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Childcare Center Evacuation to Vertical Shelters in a Nankai Trough Tsunami: Models to Predict and Mitigate Risk

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Abstract: Following the Great East Japan Earthquake, vertical evacuation shelters (VES) were constructed to reduce tsunami risk. Childcare centers (CCs) in the inundation area are required to evacuate to the nearest VES in the event of a tsunami. The study aim was to identify CCs and VES predicted to be inundated by a Nankai Trough earthquake-generated tsunami, and to clarify CC inundation risk. We identified 52 (45.6%) CCs in the tsunami inundation area and found that 14 (25.9%) would evacuate toward the tsunami. If the walking speed was 2.24 km/h and a 0.3 m tsunami arrived in 10 min, nine (17.3%) CCs would be late to safe evacuation. If the tsunami arrival time was 20 min, four (7.7%) CCs would have late evacuation. At a walking speed of 1.00 km/h, 38 (73.1%) and 20 (38.5%) CCs would have late evacuation, with tsunami arrival times of 10 min and 20 min, respectively. Evacuation direction is important in avoiding tsunami damage. An evacuation strategy is needed that evacuates people away from the tsunami, and takes into account children's age, walking speed, and evacuation method. The evaluation of tsunami risk in this study may support the development of tsunami countermeasures in other coastal areas with latent tsunami risks.

Keywords: childcare center; vertical evacuation shelter; tsunami; Nankai Trough earthquake; geographic information system

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1. Introduction

In 2011, a tsunami generated by the Great East Japan Earthquake led to more than 23,000 human casualties in Japan [1]. Hori et al. predicted that a Nankai Trough earthquake will occur in the 2030s and will be as large as the 1845 Ansei Nankai earthquake [2]. The Japanese government is asking local governments to develop measures against a possible tsunami generated by a Nankai Trough earthquake. Tsunami disaster countermeasures are an important issue for cities on the Pacific coast that are expected to experience damage from a Nankai Trough earthquake in the near future. Kochi City faces the Pacific Ocean and has a population of approximately 323,000. Approximately 47% of the population of Kochi Prefecture is concentrated in Kochi City [3]. If a Nankai Trough earthquake occurs, the tsunami may reach a height of 16 m and is expected to cause long-term flooding of approximately 2800 hectares [4]. Since the Great East Japan Earthquake in 2011, some buildings have been designated as emergency evacuation sites in the event of a tsunami, in case it is not possible to evacuate to outside the flooded area [5]. On the coast, local governments are building tsunami evacuation towers (TETs) as refuges for individuals unable to quickly escape the flooded area [6].

In Japan, childcare centers (CCs) care for children aged 0–6 years. The Child Welfare Act requires CCs in Japan to conduct evacuation drills once a month [7]. A study of evacuation behaviors during the Great East Japan Earthquake found that children aged 3–5 years were instructed to walk side by side under the guidance of a teacher, and children aged 0–2 years were carried piggyback or in strollers for multiple passengers. Local support for evacuation was also provided [8]. Analysis by Akizuki et al. of evacuation behaviors during the Great East Japan Earthquake suggested that during tsunamis, it is impossible to prevent local residents from trying to save children in CCs, even though residents know they are at risk from the tsunami. Therefore, CCs should be located higher than the tsunami flood levels [9]. In the areas affected by the tsunami caused by the Great East Japan Earthquake, construction work is being carried out to raise the land and residents are moving to higher ground. However, there are many residents and CCs in areas that were not affected by the Great East Japan Earthquake but that are predicted to be affected by tsunamis.

Iwate, Miyagi, and Fukushima were severely damaged by the Great East Japan Earthquake. There were 15,876 victims in total one year after the disaster, of whom 466 were 0–9 years old. In this disaster, most of the children affected were in schools and childcare facilities [10]. It is speculated that it was particularly difficult to evacuate toddlers, who walk slowly. The impact on children who survived the tsunami is also serious. Many had post-traumatic stress disorder and depressive symptoms after the tsunami [11,12], and felt guilty that they had survived [13]. The effect of the tsunami disaster on children was therefore complex.

To enable children in CCs to quickly evacuate in the event of an earthquake-generated tsunami, it is necessary to identify the nearest non-flooded area and the shortest route to that location, and to formulate a carefully considered evacuation strategy. Above all, it is important that CCs near the coast have tsunami evacuation strategies to save children's lives and avoid damage to the CC. There have been reports of tsunamis caused by earthquakes around the world. When a tsunami occurs, the epicenter is important, but tsunami damage is not limited to the immediate location or by the size of the earthquake. The rise in sea level due to global warming and urban development in low-lying coastal areas both have effects [14,15]. Tsunami evacuation strategies for CCs, where children spend long hours during the day, should be considered in all coastal areas of the world.

To develop evacuation measures for a Nankai Trough earthquake-generated tsunami, several researchers have conducted agent-based modeling and simulation of tsunami evacuation. In 2020, Muhammad et al. evaluated the evacuation plan for Saga City, Kochi Prefecture, and highlighted the necessity of vertical evacuation shelters (VES) and the importance of evacuation speed [16]. Assuming that vulnerable people will evacuate by car, Takabatake et al. conducted a simulation of pedestrian and car evacuation. They found that shelter location and route selection are important for successful evacuation [17]. Kondo has estimated that approximately 46,000 people would be killed even if TETs and tsunami evacuation buildings (TEBs) were constructed, and suggested that in the event of a Nankai Trough earthquake, residents should relocate to higher ground [18]. Geographic information system (GIS) network analysis tools help to determine the reachable range of optimal evacuation sites, evacuation routes, and walking speeds.

There is considerable research on tsunami damage assessment and evacuation using GIS, including traffic flow simulations from a tsunami hazard zone by Wood et al. [19]. According to Kubisch et al., in the event of a tsunami, approximately 40% of the population of Talcahuano, Chile, would not be able to reach the evacuation range even if their walking speed increased [20]. Therefore, walking speed is an important evacuation factor because of delays owing to traffic jams and the destruction of infrastructure. In one study of the Cilacap coastal area of Indonesia, ArcGIS network analysis was used to locate the nearest evacuation shelter buildings, taking into account road conditions and walking speed [21]. In addition, GIS network analysis has been used to search for optimal tsunami evacuation routes and service areas. For example, Sutikno et al. used GIS network analysis to identify appropriate evacuation routes and shelter allocation during a possible earthquake in Pacitan City, Indonesia [22], and Sutikno and Murakami evaluated access to shelters in Indonesia to identify shelters that could not be reached in the event of a tsunami [23]. Kumagai et al. calculated the walking distance from evacuation centers based on lessons learned from the Great Hanshin-Awaji earthquake, and estimated the number of evacuees in each area [24]. We previously assessed the effectiveness of the installation of guide signs to evacuate hearing-impaired people from a tsunami [25]. A previous study on risk assessment for hurricanes examined the suitability of existing shelters and the construction of a model to determine the placement of shelters [26]. Bagewadi et al. used GIS to evaluate and visualize the vulnerabilities in each district in Mumbai, India [27], and Ye et al. used GIS to analyze evacuation demand, access, and optimal evacuation destinations in Shanghai, China, in preparation for an earthquake [28]. In a 2016 study, a tsunami risk map was generated that combined a vulnerability map and an evacuation resilience map to identify important tsunami resources [29].

The walking speed of evacuees is important in timely tsunami evacuation [30]. CCs care for children aged 0–6 years, and the speed of evacuation varies according to the age of evacuees. However, no studies have examined the route to the nearest VES in the event of a tsunami caused by a Nankai Trough earthquake, taking into account the walking speed of children. In this study, we identified the CCs and TEBs/TETs (TETs are VES) in Kochi City that are predicted to be flooded by a tsunami caused by a Nankai Trough earthquake. VES capacity, hierarchy, evacuation environment, CC capacity, and inundation depth were determined. Furthermore, taking into account walking speed and tsunami arrival time, we estimated the number of people who would be late in evacuating to the nearest VES. In recent years, attempts have been made to estimate mortality risks from tsunamis on a global scale [31]. The evaluation of tsunami risk in areas likely to be affected by tsunamis from Nankai Trough earthquakes may help in developing tsunami countermeasures in other coastal areas with latent tsunami risks.

2. Materials and Methods

2.1. Terms Used in This Study

Tsunami Evacuation Buildings (TEBs)

These are buildings used for temporary evacuation in the event of a tsunami. For example, condominiums and office buildings are designated as TEBs by the local government in normal times and published on a website [24].

Tsunami Evacuation Towers (TETs)

These buildings are located in coastal areas where tsunami evacuation is difficult. The towers are used for temporary evacuation from the tsunami [25].

Vertical Evacuation Shelters (VES)

Taking into account the ground subsidence caused by the earthquake and the height of the tsunami, four-story TEBs and TETs or above are defined as VES.

Inundation Depth

In this study, we use the term inundation depth, also termed flow depth in some studies, to refer to the depth at which the (usually dry) ground is covered with water by the tsunami. The flow and approach direction of tsunamis are not considered [32]. In Japan, local governments use hazard maps to indicate the depth of inundation caused by tsunamis and call on residents to evacuate early [33].

Late Evacuation

We use the term "late evacuation" to refer to instances when our model indicates that CCs would not be able to reach safety in the estimated time available to them.

2.2. Types and Sources of Data Used for Analysis

Types and Sources of Data Used for Analysis are shown in Table 1.

Table 1. The types and sources of data used for analysis.

No.	Data Type	Source	Use
1	Childcare center list (point)	Kochi City website	We created a list by collecting information on the name, address, and capacity of childcare centers. We converted the addresses to coordinate values and plotted the centers on a map.
2	Tsunami evacuation building list (point)	Kochi City website	We created a list by collecting information on the name, address, capacity, and building hierarchy of tsunami evacuation buildings. We converted the addresses to coordinate values and plotted the buildings on a map.
3	Tsunami evacuation tower list (point)	Kochi City website	From the list of evacuation sites in Kochi City, we extracted the names and addresses of tsunami evacuation towers and created a list. We converted the addresses to coordinate values and plotted the towers on a map.
4	Tsunami inundation area (polygon)	Ministry of Land, Infrastructure, Transport, and Tourism	From the download service of the Ministry of Land, Infrastructure, Transport, and Tourism, we obtained a polygon of the tsunami inundation area with information about the inundation depth. We added this to the map.

2.3. Data Collection

We obtained a TEB list, a TET list, and a CC list from the Kochi City website [5,34,35]. To identify the CCs in the tsunami inundation area of Kochi City, we obtained polygon data of the tsunami inundation area from the website of the Ministry of Land, Infrastructure, Transport, and Tourism [36].

2.4. Target Area

The target city is Kochi City, Kochi Prefecture, in the Shikoku region of Japan. Kochi City is located on the Pacific coast and has a population of 324,191 (Figure 1) [37]. A Nankai Trough earthquake may have a seismic intensity of 7 in the area between Shizuoka Prefecture and Miyazaki Prefecture, and will likely cause a large tsunami of 10 m or more [38,39]. The Nankai Trough has an average depth of 4000 m and a depth of 150–200 km off the coast of Kochi Prefecture, and has caused several earthquakes of magnitude of 8 or more at intervals of approximately 100 years [38]. If a Nankai Trough earthquake occurred, it is estimated that the ground in Kochi City would subside 1.5 m and approximately 2800 hectares of land would be inundated for a long time [4].

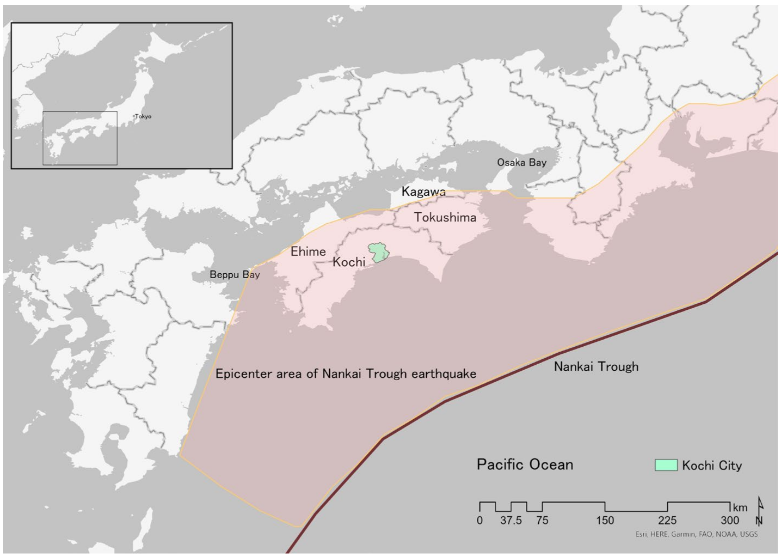

Figure 1. Location of Kochi City, Japan, the epicenter area of the Nankai Trough, and the projected region of a Nankai Trough earthquake. Gray areas represent the sea, white areas represent the land, and the gray boundary lines indicate prefectural borders. The Nankai Trough epicenter area was determined using ocean plate data [40] 2003, Hugo Ahlenius, Nordpil, Peter Bird from GitHub with reference to a paper by Bird (2003) [41]. The Nankai Trough earthquake source zone was determined by referring to Nankai Trough earthquake source data from the Japan Meteorological Agency [39].

2.5. Location of Vertical Evacuation Shelters (VES) and CCs in Tsunami Inundation Area

We counted the number of TEBs and TETs in Kochi City. For TEBs, we calculated the building hierarchy, the evacuee capacity, and the distribution of locations in flooded areas. We used GIS to plot CCs, TEBs, and TETs on the map to depict the tsunami inundation area. We used the Intersect tool to identify CCs in the tsunami inundation area. We calculated the inundation depth, total capacity, and median of CCs in the tsunami inundation area. Figure 2 shows the CCs and VES in the tsunami inundation area of Kochi City.

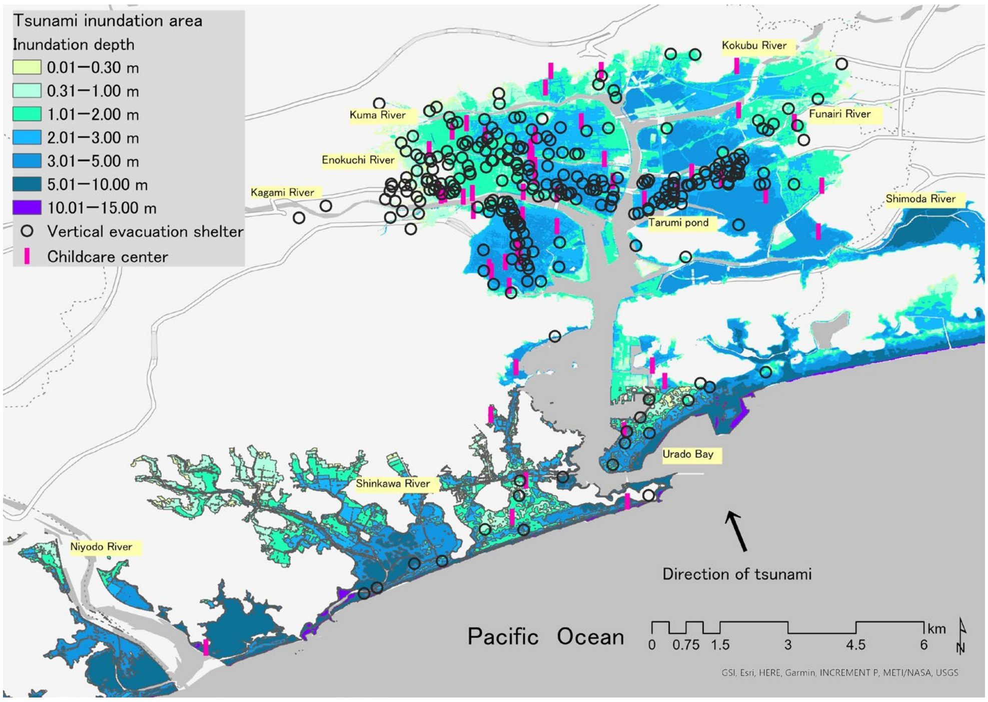

Figure 2. Childcare centers and vertical evacuation shelters in tsunami inundation area of Kochi City. Gray areas represent the sea; white areas represent the land.

2.6. Analysis of Disaster Risk Taking into Account Walking Speed and Tsunami Arrival Time

Using the Find Closest Facilities tool in Arc GIS Pro, we identified pedestrian routes from each CC to the nearest VES. Assuming that the tsunami flows from the coast to the mountains, we visually confirmed the movement path of each CC and the direction of the tsunami inflow from the coastal area, and simply counted the CCs moving toward the tsunami. It should be noted that the direction of evacuation is determined based on visual observation and the results are approximate. For this search, bridges over bays, rivers, and ponds were set to be closed (specifically, Urado Bay, Niyodo River, Shinkawa River, Kagami River, Enokuchi River, Kokubu River, Kuma River, Funairi River, Shimoda River, and Tarumi pond). Walking speed was set as the average speed when evacuating from the Great East Japan Earthquake tsunami toward a hill on foot. The speed of individuals with a companion who had difficulty walking was 1.88 km, and the speed of those accompanied by elderly people and infants was 1.66 km. The baseline travel speed was set as an average value of 2.24 km, assuming that the pedestrian had a stroller and was walking on flat ground [42]. However, there are some limitations to setting a baseline value for travel speed. Walking speed varies according to the child's age and physical strength, and the number of strollers available. Walking speed also varies according to the person carrying the child.

We calculated the distance from each CC to the nearest VES, the median (range) walking time, and the number and percentage of CCs that would evacuate toward the tsunami. With reference to the Kochi Prefecture Disaster Prevention Map [43], we calculated the number and percentage of CCs that are not expected to evacuate within the time it takes for a 0.3 m tsunami to reach them. Kochi Prefecture has published a map of the arrival time of a 0.3 m tsunami, which states that it will be impossible for residents to evacuate on foot and asks residents to evacuate quickly [33]. However, setting the arrival time of a 0.3 m tsunami has important limitations. It does not consider the damage risk until the tsunami reaches 0.3 m. Therefore, it should be noted that there is a risk of disaster before reaching 0.3 m of inundation, and a tsunami may go on to have flow depths that greatly exceed 0.3 m. For GIS analysis, ArcGIS Pro 2.8.0 from Esri (California, CA, USA) was used.

2.7. Estimated Number of CCs Expected to Have Late Evacuation Times for Each Walking Speed

We estimated the number of CCs expected to have late evacuation times at each walking speed. The baseline walking speed was set at 2.24 km/h, a slow walking speed scenario was set at 1.00 km/h or 2.00 km/h, and a fast walking speed scenario was set at 3.00 km/h, 4.00 km/h, or 5.00 km/h.

The analysis flow is shown in Figure 3.

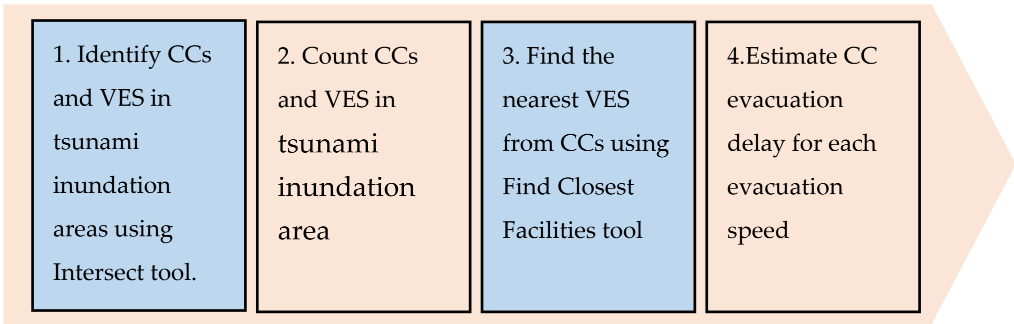

Figure 3. Analysis flow. Analysis using ArcGIS Pro tools is shown in blue. CCs, childcare centers; VES, vertical evacuation shelters.

3. Results

3.1. VES Breakdown and Capacity, Building Hierarchy, and Evacuation Site Environment

The median TEB capacity is 302, with a range of 8 to 71,645. The median number of building stories is five (range: 1–22 stories). Table 2 shows a breakdown of VES building hierarchy and evacuation site environment.

Table 2. Breakdown of VES building hierarchy and evacuation site environment (n = 341).

Items	n	(%)
VES building hierarchy		
TEB	332	(97.3)
1-story or 2-story	49	(14.4)
3-story to 10-story	256	(75.1)
11-story to 22-story	27	(7.9)
TET	9	(2.6)
Evacuation site environment		
indoors	184	(54.0)
partially outdoors	93	(27.3)
outdoors	64	(18.8)

VES, vertical evacuation shelters; TEBs, tsunami evacuation buildings; TETs, tsunami evacuation towers.

3.2. CCs in Tsunami Inundation Area (n = 114)

Kochi City has 114 CCs, with a total capacity of 5531 people, a median of 101 people, and a capacity range of 20 to 265 people. Of CCs, 52 (45.6%) are in areas where tsunami inundation is expected. Figure 4 shows the number of CCs for each inundation depth.

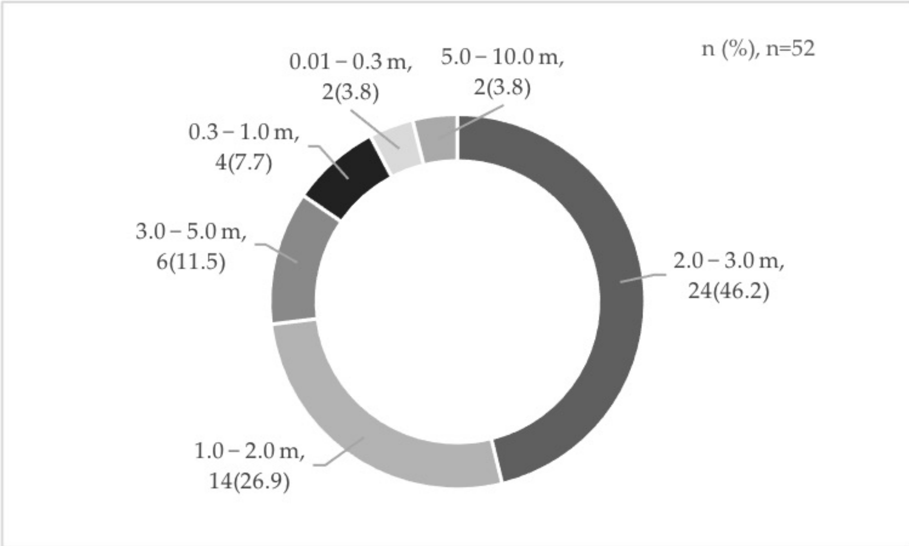

Figure 4. Number and percentage of childcare centers by inundation depth.

3.3. Route Analysis from CCs in the Inundation Area to Nearest VES Using the Find Closest Facilities Tool

In the event of a tsunami, if a person walked at 2.24 km/h and evacuated to the nearest VES, the median evacuation distance would be 0.24 km and the range would be 0 to 3.47 km. The median walking time would be 6.32 min and the range would be 0 to 93.08 min. If the CCs moved toward the nearest VES, 14 CCs (25.9%) would evacuate toward the tsunami inflow and two CCs (3.8%) would not reach the VES by the time a 0.3 m tsunami arrived. If the walking time is subtracted from the tsunami arrival time, two CCs would have late evacuations (shown by negative values): ID1 (−73.08 min) and ID6 (−12.04 min). ID1 and ID6 would be able to evacuate quickly from the flooded area by moving toward the inflow direction of the tsunami instead of moving to the nearest VES (Figure 5). If they evacuated toward the nearest VES, the following CCs would move toward the coast (their Euclidean distances from the coast are shown in parentheses): ID2 (approximately 527 m), ID3 (approximately 131 m), and ID7 (approximately 835 m) (Figure 6).

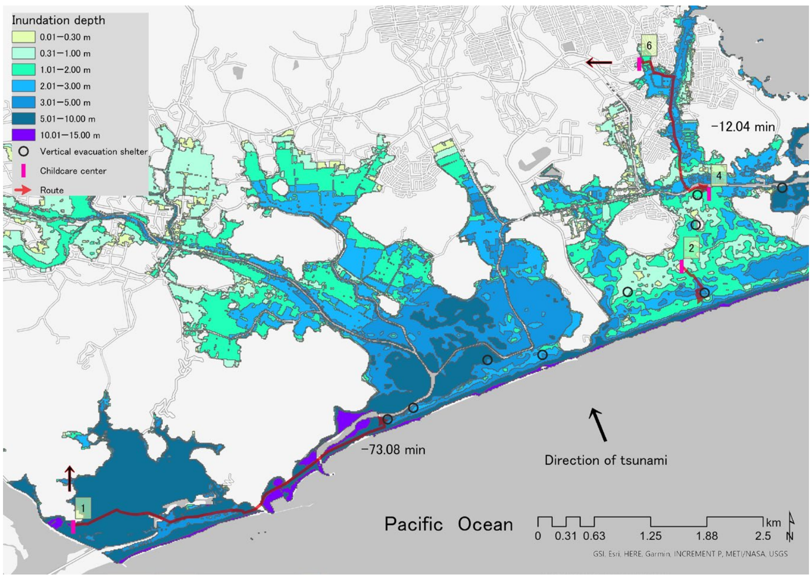

Figure 5. Routes to the nearest vertical evacuation shelter of childcare centers ID1 and ID6 and the direction of rapid evacuation from the tsunami. The direction required for rapid tsunami evacuation is indicated by a black arrow with a red border.

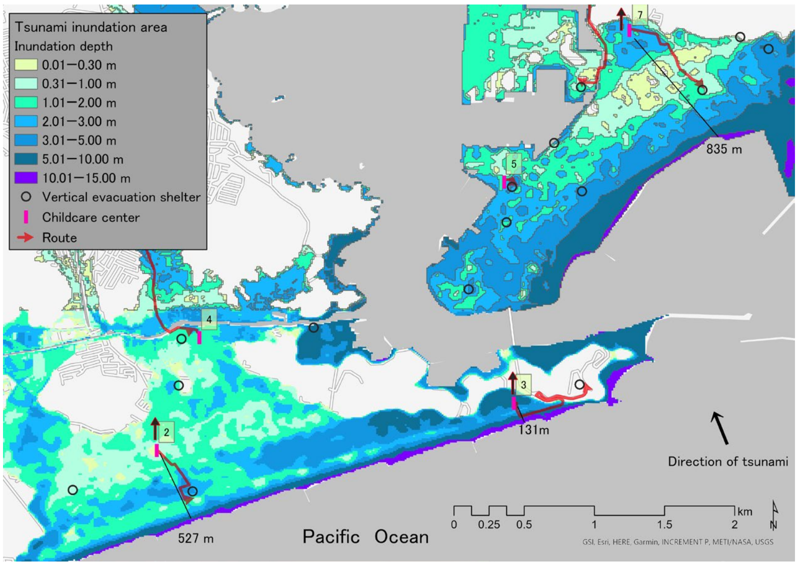

Figure 6. Routes to the nearest vertical evacuation shelter of childcare centers (CCs) ID2, ID3, and ID7, directions of rapid tsunami evacuation, and distances from CCs to the coast. The direction required for rapid tsunami evacuation is indicated by a black arrow with a red border.

3.4. Estimation of CCs That Could Not Evacuate Using Walking Speed and Tsunami Arrival Time

Figure 7 shows the estimated number of late evacuations for each tsunami arrival time according to differences in walking speed. If a 0.3 m tsunami arrived in 10 min, assuming a base walking speed of 2.24 km/h, 17 CCs (32.7%) would have late evacuations. The number of late evacuations for speeds faster than the base walking speed would be 14 CCs (26.9%) at 3.0 km/h, 11 CCs (21.2%) at 4.0 km/h, and 9 CCs (17.3%) at 5.0 km/h. The number of late evacuations for speeds slower than base walking speed would be 20 CCs (38.5%) at 2.0 km/h and 38 CCs (73.1%) at 1.0 km/h.

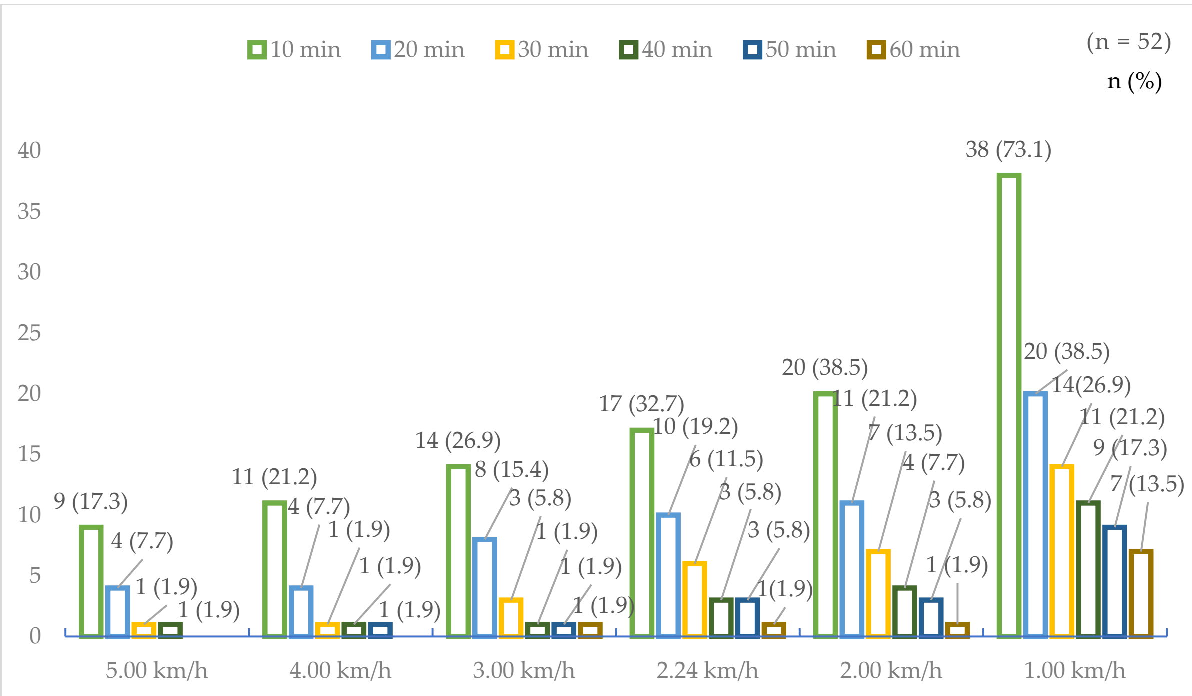

Figure 7. Number of late evacuations by walking speed for each tsunami arrival time.

4. Discussion

In the event of a tsunami caused by a Nankai Trough earthquake, approximately 14% of VES may be damaged from land subsidence because of insufficient building height. Findings from the 2011 Great East Japan Earthquake emphasize the need for VES that are high enough to withstand the estimated tsunami height [44]. Land subsidence has occurred in Kochi Prefecture as a result of a previous Nankai Trough earthquake [45]. During the Nankai Trough earthquake of 1946, land subsidence of approximately 1 m occurred, and it took approximately a month for the seawater to completely disappear [38]. The designation of three-story buildings and below as VES should be carefully considered because of land subsidence. We recommend that policy makers review VES designation taking into account land subsidence caused by a Nankai Trough earthquake.

A tsunami often causes long-term inundation of low-lying land [46]. There are concerns about long-term inundation of the plains in Kochi Prefecture in the event of a Nankai Trough earthquake and tsunami [47]. During the tsunami caused by the Great East Japan Earthquake, some people evacuated to the roofs of school buildings; they had to wait until the next morning for helicopters to arrive [48]. Data from Kochi Prefecture estimate that approximately 130,000 people will be left behind in VES if a tsunami occurs [47]. People who evacuate to VES must expect to wait tens of hours for helicopter rescue. Because 18.8% of VES evacuation sites are outdoors, some evacuees may become ill from exposure to heat or cold. Policy makers need to develop policies that take into account VES capacity, rescue time, and the effect of climate on evacuees' physical condition. Specifically, it is recommended that outdoor VES be insulated from the heat and cold and be equipped with drinking water and an emergency battery, because people may have to remain outdoors for some time after evacuation.

It has been noted that the use of TETs in areas near the coast of Japan may increase casualties by directing evacuees living on higher land to evacuate to TETs on lower land that are at higher risk of flooding [49]. The route analysis using the Find Closest Facilities tool showed that if people evacuate from CCs to the nearest VES, 25.9% will move toward the tsunami. Simply instructing people in CCs to evacuate to the nearest VES is not enough to avoid damage from the tsunami. If ID2 and ID7 in the coastal area move to the nearest VES, they would be moving toward the tsunami. ID3 would also move toward the tsunami, then bypass the coast and move out of the flooded area to the hill. ID2, ID7, and ID3 could evacuate from the flooded area faster by moving toward the tsunami than by moving to the nearest VES (Figure 6). People in areas near the coast do not have time to wait for warnings from the authorities. It has been pointed out that people should act immediately after ascertaining that an earthquake has hit [50]. When developing a coastal CC evacuation plan, it is important to consider the tsunami arrival time at the evacuation route, the direction of the tsunami, and the distance to the land outside the flooded area to determine if evacuation to the nearest TET is optimal. CC evacuation behavior should differ according to the age of the children. Children aged 3–5 years tend to be instructed to walk two abreast under the guidance of teachers, and children aged 0–2 years tend to be carried piggyback or transported in multi-passenger baby strollers [8]. This means that children aged 3–5 years and their teachers must evacuate at the walking speed of a 3-year-old. According to the Ministry of Health, Labor, and Welfare, CC evacuation drills show that the walking speed of a 3-year-old child is approximately 1.0 m/s (3.6 km/h) [51]. Taking into account the child's physical strength and walking endurance, future evacuation plans must assume a walking speed slower than 3.6 km/h. Geographic least-cost distance modeling, which incorporates time-variable exposure, distributed travel speeds, and uncertain evacuation departure time, shows that evacuation departure time has a large effect on total evacuation time [52].

In recent years, the importance of risk reduction in disaster risk management has been highlighted [53,54]. After the Great East Japan Earthquake, Japan implemented a program of TEB designation and TET construction in tsunami inundation areas to reduce risk from tsunamis [55]. The main implications of our findings for CC disaster risk management are that TEB designation, TET construction, and evacuation requests do not reduce risk sufficiently. CC geographic features, tsunami arrival times, walking speeds, and evacuation directions should also be considered to prevent child casualties. Several real and hypothetical tsunami evacuations by Chen et al. [56] show significant delays in departure times. CCs require more evacuation time than institutions with adults, and further research on the evacuation preparation time of nursery schools is necessary. We suggest that such considerations be applied not only to CCs but also more generally in areas of expected tsunami inundation.

This study has some limitations. The present study did not consider the time from the occurrence of the earthquake to the evacuation departure time. Because the time required for departure may vary depending on the age and condition of the child, a more elaborate evacuation strategy is required that takes into account children's age and condition. Incorporation of departure delays would produce higher estimates of fatalities and thus, further research is needed to assess departure time delays for CCs. In the ArcGIS Pro Find Closest Facilities analysis, the tsunami arrival time was set at 0.3 m. This inundation depth simply indicates the height of inundation from the ground surface. It does not consider the direction of the tsunami, the flow speed, or the effects of slope and terrain. Furthermore, depending on children's body shape and walking speed, it is highly possible that children will be unable to evacuate owing to flooding of several cm. We did not consider the time between the occurrence of the earthquake and the start of evacuation. In calculating the difference between the time required for evacuation and the tsunami arrival time, the time taken for the tsunami to reach CCs was calculated, but the time taken for the tsunami to reach the evacuation route was not taken into account. Formulating a CC evacuation plan requires interviews with CC managers about planned evacuation routes and a detailed analysis that includes all additional factors. However, earthquakes occur around the world. This model may also be useful for developing tsunami evacuation plans that match the actual conditions of coastal areas elsewhere.

5. Conclusions

VES need to be well provisioned, and it is also important to take into account evacuation direction, walking speed, and the tsunami arrival time at the evacuation route to prevent late CC evacuation. CCs exposed to short tsunami arrival times should consider relocating to higher ground or, if that is not possible, installing a TET adjacent to the CC. The TEB designation for three-story buildings and below should be reviewed to take into account the land subsidence caused by a Nankai Trough earthquake.

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Data Availability Statement: Information about the addresses and capacity of CCs in Kochi City can be found on the Kochi City Website, List of Childcare Centers in Kochi City 2021 (https://www.city.kochi.kochi.jp/soshiki/34/hoikuyotiitiran.html) accessed on 14 June 2021. Information about the addresses and capacity of TETs can be found on the Kochi City Website, List of Evacuation Sites and Shelters (https://www.city.kochi.kochi.jp/site/bousai/hinanbasyo-hinansyo.html) accessed on 14 June 2021. Information about the addresses and capacity of TEBs and the evacuation environment is published on the Kochi City Website, Tsunami Evacuation Building (https://www.city.kochi.kochi.jp/soshiki/12/tunamihinannbiru.html) accessed on 14 June 2021.

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Conflicts of Interest: The authors declare no conflict of interest.

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