# Evacuation and Sheltering Assistance for Persons with Special Needs at Times of Disaster: Lessons Learned from Typhoon 23, Heavy Rainfall and Earthquake Disasters in the Year 2004

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## Abstract

A series of heavy rainfall, typhoon and earthquake disasters caused a proportionately large number of deaths among the elderly in the year 2004 in Japan. In response to these tragedies, the national government set up committees to reduce damage within the disaster vulnerable population for the next three years. The discussions in the committee led to a new conceptualization that disaster vulnerability was caused by a lack of interaction between a person's special needs and the environment's capacity and resources to meet them. This person-in-environment model of hazard vulnerability was applied to those who resided in the Nankai-Tonankai tsunami hazard-prone area. 123 home care service users were interviewed in terms of their self-evacuation ability, degree of social isolation, and building weakness as well as tsunami exposure risks. Results were quantified and scores of person-in-environment-model hazard vulnerability were obtained. These scores were then used to visualize socially created vulnerability by means of weighted kernel density mapping of both persons with special needs (PSN's) and persons with special needs at times of disaster (PSND's).

***Keywords***: *Persons with Special Needs, Disaster, Evacuation and Sheltering Assistance Hazard Vulnerability, Person-in-Environment Model, GIS Mapping of Social Vulnerability*

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## 1. Introduction

Future historians will remember the early 21st century in Japan as a time of a high frequency of natural disasters including strong typhoons, heavy rain falls, floods, land slides, and earthquakes. The scientific community, government, business, as well as the civil society sectors currently share the view that the Japanese Archipelago has entered into a high earthquake occurrence period since the 1995 Kobe earthquake. The same is true for typhoons. Figure 1 shows 10-year averages of typhoon disaster casualties by their magnitudes (Fukuma, 1993) [1] from 1913 to 2005. Figure 1 indicates that no typhoons of the strongest magnitude attacked the Japanese islands between 1961 and 1991. However, this trend disappeared and extremely strong magnitude typhoons started causing damage and casualties almost every year since the end of the 20th century. It should be noted that 5 out of 10 typhoons that hit Japan in the year 2004 were at the strongest magnitude level. The total number of typhoon casualties during the last 40 years of the 20th century (167 deaths) is approximately the same as those in the year 2004 alone (163 deaths). In addition to typhoons, heavy rain fall in July and the October Niigata-Chuetsu earthquake also caused severe damage and losses within the very same year.

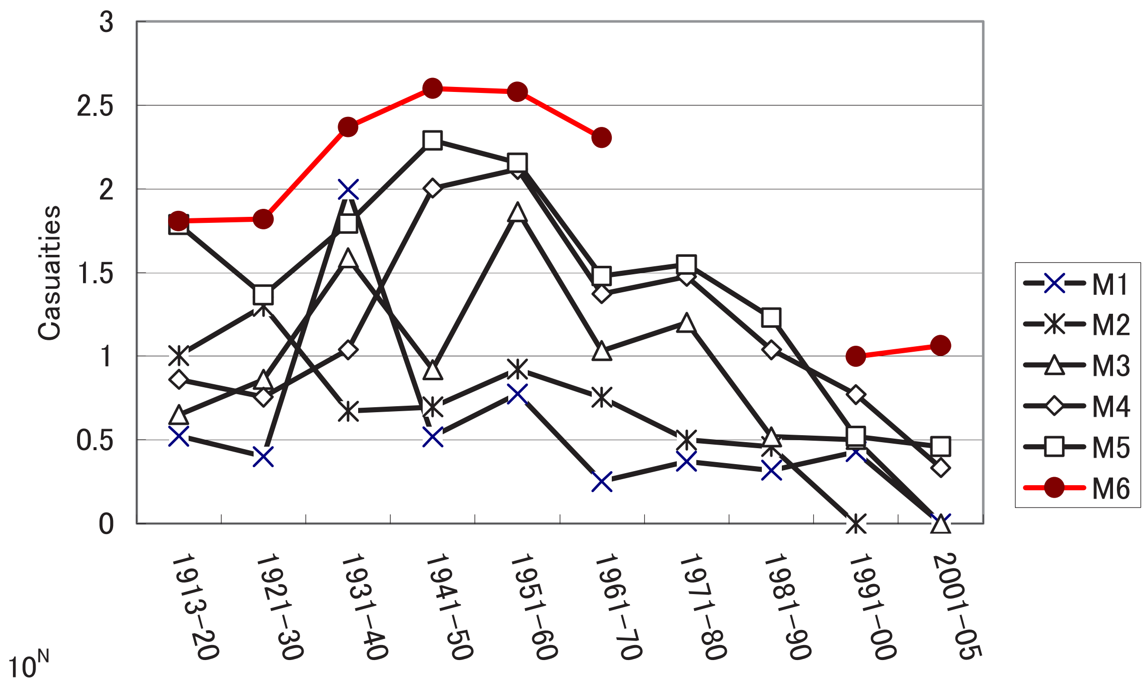


Fig. 1 10 Year Averages of Typhoon Disaster Casualties by Magnitudes from 1913 to 2005.
Source: Fukuma (1993) and Meteorological Agency Annual Reports from 1994 to 2005.
Typhoon magnitudes were calculated by means of the maximum wind velocity and radius as proposed by Fukuma (1993).

It should be noted that more than 60 % of the 2004 natural disaster victims were those who were over the age of 65. In October, 2004 as a response to these tragedies, the National government set up a committee on disaster information communication and evacuation/sheltering to provide assistance for the elderly/disadvantaged population during heavy meteorological and other disasters. The committee published Evacuation/Sheltering Assistance Guidelines for Persons with Special Needs at times of Disaster (or PSND) the following March, 2005[2]. Following a series of heavy rainfall, flood and land slide disasters in the year 2005, another committee conducted field research of the 2005 meteorological disaster sites and revised the guidelines that were published in March 2006[3]. The revised guidelines emphasized three policies: 1) establishing a special team in each local government that was in charge of communicating disaster information to the target population through neighborhood associations, 2) encouraging the information sharing of special needs population within the local government and, if possible, with local neighborhood-based associations, and 3) planning individualized evacuation/sheltering procedures for each PSND. In the following years 2006 and 2007, the committee on PSND continued working out policy directions with regard to collecting/sharing PSND information, workflows and more detailed procedures to make individualized evacuation/sheltering assistance plans. The author was a member of the committee from fiscal year 2006 to 2007. Based on discussions made during these years, this paper aims to define the concept of PSND, and to propose a GIS-based technical solution in order to visualize the whereabouts of PSNDs in order to facilitate implementation of individualized evacuation/assistance programs for PSNDs.

## 2. Disaster and Vulnerability: Socially Created Phenomena

Past urban mega-disasters have offered many lessons for society. One valid lesson is that a hazard does not affect an impacted area equally. In other words, the magnitude of hazard damage (D) is determined not only by hazard (H) itself but also by vulnerability (V) (Blaikie et. al., 1994) [4] or D = f(H, V).

Vulnerability was defined as “the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard” (Wisner et.al., 2004, p.11) [5]. This implies that disaster is a socially created phenomenon. The year 2009 marks the 50$^{th}$ anniversary of the 1959 Ise Bay Typhoon that caused more than five thousand deaths. Figure 2 illustrates the flooded area in Mie prefecture during the typhoon attack, which caused banks and levees to collapse due to the high tide and

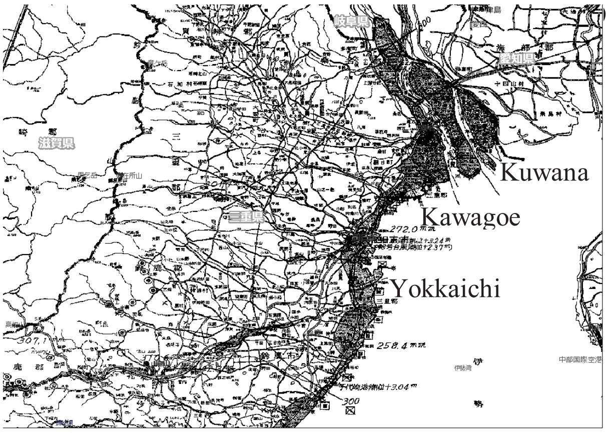

Fig. 2 Mie Prefecture Flooded Area due to 1959 Ise Bay Typhoon.

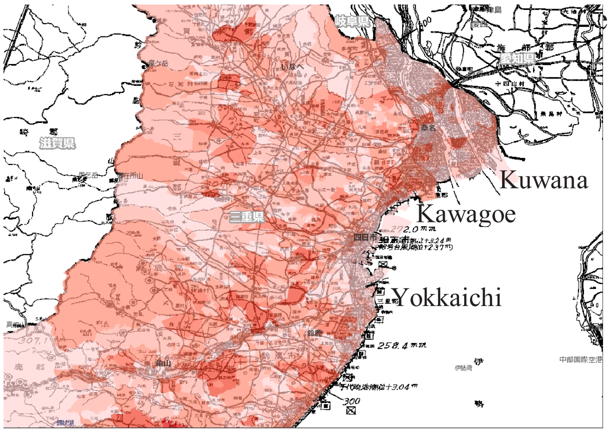

Fig. 3 The Current Population Density and the 1959 Ise Bay Typhoon Flooded Area Overlay

strong storm surge. Figure 3 shows the 1959 typhoon flooded area and the current (i.e., the year 2005 census) population density overlay. It should be noted that the 1959 typhoon flood attacked central regions of Chukyo Industrial area. The responses to the typhoon disasters, however, differed among municipalities. Yokkaichi city, one of the leading petrochemical industry bases in the country, initiated mitigative measures to encourage re-settlements to higher ground after the 1959 flood. This made the city less susceptible to future flooding disasters. In contrast, settlements in the flood-prone area in the township of Kawagoe and parts of Kuwana city increased over the following fifty years. These two municipalities attracted an influx of new residents who found the location very convenient for commuting to either Yokkaichi or Nagoya city, the central business region of the Chukyo Industrial area. As a result, flood disaster susceptibilities in these two regions continued or even increased over the past 50 years through socio-economically created processes.

The investigation of causes of death due to the 2004 Niigata flooding disasters by Hayashi and his associates (Hayashi & Tatsuki, 2004 [6]; Hayashi and Tamura, 2005) [7] identified three types of causes: 1) Rapid water flow which crushed the wooden houses that were near where the levee broke (3 casualties), 2) drowning during a sudden increase of water level while being outside (two were on their way to evacuation center) (5 casualties), and 3) drowning because no one came to assist them to evacuate when the water level rose above the floor (4 casualties). The last category of people shared the following characteristics: They were all over the age of 75, had trouble walking due to age-related illness and thus were receiving home care services, were either single or in two person (both being elderly) families, and lacked key persons who they could rely on at times of emergency except for formal service providers. The last characteristic was found to be the most crucial cause of death. Although they were physically frail, these 4 elderly were able to enjoy everyday life in their own homes thanks to the help available from home care services that were provided by public long term care insurance programs. The flooding disaster attacked not only house care service users but also service providers alike making it impossible for them to come to the rescue.

The above investigation results implied that hazard vulnerability was *not* intrinsic to a person or group, but it was created due to the lack of interaction between persons who had special needs for assistance at times of disaster and his/her immediate environment. In other words, hazard vulnerability is also created socially. This model was named the person-in-environment model of vulnerability where vulnerability (V) is defined as a function of person (P) and environment (E) factors or $V = f(P, E)$.

If we incorporate the discussions of 1) disaster as a socially created phenomenon and 2) hazard vulnerability as also being socially created, we come to the following understanding of damage (D) caused by disaster or $D = f_1(H, f_2(P, E))$

The above definition provided the conceptual framework for the aforementioned committees to recommend Evacuation/Sheltering Assistance Guidelines for Persons with Special Needs at Times of Disaster[2] [3].

**3. GIS Mapping of Persons with Special Needs at times of Disaster (PSND)**

Suzan Cutter has been one of the most influential proponents of GIS Mapping of social vulnerable population (e.g., Cutter, 2006) [8]. In her work, social vulnerability has been defined according to the model, $D = f(H, V)$, as proposed by Blaikie et.al. (1994) and Wisner et.al. (2004). The indices of social vulnerability thus included 1) lack of access to resources including information, knowledge, and political power, 2) certain beliefs and customs, 3) weak buildings or individuals, and 4) infrastructure and lifelines. She obtained census and other street block data related to the above indices and mapped them over the hazard layers. Using basically a similar technique, however, the current author proposed the person-in-environment model of vulnerability, i.e., $D = f_1(H, f_2(P, E))$. This required the gathering of individualized person-in-environment data in order to measure each individual's social vulnerability. In order to illustrate the difference from the conventional approach, results from one of the social vulnerability mapping projects (Ochi & Tatsuki, 2007) [9] are presented the below.

**3.1 Method**

The sample consisted of 123 individuals who were using home care services in Kobe city's Uozaki area that are likely to be flooded by the next Nanka-Tonankai earthquake tsunami. The population of endangered home care service users in the Uozaki area was 1210.

386 service users were approached by their case managers and 123 agreed to answer the interview questionnaires. The questionnaire asked three types of variables. The first variable was concerned about person factor in terms of self-evacuation ability as measured by a level of required home care services (ranging from pre-care, level 1 to 5). The second set of variables asked the degree of social isolation that was measured by gender, age, types of home care service being used, family structure, if he or she being alone during day time, types of key person, and key person address. The third variable examined building weakness (building age) and tsunami exposure risk (bedroom on the first, second floor or above).

### 3.2 Results

With regard to a person factor, nearly half (58) of the 123 respondents were above care level 3, indicating difficulty of self-evacuation. Social isolation variables were analyzed by Dual/optimal scaling (see Table 1). The results revealed that those who were female, over 85 years of age, using home-help as opposed to day-care or short-term stay services, living alone, not living with key person were the highest on the level of social isolation. Building weakness and hazard exposure risk variables were also Dual-scaled. It showed that those who resided in wooden houses built before 1981 (after which the new building code was introduced) and those whose bedrooms were on the first floor turned out to be more vulnerable (see Table 2).

Table 1. Dual/Optimal Scaling Results of Social Isolation Variables

| | Option | Frequency | Option Weights |
|---|---|---|---|
| Gender | Male | 46 | 0.411 |
| | Female | 77 | -0.265 |
| Age | Under 65 | 14 | -0.065 |
| | 65 - 75 | 21 | 0.080 |
| | 75 - 85 | 58 | 0.108 |
| | 85 - | 30 | -0.284 |
| Shor-term Stay Service | Yes | 17 | 0.687 |
| | No | 106 | -0.124 |
| Day-Care Services | Yes | 61 | 0.333 |
| | No | 62 | -0.351 |
| Home-Help Services | Yes | 69 | -0.614 |
| | No | 54 | 0.757 |
| Types of Family | Single | 36 | -1.247 |
| | Couple | 40 | 0.889 |
| | Living with Son | 27 | -0.009 |
| | Living with Daughter | 16 | 0.463 |
| | Living with Partent | 1 | 1.108 |
| | Living with Grandchil | 2 | -0.438 |
| | Living with Sibling | 1 | 0.421 |

| | | Frequency | Option Weights |
|---|---|---|---|
| Alone during Day | Yes | 57 | -0.802 |
| | No | 61 | 0.774 |
| | N.A. | 5 | |
| Key Person | Spouse | 32 | 1.091 |
| | Son | 36 | -0.577 |
| | Daughter | 28 | -0.218 |
| | Daughter in Law | 5 | 0.142 |
| | Sibling | 5 | -1.145 |
| | Other | 2 | -0.303 |
| | N.A. | 15 | |
| Key Person Address | The Same | 63 | 0.666 |
| | The Same Block | 7 | -0.198 |
| | The Same Ward | 13 | -0.857 |
| | The Same City | 8 | -1.511 |
| | The Same Prefctr | 4 | -1.251 |
| | Outside Prefctr | 5 | -1.469 |
| | N.A. | 23 | |

Table 2. Dual/Optimal Scaling Results of Building Weakness and Hazard Exposure Risk Variables.

| | | Frequency | Weight |
|---|---|---|---|
| Bedroom Floor | 1st Floor | 49 | -1.078 |
| | 2nd Floor or a | 74 | 0.712 |
| When the House was built | Before 1981 | 48 | -0.408 |
| | After 1981 | 75 | 0.259 |

| | | Frequency | Weight |
|---|---|---|---|
| House Structure | Woden | 31 | -1.550 |
| | RC-Reinforce | 90 | 0.537 |
| | N.A. | 2 | |

An overall degree of special needs was then calculated by combining scores for 1) self-evacuation difficulty, 2) social isolation and 3) building weakness/risk exposure. Using these scores as weights, a weighted kernel density map was created (see Figure 4), which visualized overall person-in-environment vulnerabilities which was represented by the following equation: V = f(P, E). In Figure 5, the tsunami hazard exposure factor was entered into the equation, which represented the degree of special needs at times of a tsunami disaster. In terms of formulaic representation, this was equivalent to $D = f_1(H, f_2(P, E))$.


Fig. 4 Weighted Kernel Density Map of Persons with Special Needs or PSNs.


Fig. 5 Weighted Kernel Density Map of Persons with Special Needs at Times of Tsunami Disaster or PSNDs.

The current paper proposed a GIS-based technical solution that helped not only to visualize the whereabouts of PSNDs but also to facilitate implementation of individualized evacuation/assistance programs for PSNDs utilizing the GIS data base.

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