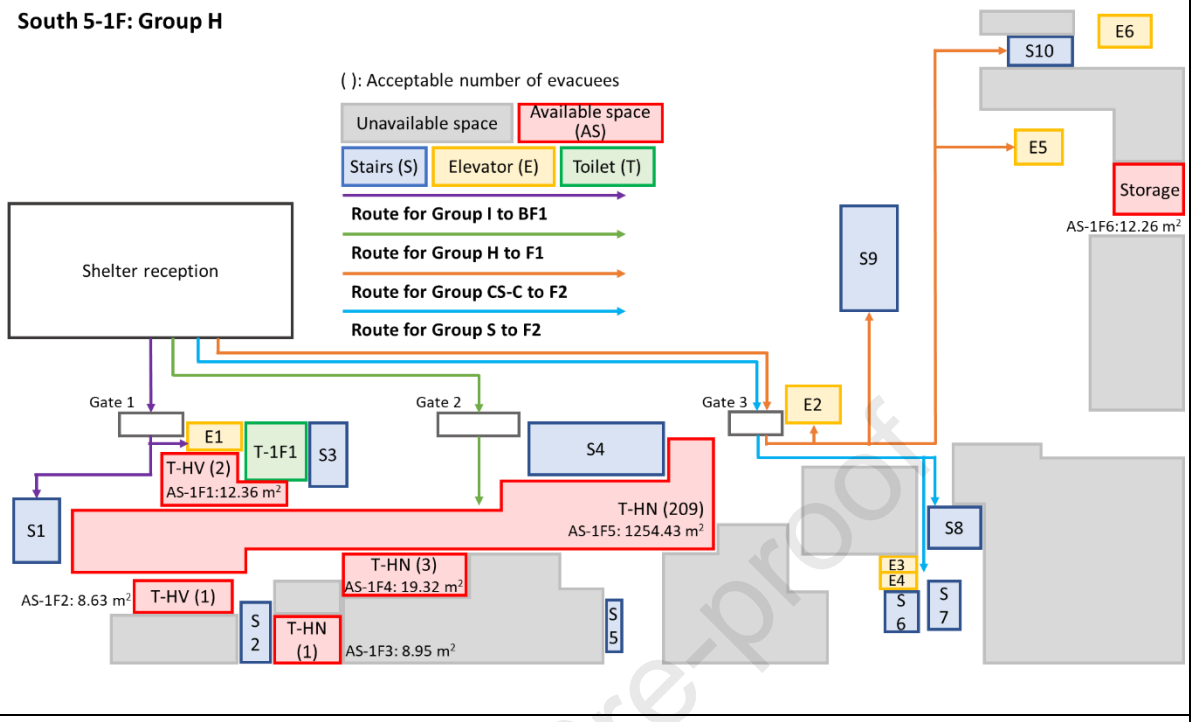
The second floor would be occupied only by Group CS-C-S. This floor has eight independent rooms, which is advantageous for allotting different separated available spaces to each Type of evacuees in Group CS-C-S. *Gate 3* is to be used exclusively by this group.

Type CSV, CSN, CV, and CN evacuees (Group CS-C) would follow the orange route to the second floor. Type CSV and CSN evacuees (Group CS) would use *Elevator 2* (E2) and move to *Available Space 4* (AS-2F4), which can accommodate four people. Type CSN evacuees would use *Stairs 9* (S9) and be assigned *Available Spaces 1* (AS-2F1) and *3* (AS-2F3), which can each accommodate two people. Similarly, out of Type CV, CN evacuees (Group C), Type CV evacuees are to use *Elevator 5* (E5) and be assigned *Available Space 5* (AS-2F5), which can accommodate three people. Type CN evacuees would use *Stairs 10* (S10) and be assigned *Available Space 2* (AS-2F2), which can accommodate 29 people. Only Group CS-C would use *Toilet 2F1* (T-2F1).

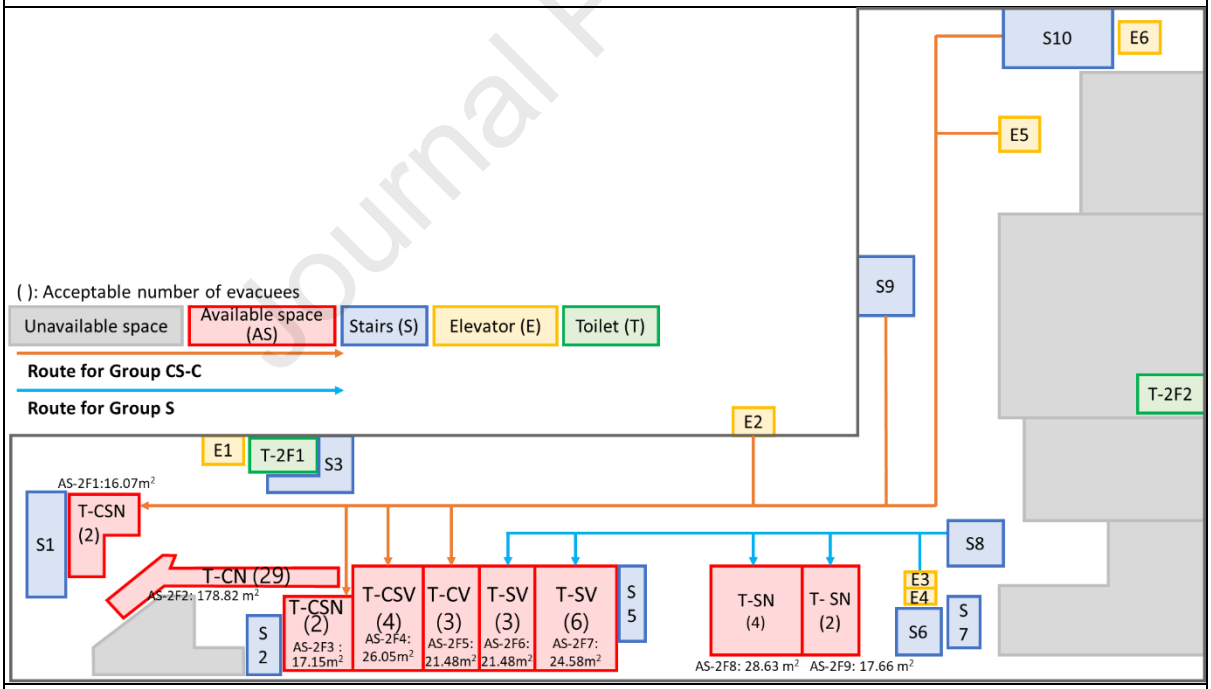
Type SV, SN evacuees (Group S) would follow the blue route to the second floor. Type SV evacuees would take *Elevators 3 and 4* (E3 and E4) to the second floor and be allotted *Available Spaces 6* (AS-2F6) and *7* (AS-2F7), which can accommodate three and six people, respectively. Type SN evacuees would use *Stairs 6–8* and be assigned *Available Spaces 8* (AS-2F8) and *9* (AS-2F9), which can accommodate four and two people, respectively. *Toilet 2F2* (T-2F2) should only be used by Group S. The traffic lines to *Toilet 2F2* (T-2F2) for Group S, and to *Toilet 2F1* (T-2F1) for Group CS-C, should be separated as much as possible.



(a) Basement: Group I (Type IV, IN)



(b) First floor: Group H (Type HV, HN)



(c) Second floor: for Group CS-C (Type CSV, CSN, CV, CN) and Group S (Type SV, SN)

Figure 4. An example shelter plan design of a building in the shopping street.

433

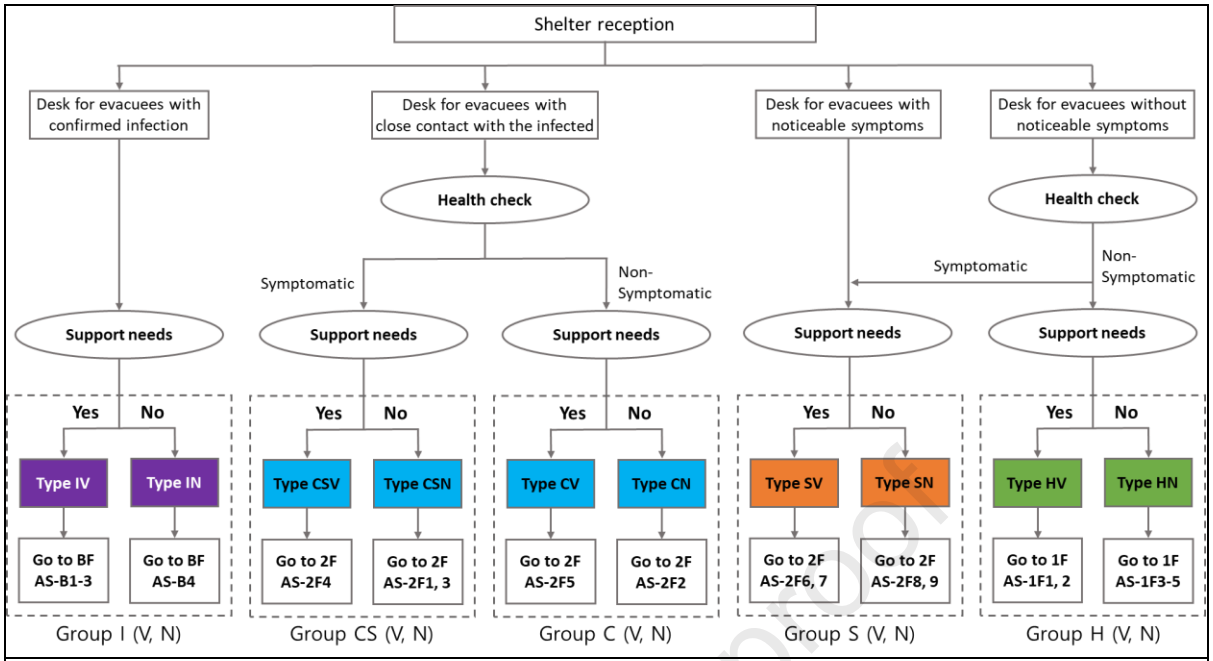


Figure 5. Evacuee allocation process.

4. Discussion

4.1 Non-homogeneity of space and shelter design flexibility

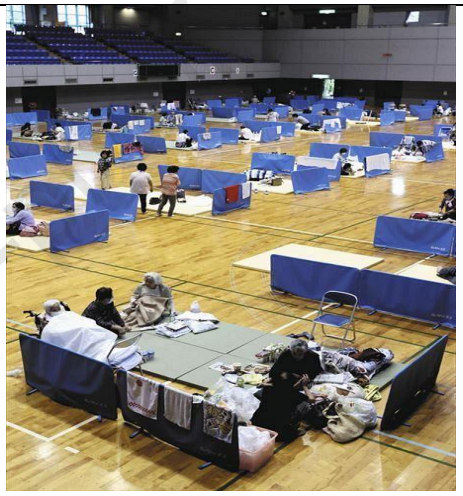
According to a survey conducted by the Small and Medium Enterprise Agency (SMEA), there are 14,035 shopping streets in Japan that contribute to local commerce. However, with an increase in big shopping malls that have larger commercial spheres, the commercial scale of local shopping streets has declined; vacant shops have increased annually from 7.31 % in 2013 to 13.77 % in 2018 [49]. While the revitalization of local shopping streets has attracted attention, this trend is expected to remain in a substantial percentage of local economies. Our concept of the shopping street evacuation shelter plan is associated with a basic motivation to reactivate local shopping streets through disaster management activities by using such vacant spaces.

In Kotani et al. [9], we identified the potential of targeted shopping street buildings, with their fire- and earthquake-proof properties, availability of vacant and common spaces, and food and drink inventories. During the COVID-19 pandemic, the buildings offer additional merits, such as multiple floors, separate rooms, toilets, and stairs, users of which can be separated based on the infection status. The buildings' non-homogeneous, separated spaces work to prevent the virus from spreading and consequently allow the evacuees to feel secure. Such advantages are more obvious when comparing these buildings with school gymnasiums, which have been the most conventional and common designated evacuation shelters in Japan, as shown in Figure 6. Maintaining distance between individuals or families with partitions was introduced after the COVID-19 outbreak, although their spaces are connected, and most gymnasiums usually have only one lavatory for each male and female user. People could

become less optimistic about evacuation if they feel that they might share space and facilities with people infected with COVID-19, which could result in them staying in a hazardous environment during a disaster. However, Building No. 5, which was examined in Subsection 3.3, accommodates 555 of 1,194 evacuees. It has 18 separated rooms and spaces in total (4 in the basement, 5 on the first floor, 9 on the second floor), and their sizes vary. While the biggest space accommodates 269 evacuees, there are 13 rooms with a capacity of less than 5 people. These small rooms are quite useful for quarantine in cases where there is a comparatively small number of Type IV, IN and Type CSV, CSN evacuees.

(Source: Tokyo Shimbun; November 26, 2019, https://www.tokyo-np.co.jp/article/9614)

(a) Chofu, Tokyo, at the time of Typhoon No. 19 in October 2019



(Source: Tokyo Shimbun; July 7, 2020, https://www.tokyo-np.co.jp/article/40608)

(b) Hitoyoshi, Kumamoto, during heavy rainfall in July 2020

Figure 6. Typical designated evacuation shelters before and after the COVID-19 outbreak.

It should be emphasized that space allotment is flexible according to the breakdown of the population by the state of infectiousness. In the previous section, we placed Group I in the basement, Group H on the first floor, and Group CS-C-S on the second floor. Nonetheless, we can also conceive of a case in which there are no Type IV or IN evacuees at the shelter because they have already moved to hospitals due to their symptom severity. In such a case, Type CSV and CSN evacuees with severe symptoms would be given the basement spaces with the expectation of moving to a hospital as and when the situation allows. However, if hospitals are busy and they need to spend several days in the shelter, they may find a small room on the second floor to be more comfortable, as the sky would be visible. Another possible arrangement would be one in which a small room on the second floor is allotted to one family that includes Type CSV and CSN members with severe symptoms.

With some expectations on the proportions of the types based on the current state of infection in society, the shelter can prepare for multiple situations to adapt to different

circumstances in advance. Thus, the shopping street shelter plan contributes to society by increasing not only the total space for accommodating evacuees but also the number of isolated rooms and the flexibility of spatial arrangement.

4.2 Responsibility for the spread of infection in the shelter

In Section 3.3, we described a shelter-space design method in which Group I-CS-C-S and Group H are kept separate, with the aim of preventing the spread of infection among residents. Moreover, unlike shelters with continuous large spaces such as school gymnasiums, which are commonly used as designated shelters, the shopping street's arcade buildings have high potential and enable a shelter design that incorporates the need for group divisions.

Nevertheless, there is a possibility that the infection could spread in shopping-street shelters if evacuees who should be identified as Type IV, IN, CSV, CSN, CV, CN, SV, or SN evacuees are miscategorized as Type HV or HN. Further, if responsibility for the spread of infection in evacuation centers could be attributed to the shelter manager, that possibility would be a major obstacle to implementing this plan. Since this would be a non-designated shelter, the plan would be implemented within the framework of community-based activities. The "shelter manager" or "operator" is a committee of community members, possibly including managers of the arcade buildings and shopkeepers from the shopping street. If the committee is afraid of being sued after the spread of the infection, they are likely to discontinue the plan. In this subsection, we will consider the issue of responsibility of the committee, that is, the shelter manager.

Cases in which a COVID-19 carrier transfers the virus to a non-carrier are classified into the following three types:

Case A: A case in which a Type IV, IN, CSV, CSN, CV, CN, SV or SN evacuee makes a false declaration and is settled in a space meant for a Type HV or HN evacuee.

Case B: A case in which an evacuee does not follow the rules of the designated traffic lines and communal facilities.

Case C: A case in which an evacuee who was identified as a Type HV or HN evacuee by not having symptoms related to COVID-19 is actually a virus carrier.

There are no measures the shelter manager can take against Cases A and Case B. Accordingly, the shelter manager is not liable for secondary infections caused by either case.

Likewise, even with Case C, there is no problem with the manager classifying such an evacuee as Type HV or HN at reception, as the evacuee was asymptomatic at the time. In addition, if symptoms such as fever appear later, and the manager moves and isolates the evacuee promptly and not unattended, even if secondary infection occurs, the manager will not be liable under the Civil Code of Japan. Article 698 (emergency administrative management) states, "If a Manager engages in the Management of Business in order to allow a principal to

escape imminent danger to the principal's person, reputation or property, the Manager shall not be liable to compensate for damages resulting from the same unless he/she has acted in bad faith or with gross negligence" [50]. Thus, providing shelter to protect community members from the risk of death or injury in the event of a disaster is an act of rescue from urgent harm, namely, an act of first aid, and is considered to fall under the category of "emergency administrative management" [51]. Therefore, managers will not be held civilly liable unless they have caused damage to another person due to malicious intent or gross negligence. Hence, as previously mentioned, as long as the manager checks the health status of the evacuees and takes appropriate measures, such as the settlement and traffic divisions, which consider the buildings' structural constraints, even if secondary infection occurs, a lawsuit could not be filed and the manager would not be held liable.

Article 698 (emergency administrative management) of the Civil Code is considered to be a provision for reducing liability with the intent to encourage people to provide first aid in an emergency [52]. Therefore, its content is considered to support the practice of this shelter plan. As such, potential managers should avoid hesitating to open non-designated shelters due to concerns over possible liability. In Japan, based on the fact that Article 698 of the Civil Code supports the opening of evacuation shelters, this provision should be understood and shared by all community members when they are formulating their local disaster management plans.

4.3 Required government attitude and response

As previously stated, there has been a shortage of available evacuation shelters during a large-scale disaster, even without an ongoing pandemic, and non-designated evacuation shelter use is increasing. If the required area per evacuee is doubled during a pandemic, then the capacity of designated evacuation centers will be further reduced. Central and local governments have already recommended distributed evacuation, and the need for non-designated evacuation centers is increasing. Therefore, non-designated evacuation centers that are community-operated and have the above-mentioned capacity, such as the shopping street evacuation shelter described in this study, can assist government-operated designated shelters by reducing their population density.

In addition, shopping street shelters would also be valuable in that they would be pre-planned by the community. Conventionally, most undesignated shelters have been cars in parking areas for overnight stays or relatives' homes, where it is difficult for local governments to estimate in advance the number of evacuees who will use non-designated evacuation shelters. Furthermore, presumably some evacuees who ultimately stayed in their cars were refused entry to a designated shelter because it had reached its capacity for accommodating evacuees. In that case, in addition to the time loss and stress that evacuees experience during the evacuation process, the population density of the designated shelter's reception space will temporarily increase amid such confusion. In that respect, the shopping street shelter, whose

554 plan is shared by the community and government in advance, is superior to designated
555 shelters.

556 It is possible, however, that community residents, including those operating evacuation
557 shelters, will not be able to dispel a certain level of anxiety until it is demonstrated several
558 times that the shopping street non-designated evacuation shelter can actually perform well.
559 It is also likely that there will be differences in enthusiasm for the implementation of the plan
560 among shopkeepers who are responsible for providing food and drinks. Given such a situation,
561 even if it is positioned as an "undesignated evacuation shelter," it can benefit the local
562 community; thus, the local government should publicly express support for such a plan or
563 take action to guarantee the plan's validity. This will greatly increase the local population's
564 confidence in and motivation to use non-designated shelters.

565 Moreover, local governments must be motivated to provide disaster relief supplies to the
566 shopping street shelter in advance. Having these disaster relief supplies stored in the empty
567 spaces of shopping street buildings would also benefit the government. Such supplies would
568 include ones that do not normally exist as commodities in the shopping district, such as
569 blankets, partitions, and non-contact thermometers, and would also address a shortfall of
570 masks during a disaster. Without shopping street shelters, such supplies would only be
571 located and used in designated shelters and kept under administrative control. Relocating
572 them to shopping street buildings in advance will strengthen the policy of distributed
573 evacuation. Section 4.1 showed that 1,194 evacuees could be accommodated in the shopping
574 street shelter, and Section 4.3 indicated that 1,194 masks, plastic bags, and wet wipes, and
575 35,820 mL of hand sanitizer, were the required hygiene supplies. These findings could provide
576 useful information for local governments when determining the size of stockpiles to be stored
577 in shopping street buildings.

578 Furthermore, the government is required to play an important role in obtaining an estimate
579 of the proportion of Type IV and IN evacuees—that is, those infected with COVID-19—among
580 all the shelter evacuees. First, the government needs to create an environment in which Type
581 CSV, CSN, CV, CN, SV, and SN individuals can quickly undergo PCR tests when there has been
582 no disaster. As a result, the number of residents of these types will decrease, and some will
583 become Type IV, IN. Severely ill patients among them would be hospitalized. To ensure this
584 process, hospitals need to be equipped with a sufficient number of beds. Then, what is
585 important as a disaster prevention policy is to encourage those who are asymptomatic or
586 have mild symptoms to be isolated in hotels and facilities with sufficient disaster safety
587 protocols. Thus, it is necessary to secure a sufficient number of isolation facilities for that
588 purpose.

589 Such measures eliminate the need for Type IV and IN residents to move to evacuation shelters
590 in the event of a disaster. In other words, those infected with COVID-19 who come to
591 evacuation shelters in the event of a disaster consist of coronavirus carriers who have not

592 undergone the PCR test and infected persons who are quarantined at home. By reducing the
593 number of such individuals in advance, the risk of spreading the infection in disaster shelters
594 is greatly reduced. The reduced risk then mitigates the anxiety of healthy residents heading
595 to shelters and encourages their active evacuation behavior. This point holds regardless of
596 whether it is the shopping street evacuation shelter or a designated evacuation shelter.
597 Governments need to implement a set of integrated multiple risk policies against COVID-19
598 and natural disasters, which are consistent with each other and cover a region or society as a
599 whole.

600 If an evacuation shelter rejects Type IV, IN, CSV, CSN, CV and CN evacuees or Type SV and SN
601 evacuees with severe symptoms who fled to the shelter, it could lead to a human rights
602 violation. To prevent such matters, it is necessary to comprehensively discuss in non-
603 emergency situations what kind of restraint should be applied legally.

604 If Type IV, IN, CSV, CSN, CV, CN, or severe Type SV or SN evacuees arrive at shelters despite
605 such proactive steps taken beforehand, they need to be transferred to a medical institution
606 as quickly as possible. In this respect, equivalent measures must be taken between designated
607 and non-designated evacuation centers. It is important for the government to take a uniform
608 approach toward isolation within evacuation shelters and in the process of moving evacuees
609 to medical institutions, assuming that many evacuation shelters do not have medical
610 professionals available. Furthermore, in 2020, the Japanese government published a manual
611 for operating shelters during the COVID-19 pandemic. This manual also points out the
612 importance of providing training to increase the number of individuals available to participate
613 in public health activities at evacuation shelters.

614 In this study, we have investigated the case of a shopping street in the Nagata Ward of Kobe,
615 Japan. In addition to using data from this area to calculate the available area for evacuation
616 and available quantity of food and drinks, the previous subsection developed a consideration
617 in accordance with the Civil Code of Japan. In this way, the topic was thoroughly explored in
618 line with the peculiarities and specificities of the targeted district. The results obtained from
619 such research procedures will raise questions regarding the finding's generalizability and their
620 applicability to other countries and regions. Some of the answers to such questions have
621 already been provided in our previous study, Kotani et al. [9], which pointed out that shopping
622 streets in many countries and regions have the potential to become "shelters with food
623 stocks,"; shopkeepers often play a central role in the community's resident network and
624 possess the foundations to become members of a shelter management group. However,
625 environmental conditions, such as the location of a shopping street and the size and strength
626 of the buildings, vary depending on the location. Additionally, laws, institutions, and norms
627 regarding the concept of emergency administrative management and its liability—that is, the
628 issue of liability for secondary infections of infectious diseases, which were dealt with in this
629 study—vary by country. In that regard, it is beyond the scope of this study to offer an
630 international institutional comparison. Nonetheless, the "generality" of this study, in terms

of its contribution to research and practice regarding the utilization of shopping street shelters in other countries is characterized by another dimension that is one level more general. This study presented viewpoints, checkpoints, methods, and thought processes when creating and characterizing evacuation shelters. Confirming the spirit implied by the laws of each society is one of them. Including the above, a way that this study considers the relationship between the individuality and generality of the research findings is in line with many area studies.

5. Conclusions

In consideration of the increasing occurrence of large-scale disasters, the shortage of designated evacuation shelters that had already been observed, and the seismic-resistant buildings in shopping districts, we proposed in Kotani et al. [9] that shopping street buildings be utilized as disaster evacuation shelters that are perpetually stocked with food and drinks as commodities and inventory. This time, after the outbreak of COVID-19 and after emergent responses began to be provided for the purpose of preventing the spread of infection in 2020, we quickly updated our idea of a shopping street evacuation shelter with conviction that this type of shelter has enhanced comparative superiority against other, more typical shelters during a pandemic.

Using the latest data from the Taisho-Suji Shopping Street in Kobe, Japan, we estimated the capacity of the shopping street shelter; it can accommodate 2,388 evacuees under the non-pandemic condition, and 1,194 evacuees—which is equivalent to 23 % of the local population—under the pandemic condition, where 6 m^2 of space is required for one person to maintain enough distance from others. Moreover, we updated our estimation of supplies, finding that the shopping street shelter could provide food for 1,202 person-days in the case of lifeline disruption, for 2,695 person-days in the case of substitute utilities being available, and drinks for 1,605 person-days. Additionally, we provided a list of necessary hygiene supplies and the quantities required for 1,194 evacuees to stay in a shelter for a week.

The novelty of this study exists in how non-homogeneous and separate spaces in the buildings are applied to prevent the spread of infection. Evacuees, who are classified by properties such as being infected, having had close contact with infected individuals, being symptomatic, or being vulnerable for reasons other than COVID-19 are separated, so that they do not share space, toilets, or traffic lines. We exemplified the shopping street shelter design, demonstrated its flexibility, and verified its physical competency. In addition, we investigated the liability issue of secondary infection at a shelter and clarified that the Civic Law of Japan supports community implementation of a shelter plan. Furthermore, we discussed the role of the government, such as providing more convenient PCR test and increased beds in hospitals and quarantine facilities, which can better promote its policy of distributed evacuation by taking several actions in support of community-based shelter management.

While it is urged amid the ongoing pandemic, as of March 2021, that the shelter plan moves to the practice stage, important issues to be addressed in future research remain. The advantages and disadvantages of the arcade buildings of the targeted shopping street against other big shopping malls should be examined. Their differences will include implementability, where the local and small areas covered by the shopping street at the community scale may manifest some strengths. For example, people can access it on foot and, moreover, evacuees may be able to share some feelings of solidarity and concerns about the damage to their residences based on the fact that they all live in the same district. Other topics that should be addressed include: (1) the estimation of opportunity costs incurred by shop owners and examination of their compensation needs[4]; (2) surveys on local people's perceptions of infection risk and the use of undesignated shelters as alternatives to designated shelters that may be dependent on demography of the community[5]; (3) simulations on the organizational process of the working staff team and logistics considering the decreased mobility among volunteers due to the pandemic; and, (4) comparative evaluations of the safety of the shopping street shelter against all kinds of possible risks versus the safety of designated shelters.

Acknowledgements

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[4] A survey conducted in the previous research, Kotani et al. [9], demonstrated that 35 % of the shops and restaurants were willing to provide items in their inventories for free, 13 % were willing to provide for a fee, 13 % were willing to provide conditionally, and 39 % were not sure whether to provide. The result indicates the potential of the corporation in question. Another interesting fact is that during the failure of the water supply system after the Great Hanshin-Awaji Earthquake in 1995, a market located near the targeted street supplied its well water to residents, and some of those residents began to shop in this market eventually. Expectations of a long-term relationship may mitigate the difficulty of the compensation issue. Nonetheless, it is important to quantitatively examine the conditions under which an adequate number of shop owners agree to the plan.

[5] Until August 2021, the level of people's perceptions on infection of COVID-19, especially the one that is consistent with their behaviors, has moved in waves in Japanese society. Meanwhile, there are several factors regarding the use of the targeted shopping-street buildings that could make local people accept the plan naturally. These are as follows: 1) the local context that the buildings were reconstructed after the Great Hanshin-Awaji Earthquake along with the recovery of their community; 2) one of the shopping-street buildings includes the disaster prevention center that stores equipment and materials necessary in an emergency; and, 3) generally speaking, it has been pointed out that people want to evacuate to familiar places when an emergency arises. For example, it was found that Muslim people in a certain city in Japan tended to want to evacuate to a mosque that they visited in their daily lives [20]. Nonetheless, surveys conducted from various viewpoints are necessary.

Appendix

A. Examples of guidelines on evacuation shelter management under COVID-19

Several international and governmental organizations published guidelines in 2020 regarding shelter management. WHO [1] suggests that evacuees maintain a physical distance of at least 1 m, use partitions, and be separated by household groups. Depending on their health status, evacuees would be classified into three groups: (i) evacuees without COVID-19 symptoms, (ii) evacuees with COVID-19 symptoms, and (iii) evacuees confirmed to have COVID-19. In addition, vulnerable people and high-risk groups should be separated from other groups and given their own space. Each group is not allowed to interact with other groups. Further, evacuees must use their specific assigned route in evacuation shelters. The groups should also use separate public facilities, such as toilets, water supply, and waste management. Environmentally, evacuation shelters should be frequently cleaned and ventilated to reduce the spread of infection. Since it is difficult to avoid the "Three Cs" (i.e., closed spaces, crowded spaces, close-contact settings) in evacuation shelters, evacuees and staff should use personal protective equipment (PPE), such as masks and hygiene supplies.

The guidelines of the Japanese government and an organization [47,48] also indicate that people should avoid the "Three Cs" by maintaining 1−2 meters of physical distance among families in evacuation shelters. At the entrance of a shelter, operators should check evacuees' health status and classify them into (i) infected evacuees, (ii) close contact with the infected, (iii) evacuees who have symptoms, and (iv) general evacuees, including determining who is vulnerable and in need of support. The concepts of separation of the settlement areas, public facilities, and traffic lines, and of cleaning and ventilation, are almost the same as those suggested by WHO [1]. It is emphasized that alcohol-based sanitizers should be located in public spaces, such as at reception, the entrances to each room/staircase/toilet, restaurants, and around places for trash. In addition, each evacuation shelter should prepare approximately 25 hygiene items for evacuees (Table A1(b)). All evacuees and staff should also use PPE, such as masks, face shields, and alcohol-based sanitizers.

B. Necessary relief supplies during a disaster and pandemic

Table A1(a) shows the authors' previously developed list of essential disaster relief supplies [53]; however, this list lacks hygiene supplies for preventing disease transmission. In September 2020, to prepare for natural disasters during COVID-19, the Japanese government published a list of necessary emergency hygiene supplies that evacuation shelters are expected to keep on hand, as shown in Table A1(b) [54]. Nevertheless, the government also recognized that it is not easy for these supplies to be kept sufficiently stocked in shelters, and thus requested citizens take some of their own simple hygiene supplies, such as masks, alcohol-based sanitizer, and wet wipes when evacuating to shelters. Accordingly, it is implied that if a certain percentage of evacuees prepare themselves, the needs of other evacuees

may be covered by the supplies stocked at the shelter. However, this would not be the case for undesignated shelters. Evacuees who use undesignated shelters have to assume that, in most cases, they need to procure both basic relief supplies and hygiene supplies.

Table A1. Basic relief supplies (a) and necessary hygiene supplies during a pandemic (b)

(a) Basic relief supplies [53]
Water
Food
Powdered milk and nursing bottles for babies
Blankets
Heating pads
Sanitary goods
Diapers
Toilet paper
Toilet bags
Bags for toilet bags
Portable toilets
Partition walls

(b) Necessary hygiene supplies during a pandemic [54]
Masks
Alcohol-based hand sanitizers
Thermometers
Non-contact thermometers
Alcohol wipes for cleaning
Disposal towels
Paper towels
Paper bags (for vomiting)
Hand soap
Household detergent for cleaning
Sodium hypochlorite for sanitization
Face shields
Raincoats
Poly gloves

Wraps

Three types of polybags

Zipper bags

Multipurpose baskets

Spray containers

Trash cans with foot pedals

Portable toilets

Cardboard beds

Partition walls

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Designing the Building Space of a Shopping Street to Use as a Disaster Evacuation Shelter During the COVID-19 Pandemic: A Case Study in Kobe, Japan

Highlights:

- This study considers a plan of disaster evacuation during a pandemic.
- The idea of utilizing shopping-street buildings as a temporary shelter is extended.
- A shopping-street shelter in Kobe, Japan, can accommodate 1,194 evacuees.
- A method of designing shelter space is shown with the classification of evacuees.
- The liability issue of secondary infection at the shelter is examined.

Declaration of interests

☒ 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.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: