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A Study on Mega-Shelter Layout Planning Based on User Behavior

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Abstract: We explore the spatial layouts of mega-shelters and suggest better spatial planning strategies. A mega-shelter for refugees contains multiple functions, such as dormitory, dining, medical, kitchen, storage, and community areas. Post-disaster refugees often suffer from PTSD that affects their mental health and spatial cognitive ability. The spatial configuration of a mega-shelter can accelerate their recovery by providing an environment that not only satisfies the basic needs, but one that can improve their spatial cognitive ability and promote a sense of community in this new, albeit temporary, small society. Four mega-shelters in the U.S., Australia, and Japan were analyzed using space syntax methods, specifically axial line analysis and visibility graph analysis (VGA), as well as justified graph analysis. The comparative analysis shows that while specific spatial layouts are different, all shelters were designed from a manager's perspective. The movements of the refugees were sometimes unnecessarily exposed to supervision and control, and community areas were often found in locations with low accessibility. By incorporating strategies such as siting community space in areas with high global integration values and adopting transition areas, mega-shelters can create an environment that can enhance the refugees' will to recover and rebuild by promoting communications with neighbors and various community activities.

Keywords: disaster; mega-shelter; spatial behavior; planning guideline; space syntax

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1. Introduction

Natural disasters such as typhoons, earthquakes, and floods and social disasters such as terrorism, wars, and fires occur frequently. In such cases, mega-shelters are built to protect the refugees in a safe environment. The term 'mega-shelter' was first used in the Mega-shelter Planning Guide [1] prepared by the International Association of Venue Managers (IAVM) and the American Red Cross (ARS). A mega-shelter is a type of congregate shelter, generally capable of accommodating 2000 to 25,000 people. Such a facility, usually set up in a very short time by the government, provides a safe and sanitary environment to temporarily accommodate refugees [1] (p. 10). Mega-shelters are usually set up during disasters and other emergency situations in large public facilities, such as sports stadiums, convention centers, schools, and churches [1] (p. 10). The spatial planning of mega-shelters needs to take the following two perspectives into account.

First, while a mega-shelter usually operates for less than a year, it contains all functions for everyday life. In addition to basic residential space for sleeping, dining, and sanitary (laundry room, restroom, and shower) uses, there are also spaces designated for community activities, education, child care, medical treatment, and management. Therefore, a mega-shelter is a complex space with a diverse range of functions, and the spatial planning of a mega-shelter is, in fact, creating a new social environment where refugees temporarily live. Given the relationship between spatial configuration and social behavior, which has been the subject of extensive research following the study by Hillier and Hanson [2], how to create a better social environment for refugees through spatial planning needs to be considered. Second, multiple studies have reported that individuals who experienced disasters suffer from PTSD (post-traumatic stress disorder) [3–7]. Many refugees become psychologically unstable during this time of uncertainly and often have a declined level of spatial cognitive ability because of stress [8]. PTSD influences human spatial behavior, and a high level of stress can reduce the level of spatial cognitive ability. In a shelter, refugees face an unfamiliar environment that confuses them further, and their spatial-use behavior is different from in normal times. Hence, the spatial planning of mega-shelters needs to take into account the fact that many refugees have reduced spatial cognitive ability.

Sanderson and Burnell [9] pointed out the two perspectives listed above and argued against focusing on only the supply of mega-shelters without reflecting the demands of the refugees. They stated that temporary residential facilities that do not consider shelter functions, supporting refugee communities, and other social, environmental perspectives can reduce the refugees' will to rebuild their lives and reduce such opportunities [9]. They emphasized that since temporary residential facilities influence the refugees' will to rebuild, the planning guideline for such a facility that incorporates key considerations was extremely important [9]. A review of recent research indicates that while spatial plans of shelters emphasize the importance of community facilities or study shelter layouts, an objective standard for allocating space has not been proposed [10,11]. In the same context, Zhang and Dong [12] stressed that based on Maslow's hierarchy of needs theory, a shelter needs to consider a wider range of perspectives in addition to the functional design focused on the demand for a sanitary and safe environment. Instead of a minimal, functional shelter that provides a sanitary and safe environment, they emphasized a more advanced design, one that is consumer-focused and human-centered [12].

A review of the literature on shelter planning uncovered that there have been a number of research studies on layouts of residential facilities, designs of residential units space, and planning guidelines [11,13–15]. For example, Hirata et al. [16] presented a checklist for the design and operation of shelters. These studies mostly focused on residential functions, and there are almost no studies that examined the spatial planning of an entire shelter—a multi-functional space with sanitary, medical, and other uses in addition to residential use. One study classified the layout of shelters with multiple functions [17] but did not consider the appropriateness of a layout based on human behavior. Most are post-occupancy evaluation studies [17,18] and almost none examined the characteristics of spatial behavior connected to the shelters' spatial configurations, or their relationship to the creation of a social environment. In addition, the shelter guidelines prepared by the U.S. Federal Emergency Management Agency (FEMA) [19], the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT) [20], and the Australian government [21] all focus on space size and functions from a management and operations perspective. These design guidelines also do not consider the spatial behavior of refugees, who are the shelter users.

In this context, the goal of this study is to examine the effect of the spatial configuration of a mega-shelter on users' spatial and social behaviors, and based on the results, provide an academic basis for preparing a mega-shelter planning guideline. Accordingly, first, the effect of spatial configuration on a shelter user's spatial behavior and social environment is studied, and second, spatial configurations of selected mega-shelters are analyzed. Finally, strategies to improve existing mega-shelter planning guidelines are proposed by considering the impact of spatial configuration on human behavior.

2. Literature Review

2.1. Behavior and Psychology after Experience of Disaster

Frequently, individuals who experienced disasters suffer from PTSD. Two points are especially relevant to this study.

First, the symptoms of post-disaster PTSD include chronic tiredness, loss of interest in everyday activities, anxiety, depression, and anger [3–5]. Hence, for disaster victims to recover from the traumatic event and restore their lives, substantial assistance and support is needed from the surrounding environment—for example, from neighbors and the local community. Many studies have reported that community support is an important force that helps refugees return to their normal lives [6,7,22,23]. In particular, Littleton et al. [22] showed that individuals who receive less support after experiencing disaster are more vulnerable to losses in community solidarity and may potentially suffer persistent PTSD symptoms. Second, the stress suffered by individuals who experienced disaster reduces their spatial cognitive abilities [8]. As a result, refugees travel on familiar routes within a shelter rather than using shortcuts. Tang et al. [24] argued that chronic tiredness and loss of interest in everyday activities can lead to physical inaction and increase the risk of suicide. These studies show that given the close relationship between spatial configuration and spatial behavior presented by Kim and Penn [25], a careful spatial planning of shelter facilities that incorporate the spatial behavior of refugees is very important.

2.2. Spatial Planning of Shelters

Several studies have been conducted on the spatial planning of temporary shelters. Biswas [26] showed that the planning and design method of post-disaster housing program affects the mid- to long-term recovery of residents. Nappi and Souza [10] focused on the potential formation of a community based on a user–environment relationship when planning a local shelter. They emphasized the need for a clear axis that can promote the bond between neighbors by expanding the bond of families—the smallest unit of a community. They also argue that various functions in a shelter need to be spatially aligned, and that a shelter should be designed so that users are able to perceive the entire structure, and that the visual information in regard to spatial configuration enables users to confirm his/her location and current direction. Similar research examined functional planning considerations when utilizing a school as a shelter, including operation, residential area, and minimizing movement circulation for medical treatment activities [17].

In addition to academic studies, mega-shelter planning guidelines prepared by public institutions in various countries also need to be reviewed. Standards for shelter space in the U.S. [19], Japan [20], and Australia [21] were examined. Based on these guidelines, mega-shelters contain 10 key function categories. They include entrance, registration, management, welfare, medical and mental health service, dormitory, sanitary, dining, community, and logistics. Table 1 shows guideline elements related to spatial planning. The guidelines list criteria for connectivity and access control of the space for each function.

Table 1. Mega-shelter planning guideline elements that influence spatial configuration.

Function	Use	Guideline
Entrance	Entrance	- There should be only one main entrance for better control of resident movements - Entrance should be located where the number of users is the largest, to control the flow of people
Registration	Registration Space	- Should be easy to find, close to the main entrance
	Information Center	- Information center should be close to control room so that updated information can be rapidly distributed to the residents
Management	General	- Staff-only corridor is needed for efficient movement
	Control Room	- Control room should be located at the center of communication, between inside and outside of the facility
	Staff Resting Area	- Staff resting area should be in a quiet location - Away from major traffic areas - Should be located close to the control center

Table 1. *Cont.*

Function	Use	Guideline
Welfare	Space for Vulnerable Groups	- Should be located close to the entrance for good accessibility
Medical and Mental Health Services	General	- Should have easy access to outside (parking lot) for ambulances and medical supplies - Medical service area should be close to the registration space - Registration space manager should perform screening test with medical space manager and create a list of residents who need assistance - Medical service area should be close to restrooms
	Counseling Room	- The locations of medical and mental health counseling space should be planned to be away from residential space to protect privacy of the refugees
	Quarantine Facility	- Quarantine space should be located away from residential/common areas to prevent spread of contagious diseases and to protect privacy of the patients
Dormitory	General	- Of all uses in the shelter, requires the highest level of privacy - Should be close to sanitary facilities in a low-traffic area - Should be close to other amenities - Should not be located to areas with high level of noise - Should have internal corridor access
	Prayer/Reading Rooms, Workspace, etc.	- Individual activity room should be located in low-accessibility locations to protect privacy
Sanitary	Public Restrooms	- Restrooms should be close to residential space and waiting space of the registration space - Sanitary facilities close to residential space should be located in low-traffic areas
	Temporary Restrooms	- Outside space for installation should be reserved in advance - Should be accessible by vehicles
Dining	Dining	- For efficient distribution of meals, movement plan needs to be prepared for dining area
	Kitchen	- Kitchen should be close to kitchen storage space
	Kitchen Storage	- Kitchen storage should be located close to outside to enable convenient disposal of trash
Community	General	- Should be located in an area that does not disturb shelter residents
	Community Recreation Room	- Should be located in a closed space for activities that require minimum level of exposure and access control - Recreation activities should be monitored by managers
Logistics	Supply Storage	- Should be located close to outside for convenient delivery of materials and goods - Controlled access and management are needed
	Logistics Center	- Logistics center should be easily accessible by the residents and at the same time be in a secure space for distribution and storage

Review of both academic studies and shelter planning guidelines prepared by public institutions indicate that a human-centered design approach for users is required for mega-shelter planning. Rather than simply helping people survive by satisfying minimal sanitary and safety desires, a mega-shelter needs to enable users to overcome their trauma and restore psychological stability through the community that can form and develop in a shelter. There have been multiple studies on layouts of residential facilities in shelters. The United Nations High Commissioner for Refugees (UNHCR) [13], Park [14] and Kim et al. [27] proposed a form of modular planning for residential units when setting up a mass shelter. Jung et al. [15] lists key strategies for spatial allocation when using an existing public community facility as a temporary shelter, with the residential function occupying the central area connected to other functions horizontally and vertically. Lee et al. [11] proposed construction and spatial design guidelines for essential non-residential functions in long-term, large-scale temporary shelters. In a non-quantitative guideline, they suggested that a street network first be established along residential units, followed by allocation of space for other functions depending on street types. However, there have been almost no study that examined spatial layout of an entire shelter containing a diverse range of functions such as community facility, medical facility, and education/childcare space in a comprehensive manner. One study classified the layout of shelters with multiple functions [17] but did not provide an objective basis for the proposed layout. In addition, most government guidelines were prepared from a facility manager's perspective, focusing on controlling the access and activities of the refugees, as well as logistics. There is little guidance for spatial planning of the facility. Finally, there have been almost no studies that quantitatively examine the effects of a spatial configuration on users' spatial behavior and community formation using spatial syntax methodology.

3. Research Methodologies and Cases

3.1. Spatial Configuration Analyses of Shelters

To assess the validity of various uses in a mega-shelter, the characteristics of each space and suitability of spatial arrangement—which influence a user's behavior—need to be understood. To this end, spatial configurations of shelters were analyzed to examine the characteristics of each space, and based on the results, the suitability of the spatial arrangement was evaluated. Specifically, the perceptibility and accessibility for users of each space in a shelter were analyzed. This procedure reveals the overall layout of a shelter, and depending on the layout, the level of visibility, accessibility, and probability of use of each space from a user's perspective. Specifically, axial line analysis, visibility graph analysis (VGA), and justified graph were created using the space syntax method. For the four selected case studies, spatial topology and global integration values were assessed, as well as space syntactic properties. The results provide the quantitative basis for assessing the accessibility and probability of the use of each space within the mega-shelters.

3.1.1. Calculation of Integration Value Using Axial Graph Analysis and VGA Analysis

The space syntax method is used to study the relationship between spatial configuration and social phenomena based on space visibility. Spatial configuration affects movement patterns and encounters between residents, and such encounters in turn have a positive impact on the development of social relationships [28]. Integration, one of the space syntax properties, is closely correlated to encounters and interactions between people [29,30].

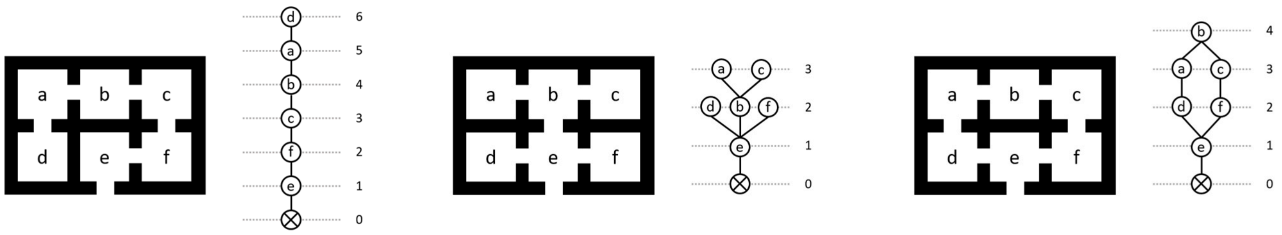
Global integration is an important indicator in space syntax theory that shows ease of accessibility from each space to all other spaces and is calculated in depth value. A high level of integration indicates a small depth value, whereas a low level of integration indicates a high depth value. A high global integration value of a specific space shows that accessibility is high from this space to all other spaces, and this may be used to analyze accessibility and assess suitable uses for each space in a shelter.

Global integration is calculated using 'Axial Line Analysis' and 'VGA' by depthmapX software (Version 0.8.0, Turner, A., 2020) based on space syntax theory. An axial map represents space based on visibility and is used to analyze the relationships between spaces. VGA was additionally conducted to further examine the spatial configuration characteristics of the shelters. It is based on the isovist theory proposed by Tandy [31]. To overcome the limitations of Tandy's isovist theory, Turner [32] proposed VGA methodology in which the visibility graph was replaced by the concept of visual depth in space syntax theory. Using VGA, the accessibility, visibility, and spatial configuration characteristics of all spaces in the study area can be examined.

3.1.2. Analysis of Spatial Depth and Hierarchy Using Justified Graph

Justified graph analysis is a method to study the relationship between a given space and other spaces by examining how they are connected. A justified graph is an expression of relationships of spaces from a specific point topologically, and spatial hierarchy and relatively depth from the given point can be assessed.

As seen in Figure 1, the justified graphs of the diagrams, having the same geometric form but including different spatial transitions, are indicated. Although the geometries are the same in the diagrams, it is clearly seen that the configuration differentiates with the change of spatial relations and depth changes in the justified graph. In the images, Figure 1a is a deep tree (6 depth), Figure 1b a shallow tree (3 depth), and Figure 1c a shallow ring (4 depth) justified graph model. By 'tree' we mean that there is one link less than the number of cells linked, and that there are therefore no rings of circulation in the graph. All trees, even two as different as in the two in the figures, share the characteristic that there is only one route from each space to each other space—a property that is highly relevant to how building layouts function. However, where 'rings' are found, the justified graph makes them as clear as the 'depth' properties, showing them in a very simple and clear way as what they are, that is, alternative route choices from one part of the pattern to another [33].



(**a**) (**b**) (**c**)

Figure 1. Examples of different justified graph: (**a**) deep tree formed graph model; (**b**) shallow tree formed graph model; (**c**) shallow ringy graph model.

The results can show which spaces are connected closely, the accessibility of each space from the entrance or other key spaces, and which spaces have similar levels of accessibility.

3.2. Selected Case Studies

Mega-shelters can be set up either by rapidly constructing temporary structures or utilizing existing buildings. This study will examine both cases. First, case studies from the U.S. [19] and Australia [34] are presented where shelters were newly constructed. In the mega-shelter guidelines, both countries provide a standard floorplan for setting up a shelter either in an indoor gym or on school grounds. Second, case studies from Japan [20] are presented where existing buildings are used as shelters. Japan utilizes school facilities across the country as local shelters, and the guideline prepared by the Japanese government provides how to allocate various functions of a shelter in existing school buildings.

In Figure 2, Cases 1 [19] and 2 [34] show a standard floorplan for new construction, while Cases 3 and 4 [20] show plans for the utilization of existing school buildings.

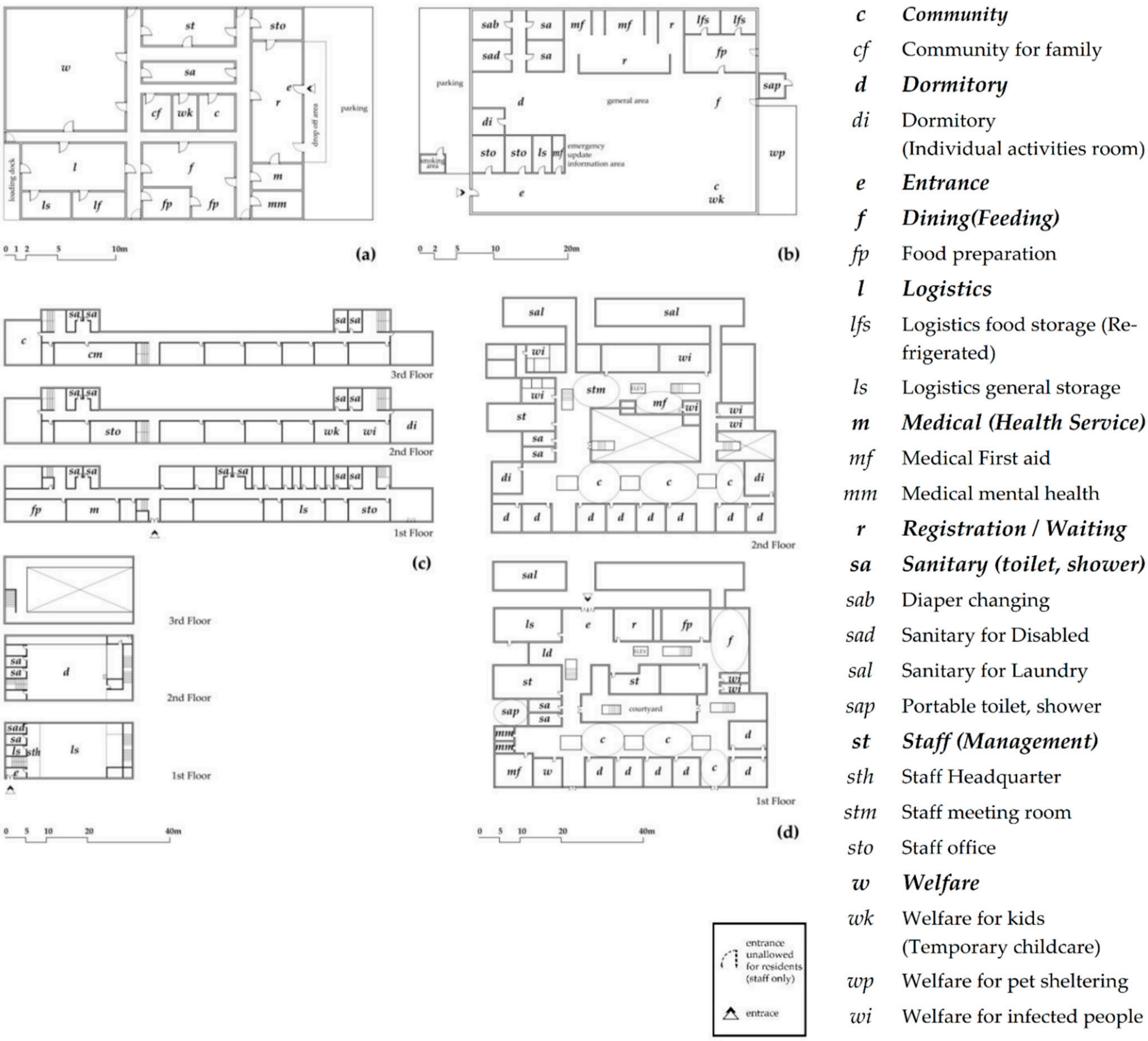


Figure 2. Mega-shelter floor plan: (**a**) case 1 (U.S.); (**b**) case 2 (AU); (**c**) case 3 (JP1); (**d**) case 4 (JP2).

In Case 1, as shown in Figure 2a, all functions are clearly defined and are connected by a corridor. The corridor along the *y*-axis divides the shelter into three zones: management zone, common area zone, and residential zone. In Case 2, as shown in Figure 2b, the general area, dining area, and recreation area are located in the central open space. Other functions are separated, including registration, medical, sanitary, staff, and kitchen. Case 3, as shown in Figure 2c, shows an existing school facility used as a temporary shelter, and the teachers' quarter is used for management and other common uses while the annex buildings are used as residential areas. Case 4, as shown in Figure 2d, shows a courtyard and community facilities on the ground floor of the central area. It also has a welfare space for patients with colds and other mild diseases, in case the duration of facility use is extended.

4. Results

4.1. Depth of Space and Hierarchical Analysis by Justified Graph

To understand spatial structure, it is necessary to comprehend how the space is experienced from user's perspective. Justified graph analysis was conducted to examine the depth and hierarchy of the shelter space, from the entrance to its deepest interior space. The results are presented in Figure 3.

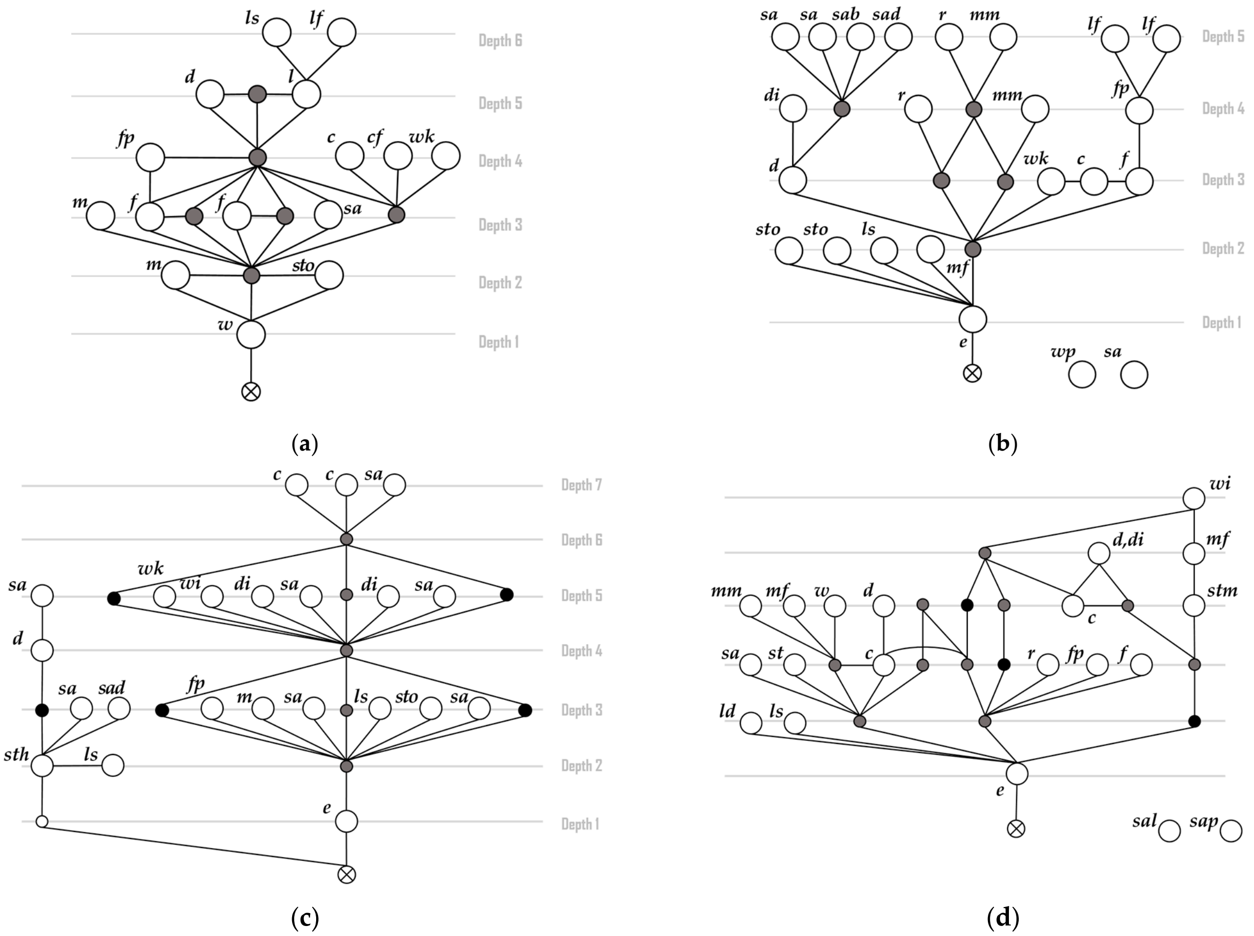


Figure 3. Justified graph analysis (see Figure 2 for key to room functions; black nodes indicate verticals, while grey nodes indicate corridors): (**a**) case 1 (U.S.); (**b**) case 2 (AU); (**c**) case 3 (JP1); (**d**) case 4 (JP2).

In Case 1 (U.S. shelter), as shown in Figure 3a, the registration space near the entrance is the shallowest space, most easily accessible from outside. It is followed by staff office and medical space. Three functions (registration, staff, and medical) are connected in a ring structure in the justified graph. The sanitary function, with depth value of 3.0, connects programs in inner and outer spaces. In the same hierarchy exist feeding and other staff facilities, followed by community and welfare (childcare) spaces for residents. At the end of the corridor there are dormitory and logistics facilities. The analysis shows that spatial layout of the U.S. shelter is efficient from a manager's perspective since it allows access to all spaces with only few depths. However, from a resident's perspective, even visiting a sanitary facility requires moving through a corridor shared with the manager. Since space where the residents can move freely and privately is limited to the dormitory, some may feel that their movements are monitored and controlled.

In Case 2 (Australia shelter), as shown in Figure 3b, staff, medical (first aid station), and logistics storage spaces near the entrance are the shallowest space, with average depth of 1.67. With the general area in the center, spaces are connected in a tree-shaped structure. Main functions include dormitory, registration, and community space. The dormitory's individual activity room and sanitary space are connected to the dormitory. Registration space is located relatively inside, at depth of 4.5. It is adjacent to the medical (mental health) space, where refugees who need special supervision are screened. The feeding space has the same depth as welfare (childcare) and community spaces, and is adjacent to food preparation and logistics (food storage) spaces. The analysis shows that with the general area in the center, the Australian shelter separated facilities where the privacy of the residents must be protected and those where it does not. Hence, even when a space may show the same depth value in the justified graph, the characteristics of the Australian facility may be very different with the general area acting as a buffer zone. The functions with similar goals are connected on the same branch in the tree structure starting from the general area—dorm–sanitary spaces, registration–mental health spaces, and dining–welfare (childcare), and community. All three function clusters are heavily used by the refugees or are required to promote refugee communities.

In Case 3 (Japan shelter #1), as shown in Figure 3c, the main building and the annex building are separated, containing primarily management functions and resident service functions, respectively. Functions needed for the management of the shelter are concentrated in the main building, and all functions on each floor have equal depth values. In the main building, the facilities with the shallowest depth are food preparation, medical, logistics storage, staff office, and sanitary use at a depth of 3.0. On the other hand, the community space at a depth of 7.0 is the deepest interior space. In the annex building, staff headquarters and logistics are located in the shallowest space. In the main building, the lower floors house service functions related to sustenance of life (dining, medical, and logistics) and the upper floors house service functions related to social desires of a higher level (welfare, dorm (individual activity room), and community spaces). While the dormitory facility in the annex building may have privacy since it is located in the innermost space at a depth of 4.0, residents need to move through the headquarters to go outside and some may feel that they are being controlled.

In Case 4 (Japan shelter #2), as shown in Figure 3d, logistics storage, logistics distribution center, and registration with uses are located closest to the entrance. Management functions such as food preparation, staff office, and dining facilities at a depth of 3.0 share a corridor with registration. Staff office and sanitary use are located along the corridor to the courtyard, and welfare–medical space and community–dormitory space are located on different branches. The corridor leading to a community space with a depth value of 3.0 is connected to dining use. The dormitory and medical and welfare are the deepest space with a depth of 4.0 on the first floor. On the second floor, the courtyard divides the management zone and refugee zone. Staff headquarters, medical (first aid station), welfare for infected people, and sanitary spaces are contained in the management zone, while the dormitory and community are the primary use in the refugee zone. In this case, a total of four vertical circulation routes are creating various circulation routes via corridors. The vertical circulation route in front of the entrance leads directly to the management facility on the second floor, and essential functions for shelter management are located along the corridor on the first floor. Resident facilities—dormitory and community spaces—are located inside the courtyard, thus completing the corridor–community–dorm loop. This design is applied to the second floor in same manner, thereby promoting communication and strengthening bonds among refugees.

From the analyses of mega-shelters, the common characteristics are as follows. First, the spatial layout of the mega-shelter closely follows the process by which the refugees are admitted, beginning with registration and ending with the residential space. The spatial order and depth increase as a new resident moves through the entrance, then through the spaces of the management (registration (or staff headquarters), medical (first aid station), and staff space), and then finally to the dormitory, which is a private space. However, the depths of welfare, medical (mental health), and community spaces varied by shelter, indicating that considerations for facilities required for long-term shelter operation were not fully integrated into the planning of the shelters. Second, the most essential functions to sustain the lives of the refugees, such as dining and logistics, were located in shallow spaces. However, sanitary facilities showed varying depths in all cases, since they were built as single facilities for both refugees and the managers or were built as multiple facilities—depending on the size and design of the shelter. Third, the average depths of the management facilities (dining, logistics, medical, and staff) were shallower than refugee-centric facilities (dorm and community). This indicates that management facilities are located near the entrance to enable strict control of movement of the refugees to and from the outside. Fourth, the dormitory is located in either a high-depth space or away from core functions to protect the privacy of the residents. Finally, complementary functions can be found on the same branches of the justified graphs. It indicates that those programs have been sited in proximity for efficient operation of shelters.

Similarities found between the shelters are as follows. In Case 1 (U.S. shelter) and Case 3 (JP1 shelter), various functions are located without separation of the circulation routes of the management and the users. In Case 2 (AU shelter) and Case 4 (JP2 shelter), programmed and private areas are separated using the general area and the courtyard as transition areas, respectively. Here, areas are separated into areas for refugees and areas for management, or areas where privacy needs to be protected and areas where it does not. From the management's perspective, some space needs to be separated from the circulation routes of the refugees—for example, for security. From a refugee's perspective, separation from the management's space can minimize unreasonable surveillance. A layer of semi-public, semi-private space contributes to residents' comfort and satisfaction [35]. The refugees' psychological level of comfort can be enhanced by providing space that can be used freely. As the privacy of the individuals is respected and the social distance between individuals is guaranteed, psychological and social benefits are maximized [10].

4.2. Analysis of Shelter Layout Characteristics by Axial Line Analysis and VGA

Spatial layout has a direct impact on users' spatial cognition and movement, as well as on space-use patterns. For spatial configuration analysis of a shelter's interior space, axial line analysis and VGA were conducted. The results are presented in Table 2, Figures 4 and 5. Since the objective is to compare levels of global integration, corridors (which connect functions) have been excluded from the analyses.

Axial line analysis of Case 1 (U.S.), as shown in Figure 4a and the first row of Table 2, indicates that logistics (1.31), dining and snack area (1.29), and staff area (1.21) belong to the integration core group with the highest integration values. In the next group are management-related facilities such as registration/waiting (1.14), medical health services (1.07), shelter manager's office (1.04), and food preparation (1.04), as well as dormitory (1.13) and sanitary (1.18) facilities. The segregation core group, with the lowest level of integration, were counseling (1.00), community space (0.92), welfare space (0.92), and logistics storage (0.75), indicating these spaces have low accessibility and usability. VGA, as shown in Figure 5a, showed that the dormitory space (excluding corridor) has relatively high visibility. The analysis also revealed that community and welfare spaces, while located in the center of the shelter, unexpectedly have rather low visibility and were relatively inactive spaces.

In sum, axial line analysis and VGA of Case 1 (U.S.) showed that the global integration values of all spaces except the dormitory were within a similar range. Logistics and dining are functions in the integration core group, while counseling, community, welfare, and logistics storage spaces are segregated from other functions. Overall, spaces where staff worked had higher potential for activities, and facilities for the refugees were in more isolated areas. As an essential function for the operation of a shelter, the dining area has a high level of integration with a large number of users; however, the community space has a low level of integration even though the space is capable of accommodating a large number of people.

Table 2. Order of global integration of functions from axial line analysis.

Case	Order of Global Integration of Functions																				
Case 1 US	*l* > 1.31	*f* > 1.29	*st* > 1.21	*sa* > 1.18	*r* > 1.14	*d* > 1.13	*m* > 1.07	*sto* > 1.04	*fp* > 1.04	*mm* > 1.00	*wk* = 0.92	*c* = 0.92	*cf* > 0.92	*lfs* = 0.75	*ls* 0.75						
Case 2 AU	*e* = 1.49	*c* = 1.49	*wk* > 1.49	*f* > 1.48	*-* > 1.43	*d* > 1.28	*m* > 1.16	*fp* > 0.85	*r* > 0.80	*sto* = 0.78	*sto* = 0.78	*ls* = 0.78	*di* > 0.75	*sap* > 0.64	*wp* > 0.63	*sab* = 0.63	*sa* = 0.63	*sad* > 0.63	*lfs* = 0.56	*lfs* > 0.56	*-* 0.52
Case 3 JP1	***sth* *1** > 0.73	***fp* 1** = 0.65	***m* 1** = 0.65	***sa* 1** = 0.65	***ls* 1** = 0.65	***sto* 1** > 0.65	***ls* *1** > 0.63	***sto* 2** = 0.54	***sa* 2** = 0.54	***wk* 2** = 0.54	***wi* 2** > 0.54	***di* 2** > 0.54	***sad* *1** = 0.47	***cg* 3** = 0.47	***c* 3** = 0.47	***sa* 3** > 0.47	***d* *2** > 0.43	***sa* *2** 0.35	**		
Case 4 JP2	***ld* 1** = 1.10	***cd* 1** > 1.10	***f* 1** > 1.00	***sal* o** > 0.99	***ls* 1** > 0.97	***sa* 1** > 0.97	***cd* 2** > 0.95	***sto* 1** > 0.94	***stm* 2** > 0.93	***sal* 2** > 0.92	***wi* 1** > 0.87	***r* 1** > 0.86	***w* 1** > 0.86	***sto* 2** > 0.85	***sa* 2** > 0.85	***mm* 1** > 0.82	***m* 2** > 0.80	***wi* 2** > 0.77	***d* 2** > 0.76	***di* 2** > 0.75	***d* 1** 0.75

■: value of integration—top 0~20% (integration core) ■: value of integration—top 21~60% ■: value of integration—top 61~100% (segregation core) * For key to room functions, see Figure 2. ** In Case 3 and 4, number below function indicates the number of floors. An asterisk in front the number indicates an annex building.

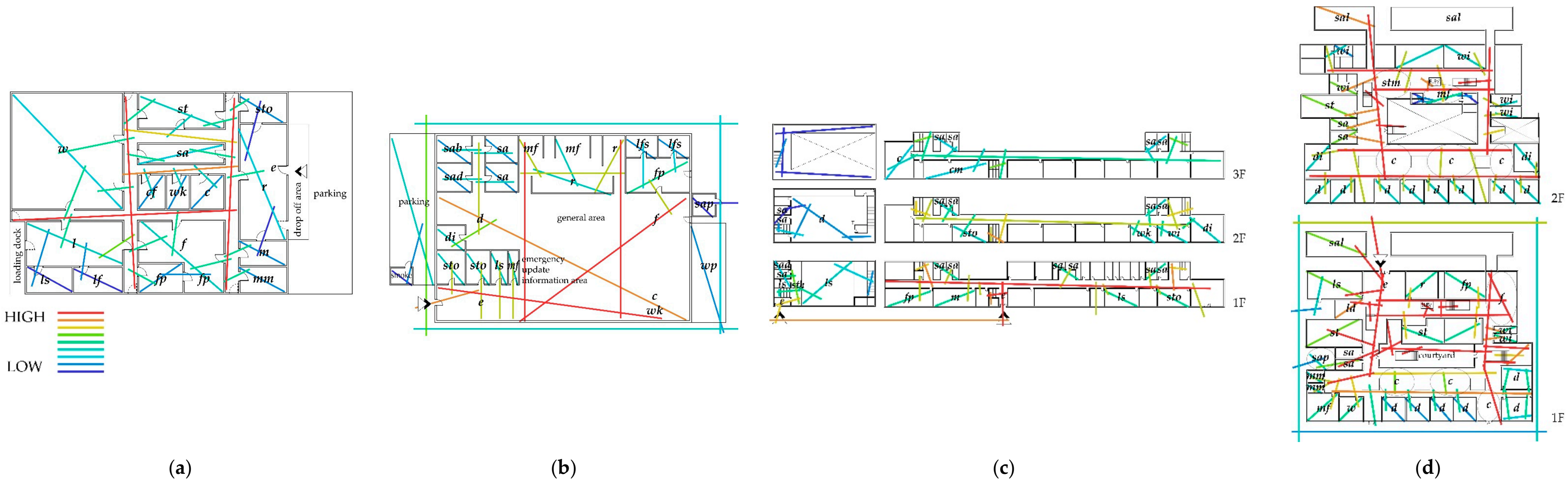


Figure 4. The axial line analysis results on cases (see Figure 2 for key to room functions): (**a**) case 1 (U.S.); (**b**) case 2 (AU); (**c**) case 3 (JP1); (**d**) case 4 (JP2).

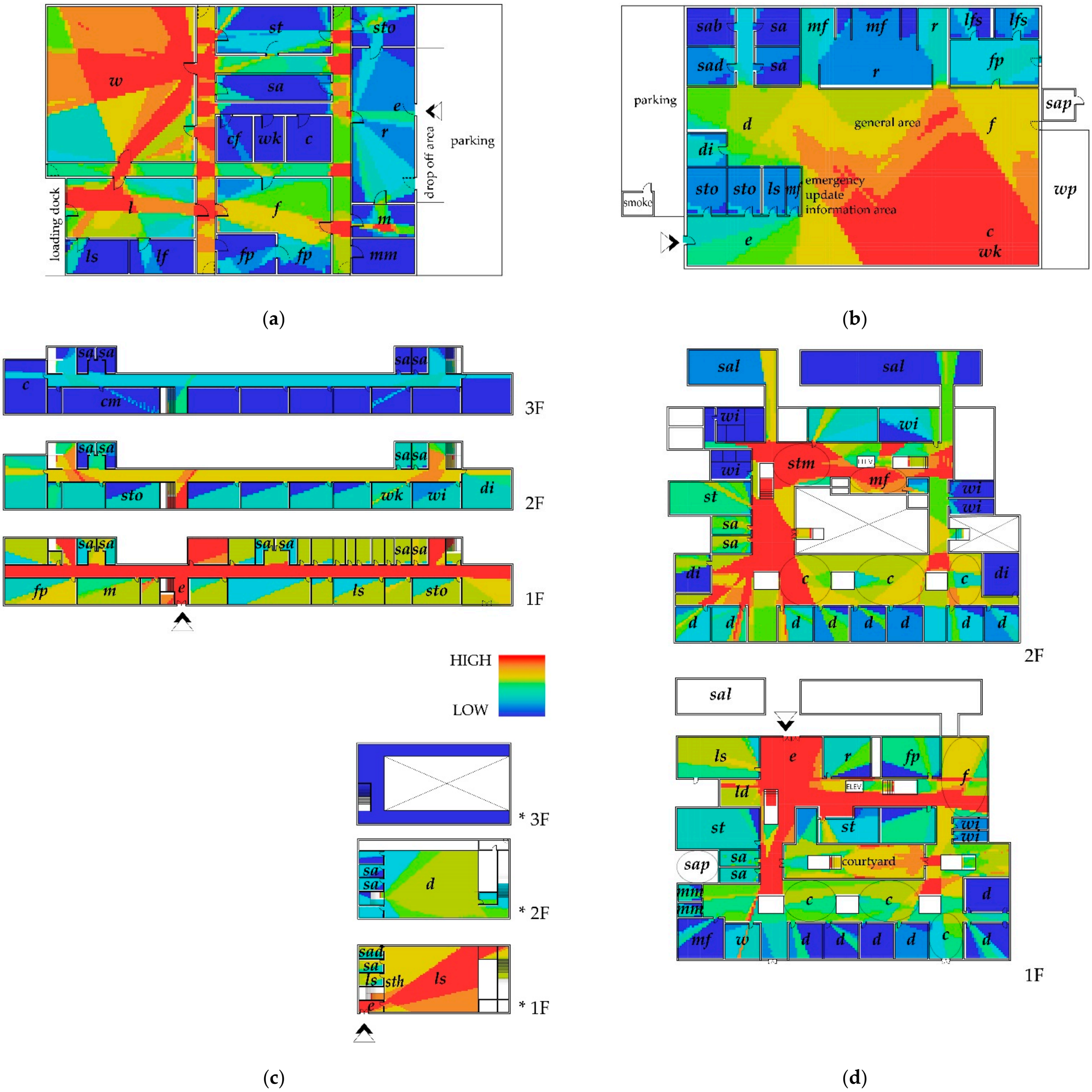


Figure 5. Visibility graph analysis of the cases (see Figure 2 for key to room functions; an asterisk in front the number indicates an annex building); (**a**) case 1 (U.S.); (**b**) case 2 (AU); (**c**) case 3 (JP1); (**d**) case 4 (JP2).

Axial line analysis of Case 2 (Australia), as shown in Figure 4b and the second row of Table 2, indicates that the entrance/meeting area, recreation area, childcare area (1.59), and dining area (1.48) have the highest integration values. Functions related to the integration core function, such as dormitory (1.28), medical (mental health) (1.16), food preparation (0.85), registration/waiting (0.80), staff office, logistics storage, and first aid station (0.78) have mid-level integration values. Finally, sanitary (0.63), kitchen storage (0.56), portable sanitary (0.64), pet sheltering (0.63), and smoking area (0.52) have the lowest accessibility. In VGA, as shown in Figure 5b, the recreation area and childcare area were shown to be the most open spaces to users, both visually and by accessibility. Functions with low accessibility were staff area, sanitary, registration, mental health services, food preparation, and storage—spaces that are visually isolated from open space.

Both axial line analysis and VGA of Case 2 (Australia) showed that community, welfare (temporary childcare), and dining spaces in the central open space were the core integration functions. These functions are connected to the center of the shelter through the general area, a visually open area. The general area is a transition space without a specific designated function for the shelter. This transition space also plays the role of providing privacy for the dormitory space. The privacy of users needs to be protected—for manager, office and food storage, and for refugees, the sanitary space. The general area, acting as a transition space, functions as a buffer space between facilities that require high accessibility and uses that require the privacy of users.

Axial line analysis of Case 3 (Japan #1), as shown in Figure 4c and the third row of Table 2, shows that the level of global integration of the main building is higher than the annex building. The staff headquarters (0.73) space shows the highest level of integration. The mid-level integration facilities are food preparation, medical, logistics, staff, and sanitary (0.65) facilities on the first floor of the main building, and welfare (temporary childcare and infected people spaces), staff office, individual, sanitary (0.54) facilities, and finally, logistics storage space (0.63) on the first floor of the annex building. The facilities with the lowest level of integration were community and sanitary (0.46) spaces on the third floor of the main building, as well as sanitary for disabled (0.47) on the first floor of the annex, and dormitory (0.43) and sanitary (0.35) on the second floor of the annex. VGA, as shown in Figure 5c, revealed that food preparation, medical center, sanitary, and logistics storage on the first floor of the main building were the most active spaces. This was followed by welfare (temporary childcare and infected people) on the second floor and individual activities spaces for residents, such as reading rooms. The most isolated functions were community and sanitary spaces on the third floor.

Both axial line analysis and VGA of Case 3 (Japan #1) showed that the level of global integration was highest for the facilities on the first floor, which includes food preparation, medical center, sanitary, and logistic storage in the main building and logistics and staff headquarter in the annex building. The lowest level of integration was found in the community space on the third floor of the main building. The operating food preparation space and medical services on the first floor of the main building are convenient for the refugees since they can meet their demands for meals and health services easily. This is also convenient for staff and logistics to receive supplies and manage them. However, having a community space on the third floor with low accessibility can reduce opportunities for communications among users and lower the probability of psychological recovery through community activities. Protecting the privacy of the dormitory on the second floor of the annex building is desirable, but it has low access to individual activity rooms on the second and third floors of the main building, which are spaces for refugees. It also reduces opportunities for refugees to initiate communications.

Axial line analysis of Case 4 (Japan #2), as shown in Figure 4d and the fourth row of Table 2, shows that the functions with the highest level of global integration were logistics (distribution center) close to the entrance, the community space (1.10) in front of first floor dormitory, dining (1.00), and sanitary (laundry) (0.99) outside. The facilities with the lowest level of integration were medical/mental health (0.82), dormitory and individual activity rooms (0.75) on the first floor, dormitory (0.76) and medical care space for infected people (0.80), and welfare dormitory for infected people (0.72) on the second floor, mostly related to the refugees. VGA, as shown in Figure 5d, predicts that the facilities along the open corridor on the first floor dining and staff meeting room, medical center, and community space in front of the dormitory on the second floor will have large numbers of users. Finally, logistics (distribution center), courtyard, and the community space in front of the dormitory on the first floor have a high level of integration.

Both axial line analysis and VGA of Case 4 (Japan #2) showed that the most segregated spaces were the dormitories on each floor and the welfare for infected people space on the second floor. Both analyses also found that dining and community spaces were most active with a high level of connectivity. Most functions in both high global integration areas and the segregation core are used by the refugees. Programs were distributed according to the characteristics of the rooms of the existing structure, as well as the degree of activity required for each function. The central courtyard contributes to creating an efficient circulation route in the shelter. On a smaller scale, existing school amenities such as student shoe racks help to distinguish the classroom space from the space outside the classroom near the door. The manager space, while it may be difficult to access the refugees physically, has visual access to the living area of the refugees through the courtyard. The dormitory of the refugees is located in the shelter's most internal space, protecting their privacy. The community space in front of the dormitory can strengthen its privacy and help refugees start their own community activities.

The analyses of the four shelters revealed the following (Table 3). In all cases, logistics- and dining-related functions have excellent accessibility and are classified as active space. Logistics and dining are both essential functions directly related to maintaining a minimum quality of life, and they require substantial space area, while a dormitory is a function for which the protection of privacy is paramount but that has relatively good level of integration since it also has good access to essential functions such as sanitary and dining. While different shelters have different segregation core functions, logistics storage, welfare, and community spaces fall into this category in general.

Table 3. Global integration of shelter rooms by functions.

Value (Global Integration) \ Case	1 (U.S.)	2 (AU)	3 (JP1)	4 (JP2)
High-level rank (top 0–20%)	- management - dining - logistics	- welfare (child care) - community - dining	- management (headquarters) - dining (preparation) - medical - logistics	- dining - logistics
Mid-level rank (top 21–60%)	- registration - medical	- dormitory	- welfare	- logistics - management - medical - registration - community
Low-level rank (top 61–100%)	- medical (counselling) - community - welfare - logistics	- sanitary - management - logistics (storage)	- community - dormitory	- medical (counselling) - dormitory - welfare (infected people)

5. Discussion

Based on the literature review and case studies of mega-shelters, several issues can be raised, as follows.

First, the planning guides used for the planning and management of shelters provide instructions for spatial layout and allocation of functions only for efficient operation and assistance. For example, the movement of refugees should be controlled at the entrance, and the control center needs to be located in the center of communications between the outside and inside of the shelter. Some guidelines even stipulate that the recreation space requires supervision by managers. Given such guidelines, the spatial plans for mega-shelters have been prepared from a manager's perspective.

Second, in spaces where the activities of the two user groups are segregated, spatial configuration and the level of integration of the spatial layout show clear hierarchy. In general, logistics- and dining-related functions have been analyzed as spaces with good accessibility and high levels of activity. In contrast, spaces exclusively used by the residents were located in high-depth areas compared to spaces only used by the managers. However, in this context, welfare and community spaces used by the residents showed a low level of integration, contradicting the purpose of these spaces. It shows that the locations of uses within shelters are determined from a manager's perspective, with the goal of stable construction and operation of the shelter. In addition, the dormitory is located in the most internal space from the entrance, often segregated from adjacent spaces to emphasize protection of privacy.

Overall, only facilities required to maintain life, such as dining and logistics, are included as core integration functions in the guidelines' spatial plans. The dormitory space is mostly classified as a segregation function, for which the protection of privacy is the foremost standard. However, there remains shortcomings such as lack of clear distinction between non-dormitory refugee uses and management uses and a lack of consideration to create a community that looks beyond individual refugees and takes into account the psychology of the refugees and their spatial behaviors and plans for locations of medical (mental health) and other needed uses.

Third, when building a new shelter or utilizing existing buildings, it is important to precisely understand the spatial structure of the mega-shelter before determining how to allocate various uses. In other words, deciding on spatial hierarchy and uses in a newly constructed shelter and determining use allocation in an existing school facility based on the appropriate understanding of spatial hierarchy are in fact from the same perspective. Therefore, it is important to clearly understand circulation routes of managers and users regardless of the shape of the building space and then decide how to allocate core functions and relevant uses for the two groups of users. A discussion on the spatial hierarchy of a shelter layout, relative accessibility of various uses of a shelter, and spatial connectivity between relevant functions is needed with an objective perspective.

6. Conclusions

Analysis of the previous literature and guidelines on the management of mega-shelters have all revealed that the spatial layouts of the shelters emphasize only efficiency for the managers. However, such a spatial configuration does not play a positive role for the recovery of refugees from their traumas, and in fact, as Sanderson and Burnell [9] argued, it has a negative impact on the development of the refugees' sense of community that is essential to strengthen the refugees' will for restoration and recovery. Specifically, the following points should be noted.

First, in both academic research and the shelter planning guidelines prepared by public institutions, the spaces used by refugees are recommended to be located in a segregated space to protect the privacy of the refugees. While there is recent research that emphasizes the importance of community facilities in addition to simply accommodating residents [10,11], almost no consideration is given as to how to allocate space in an objective way for these and residential uses in a shelter [11,14]. However, such a spatial layout stems from a shelter manager's perspective, placing control and supervision of the refugees foremost. In this context, Markus [36] pointed out that the spatial layout in which patients are segregated in the periphery while the care team is located in the integrated core is related to the building types, such as almshouses, that express and enforce power. Spatial configuration has significant impact on spatial cognition and spatial behaviors [25]. When isolated in a segregated space, the user cannot easily comprehend the spatial structure of the entire shelter. As the analyses of shelters show, areas with the highest integration values were mostly areas for the management of the shelter, followed by high-traffic corridors and public spaces. If a shelter's major corridors and public spaces are located in spatially central areas with high integration values, they can facilitate communications among the residents in the entire shelter and also assist wayfinding. It can also contribute to the safety of the residents as well. In other words, a high level of integration of key public spaces can affect an individual's spatial ability, including wayfinding, and in the end has a negative impact on his/her sense of spatial control. Lynch [37] also supported this argument and articulated that illegible space is not a desirable space for users. Hillier [33] and Kim [38] described that unintelligible space hinders spatial cognition formation, which in turn acts as a constraining factor for the full manifestation of space-use patterns. In this context, the community space is very important from a space configuration perspective. Therefore, while dormitory space may be located in a segregated space, the common space of the refugees—community space in particular—needs to be located in a space where the spatial layout of the entire shelter can be grasped easily and intuitively. As Nappi and Souza [10] argued, the community space needs to be located in the center of the shelter with a high level of integration with visibility into the deepest spaces of the shelter. This will ensure that the users will perceive the entire spatial structure easily. Such a layout will increase opportunities among residents to meet and communicate, and the users can experience psychological stability and a sense of spatial control.

Second, a mega-shelter is a small society where individual refugees and their families live with other neighbors. The shelter must become a place where people with post-disaster stress and trauma can together restore their health. However, not only public institutions' guidelines [19–21] but also studies on guidelines for the planning and management of shelters [11,13–16] indicated that most studies focus on either accommodation of refugees or efficient construction and management of shelters, rather than on refugees' recovery of health through provision of user-centered community spaces. As the four case studies in this paper showed, even shelters set up with the same goals and functions can have different effects on refugees, depending on spatial hierarchy and the emphasis of spatial configurations. The results of this study indicate that the spaces used by the managers and the refugees need to be appropriately differentiated and located. Rather than allocating a manager's space to a higher level in the spatial hierarchy to enable unilateral supervision of users, both need to be at a similar level while appropriately segregated. In addition, a transition area or general area needs to exist between the two spaces so that, while managers can efficiently take care of the refugees, the refugees do not feel that they are being monitored. A transition space with no specific function can separate circulation routes of both groups and control the level of activities in a space. In other words, the managers can take care of the residents visually through the transition space; the residents can enjoy more free movement. Perhaps it is in such a spatial configuration that human-centered, natural spatial patterns can emerge, as Zhang and Dong [12] argued.

Albeit temporarily, a shelter is a space where people who suffered disaster constitute a new group, a new society, and live together. In particular, when planning for a large-scale facility such as a mega-shelter, a careful approach is required. The plan for such a facility should not only focus on accommodating and managing refugees in the short term, but also recognize that it is creating a social environment where people act in accordance with their needs and wants. The spatial planning of a shelter must meet the basic needs of the refugees, such as physiological and safety needs. However, this is not enough and as some may be suffering from PTSD, a shelter's spatial plan is important for their recovery. To this end, the spatial configuration of a shelter must be planned given the psychological state and spatial behavior of the refugees in a post-disaster, stressful situation. This study is meaningful in that it complements the shortcomings of previous studies that emphasized user-centric spatial planning but did not provide specific strategies for the design of a better spatial configuration. This study is meaningful in that it complements the shortcomings of previous studies, which focused on the efficient management of a shelter or, even when they did emphasize user-centric spatial planning, did not provide qualitative basis for spatial behaviors of the users. The academic evidence presented in this study can have practical application for future mega-shelter guideline preparation, since the criteria for the spatial planning of shelters are provided.

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