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Field report

Disaster preparedness of hillside residential area in Nagasaki city, Japan: evaluations regarding experiences related to a fire

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Abstract

Objective: An accidental fire that occurred in a hillside residential area in the city of Nagasaki was evaluated to assess the challenges faced by communities located on sloped terrains and to develop community-based support systems applicable to such hillside residential areas.

Methods: Community observations and key-informant interviews were performed in the area affected by the fire. A self-administered questionnaire survey was also conducted among residents of the affected area. Information obtained through community observations of the fire-struck area and key-informant interviews was analyzed and assessed using a two-dimensional (2D) framework.

Results: According to community observations and key-informant interviews, initial firefighting efforts were delayed due to lack of preparedness, in addition to geographic factors such as narrow roads and outdoor staircases, which allowed the fire to spread. The livelihood and health support measures for elderly residents requiring evacuation assistance were also insufficient. A hospital neighboring the area affected by the fire accident voluntarily provided some services to evacuees, but support from other nearby organizations/institutions was either not available or not offered. According to the questionnaire answers, elderly residents had little knowledge of the location and proper use of fire hydrants in their area. In addition, 65% of the respondents had never participated in disaster training exercises. From these results, the following three points could be determined: 1) The geographic features of the hillside residential area enhanced the spread of the fire. 2) The multi-sector support systems for evacuees were inadequate, collaboration among the existing systems was insufficient, and the roles of those systems were not fully clarified in advance. 3) Elderly residents in the hillside residential area did not have sufficient the knowledge and/or ability to engage in fire prevention activities and had inadequate firefighting skills.

Conclusions: It is important to improve disaster preparedness knowledge and training for local residents on ordinary times. Additionally, cross-sector collaborative disaster response, harmonious management, and support systems must be ensured and sustained before, during, and after disasters.

Key words: elderly, hillside residential area, disaster preparedness, fire disaster

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Introduction

Environmental conditions, including not only "hard" infrastructure such as buildings or vehicles but also "soft" components such as the transport system and the accessibility and availability of food and other daily necessities, are essential for maintaining a healthy human life. These environmental factors directly and indirectly influence the health status of a population, in addition to providing an equal guarantee of health systems and services[1, 2].

The city of Nagasaki, capital of Nagasaki Prefecture, is spread over a large urban area containing more than 420,000 residents. Approximately 43 percent of the city's residential area is hillside terrain where narrow roads and steep outdoor stairways limit access by cars and other vehicles[3] and those geographic factors impose difficulties on the daily life styles of elderly persons as well as those with disabilities. Previous studies have shown that environmental factors such as limited transportation and accessibility to medical and health-care services have a negative impact on the self-

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rated health of community residents[4, 5].

A recent study by the authors revealed that elderly residents living in hillside areas were more likely to experience falls and less likely to go outdoors and/or participate in social activities, and that both factors were related to their self-rated health evaluations[6]. Because of the environmental disadvantages in the hillside areas, the population there continues to decline and to age.

Other studies of hillside residential areas have examined landslides and rainfall from civil engineering viewpoints[7–9], but there have been few studies related to community health.

With the above conditions in mind, the present study focused on a fire that occurred in a hillside residential area and wrought significant damage to the local community and the lives of the residents. We used multiple approaches, including qualitative and quantitative data collection, and data integration[10] to verify the factors that functioned to cause the expansion of the fire and produced serious damage in the affected area.

The aim of this study is to illustrate the challenges of an accidental fire in a hillside residential area and to develop community-based support systems and management.

Methods

Data collection

In this research, we employed field observations, key-informant interviews, and a self-administered questionnaire distributed to the residents of the area affected by the fire. The observation and interview data obtained were analyzed by qualitative methods, while the questionnaire data were analyzed by a quantitative method. The research was carried out via the following three processes.

1) Field observations

The fire broke out in a hillside residential area in the central area of Nagasaki in 2015. The authors visited and observed the location where the fire occurred, performing field observations to assess disaster preparedness in terms of road conditions, location and availability of fire hydrants and hoses, condition of houses, and geographic characteristics.

2) Key-informant interviews

Using an interview guide we developed, we conducted semi-structured interviews with staff of a neighboring hospital which played a key role in supporting the evacuees, including a nurse manager and an administrative officer, and with two Nagasaki City Fire Department staff members. Our interview guide consisted of questions for the hospital staff about conditions after the fire and questions for the fire department staff about the fire itself and the city's fire prevention systems in general.

3) Self-administered questionnaire among residents of the fire-struck area

After obtaining qualitative data from the environment and circumstances related to the fire, a self-administered questionnaire survey was conducted to complement the qualitative analysis. This questionnaire was completed by 38 elderly residents of the area where the fire occurred, who were also health exercise class participants with foreseeable vulnerabilities in the event of disaster evacuation. The questionnaire included sociodemographic information (age, sex, and family structure), health status (diseases currently being treated, current ailments, and self-rated health conditions), economic status, need for evacuation support, disaster-related knowledge (evacuation locations, fire hydrant locations, and ability to use fire hydrants), attitudes toward disasters (disaster training participation and whether they had a plan to notify family of their safety in the event of disaster), and disaster preparedness.

Analysis

1) Qualitative data analysis

Data obtained through field observations and in-depth interviews were presented and shared among the authors in the form of cards with key concepts written on them. The cards were categorized and arranged in a framework demonstrating the risk to life on the vertical axis and the chronological stage of disaster on the horizontal axis. The assessment process was repeated several times until the authors reached consensus.

2) Quantitative data analysis

After analysis of descriptive statistics, the association between disaster preparedness and sociodemographic characteristics was analyzed by a χ^2 test. Statistical analysis was conducted using descriptive statistics, and factors related to disaster preparedness were explored using univariate analyses. IBM SPSS Statistics version 20 was used for statistical analysis. The statistical significance was set at $p<0.05$.

Ethical considerations

This study was conducted from September to December 2016 after approval by the Ethical Committees of the Nagasaki University Graduate School of Biomedical Sciences (authorization number: 16081826).

Results

Qualitative analysis

1) Fire profile

The fire, which occurred in a typical hillside residential area (Area X) on a Saturday evening, was caused by a visually impaired elderly man, living alone during the daytime, who smoked a cigarette and failed to properly put it out. Neighbors initially responded to the fire and tried to extinguish it but failed. Fire engines could not get to the scene due to narrow roads and hills with stairs access, thereby delaying initial firefighting efforts. Moreover, the fire hydrants in Area X did not fit the firefighters' hose nozzles, making hose connections impossible. The hydrants' hose fittings had been renewed one month earlier, and residents of Area X had not confirmed whether they matched the hoses.

In spite of residents' efforts to extinguish the fire by forming a bucket brigade, it continued to burn for eight hours, and the visually impaired elder whose cigarette started it failed to escape and died. After the fire, ten residents of Area X, mostly elderly, were forced to evacuate to a local community center.

2) Hospital staff interviews

The community center was not prepared to accept evacuees. The neighboring hospital provided blankets to those who suffered from the cold, and neighborhood volunteers initially provided cold meals. Later, because there were no baths in the community center, the hospital opened its bathing facilities to the evacuees and provided hot meals cooked in the hospital kitchen. In addition, because some evacuees with high blood pressure had lost their medications in the fire, the hospital director, who was a medical doctor and nurse manager, carried out medical examinations, provided health consultations, and supplied replacement medications where needed. All these services were provided pro bono by the hospital. No collaborative system existed between the hospital and the city administration; hence, no information on the evacuees' health was passed on to the city administration. Staff from the city's Community Support Service Center did not arrive until the second week after the fire. A few weeks later, evacuees were required to move into public housing or relatives' homes, where they felt uncomfortable in unfamiliar locations, having lost connections with long-time neighbors, and expressed their desire to return to their original neighborhood. Even under such circumstances, administrative staff were not dispatched to help alleviate the situation. On the contrary, elderly victims encountered difficulties going to the city hall by themselves due to distance and/or transportation cost.

3) Fire department staff interviews on general activities regarding firefighting and rescue

There are a number of civic organizations that work with the Nagasaki City Fire Department. For example, civilian fire protection clubs carry out community-based activities related to disaster prevention in conjunction with the fire department on a daily basis.

The hillside residential areas of Nagasaki, including Area X, have many narrow roads and steep outdoor stairways where ambulances or stretchers cannot pass. Additionally, most homes in such areas are old wooden structures built close together, which can allow fires to spread easily and rapidly. Rescue activities in these areas require special tools such as "Doctor-heli" (emergency medical service helicopters) or canvas stretchers, depending on geographic conditions.

Qualitative analyses by two-dimensional framework

Table 1 shows a two-dimensional framework created with data extracted from the field observations and interviews. The horizontal axis shows the four time intervals into which the fire experience could be divided: "Ordinary times", "Start of fire", "Evacuation life", and "A few weeks later". For each interval, different contexts were found and arranged according to their level of risk to human life as given on the vertical axis, from "Very low" to "Very high".

In "Ordinary times", it was found that local citizens and the fire department need to collaborate and prepare for disasters while considering local environmental conditions. We named this activity "Disaster prevention activities, systems, and characteristics".

During the "Start of fire" period, numerous fire-related risks and fire spreading factors were identified. These factors were named "Fire accident details". The facts that the fire spread easily and that initial firefighting was delayed were ranked high on the level of risk to human life. In contrast, fire extinguishing efforts by residents collaborating with firefighters were assigned as low risk to human life.

During the "Evacuation life" period, the neighboring hospital provided some life and medical support to the elderly evacuees staying in the community center. This activity, named "Relief support for evacuees", revealed numerous difficulties of evacuation life that posed risks to human life.

In the period named "A few weeks later", there was the adverse influence of translocation and support system uncertainties. Named "Lack of livelihood support", and this problem area included issues such as loss of the evacuees' relationships with their neighborhood due to translocation and the confusion regarding the roles of evacuee support groups.

Through comprehensive assessments, three major findings were identified and confirmed that: 1) Collaboration

Table 1 Framework of contexts by field observations and interviews

		Chronological stage			
		Ordinary times	Start of fire	Evacuation life	A few weeks later
		Disaster prevention activities, systems, and characteristics	*Fire accident details*	*Relief support for evacuees*	*Lack of livelihood support*
Level of Risk impact on life	1. Very low	There exists a collaboration system between citizens and fire dept. "Voluntary civil disaster prevention organizations collaborate in Nagasaki City."			
	2. Low	Citizens and fire dept. jointly engage in regional disaster prevention activities. "Meeting of disaster prevention plans within community." "Citizens help conduct disaster prevention activities."	Fire was extinguished by residents and firefighters. "Local residents helped extinguish fire by forming bucket brigades" "Fire fighters connected a hose to a distant fire hydrant"	Residents whose homes were burned were evacuated to community center. "Community hall was difficult for living. Evacuees moved to a community center."	Evacuees were moved from their homes to other places. "Evacuees were in unfamiliar locations, resulting in loss of connections with longtime neighbors."
	3. Neutral	There are special patient transportation systems for islands and remote areas. "Dispatch doctors to islands and remote areas by helicopter."	There exist multiple fire-causing factors. "Elderly living alone, visually impaired, smoking cigarette."	Many evacuees were elderly. Support was provided by local hospital volunteers. "Provision of blankets, bathing facilities, cooking of hot meals by hospital volunteers.	Confusion arose regarding support system and roles after the fire. "Administrative staffs were not dispatched. Victims encountered difficulties going to the city hall by themselves." "Lack of collaborative system between hospital and city administration."
	4. High	Special methods are required for transporting patients in hillside residential areas. "Use canvas stretchers and ensure that portable AEDs are available."	Initial firefighting was delayed due to rough hillside terrain. "Fire engines could not approach due to narrow roads, outdoor stairs" "Size of fire hydrants and firefighting hoses did not match"	Health support was provided by local hospitals. "Doctor and nurse performed medical exams and health consultations, and supplied replacement medications."	
	5. Very high	Geographic characteristics of hillside residential areas make these areas prone to high risk of fire. "Fires spread easily and firefighting may be delayed." "Most homes are old wooden structures built close together."	The fire spread easily. "Much time was required to extinguish the fire." "Initial fire extinguishment was hard."		

Category names are given in Italics, and the quotations refer to the findings from the observations/interviews.

Table 2 Socio-demographic characteristics of study participants (N=38)

		n	%
Sex	Male	1	2.6
	Female	37	97.4
Age category	60–69	3	7.9
	70–79	18	47.4
	80 and over	17	44.7
Family structure	Live alone	16	43.2
	Live with spouse	9	24.3
	Live with other members	12	32.4
Residential type	House	25	67.6
	Apartment	12	32.4
Parking beside the home	Possible	30	78.9
	Impossible	8	21.1
Self-rated economic condition	Comfortable	2	5.3
	Sufficient	29	76.3
	Poor	7	18.4
Current diseases/ailments	Yes	30	81.1
	No	7	18.9
Need support in event of evacuation	Yes	5	13.2
	No	33	86.8
Have emotional social support from neighbors	Yes	34	89.5
	No	4	10.5
Self-rated health	Very good/Good	32	84.2
	Fair/Poor	6	15.8

between community residents and the Nagasaki City Fire Department is required on a daily basis; 2) initial fire response for extinguishment by community residents, in collaboration with civilian fire protection team and firefighters, is necessary in areas with difficult terrain like Area X because delay in initial extinguishment can cause a rapid expansion of fire and increase the damage; and 3) medical health care provision during an evacuation period should be considered as a part of disaster preparedness, in addition to water supply and meal provision, especially in areas with a high density of elderly residents. Even if there were no volunteer help from neighboring hospitals, minimal community-based disaster preparedness would be essential for survival in geographically underserved settings.

Quantitative analyses of the questionnaire survey

A total of 38 elderly residents (one male, 37 females) responded to the questionnaire. Table 2 shows the demographic characteristics of these respondents. The mean age and standard deviation of the respondents were 78.2 ± 6.1 years (range: 66 to 90). Of these, 43% lived alone and 57% lived with spouses and/or other family members. Additionally, 21% lived in places where cars could not be parked beside their homes. Approximately 80% of the respondents said they had physical ailments but rated their overall health as good or very good. Furthermore, 13% stated they would need support in the event of an evacuation, and 11% felt they did not have emotional social support from their neighbors.

Table 3 shows differences in disaster-related knowledge or attitudes by age group and family structure. Here we can see that approximately 80% of all respondents knew their evacuation assembly point, but only 50% knew the locations of nearby fire hydrants, and very few actually knew how to use the hydrants. Additionally, 68% of the respondents said they were prepared for disasters, 34% had participated in disaster training, and 26% had a plan to confirm their safety with their family in the event of a disaster. For all of the related questions, there were no statistically significant differences between age groups and/or family structures.

Table 4 shows the results of the univariate analysis performed on factors related to disaster preparedness. Sociodemographics, health status, evacuation support, and disaster-related knowledge were found to be unrelated to disaster preparedness. However, disaster preparedness was found to be related to attitudes toward disaster (disaster training participation and having a plan to confirm their safety with their family in the event of a disaster).

Table 3 Comparison of knowledge and attitude regarding disaster preparedness, by age group and family structure

		Age group			Family structure		
		60–79 yrs (n=21)	80– yrs (n=17)	p-value	Living alone (n=16)	With spouses and/or others (n=21)	p-value
		n (%)	n (%)		n (%)	n (%)	
Know place for evacuation in disaster	Yes	14 (66.7)	15 (88.2)	0.148	14 (87.5)	14 (66.7)	0.248
Know place of fire hydrant	Yes	9 (45.0)	8 (50.0)	1.000	7 (46.7)	10 (50.0)	1.000
Know usage of fire hydrant	Yes	2 (9.5)	6 (35.3)	0.107	5 (31.3)	3 (14.3)	0.254
Preparedness for disaster	Yes	13 (61.9)	13 (76.5)	0.486	12 (75.0)	14 (66.7)	0.723
Participation in disaster training	Yes	6 (30.0)	7 (41.2)	0.512	8 (50.0)	5 (25.0)	0.169
Decision of safety confirmation with family members	Yes	5 (25.0)	5 (31.2)	0.722	5 (35.7)	5 (23.8)	0.474

Fisher's exact test. Missing data was excluded from analysis.

Discussion

Even in ordinary times, geographic features such as hillsides, remote areas, and islands have obvious effects on disaster preparedness. In our study case, the geography of the hillside residential area had a significant influence on the spread of the fire. Specifically, the poor access conditions, such as the narrow roads and outdoor staircases, delayed initial firefighting responses, giving the fire time to spread. Immediate firefighting action through community-based collaboration is required when fires occur in geographically underserved conditions. In addition, neighbors' collaboration against fires is crucial in physically disadvantaged conditions where there is a high density of elderly residents.

These context responses indicate that it will be necessary to manage disaster occurrences by taking the geographic conditions, such as hillside areas, into consideration[8]. In addition, in areas where fires spread easily or evacuation support is needed, special consideration will be necessary when many residents are elderly, live alone, or suffer from disabilities, because such persons face particularly high risks if a fire occurs[11, 12]. Those persons facing multiple risk factors for fire, such as the elderly living in sloped areas, are most seriously damaged when fire breaks out. A daily based collaboration between the civil society and the local government is required for tailor-made disaster preparedness, depending on geographic conditions.

Furthermore, while the elderly can be expected to need more health support or medical care, this incident shows that current support systems for evacuees are insufficient. Despite the importance of measures to protect against cold, ensure a food supply, and maintain cleanliness for elderly evacuees, such support was provided solely by neighboring hospital volunteers. Because several of these elderly evacuees had health concerns, the medical examinations and replacement medications provided by the hospital were very helpful.

It is also well known that people who have suffered disasters often experience symptoms of anxiety and depression[13]. Therefore, health support for elderly persons who have suddenly become evacuees should also take into consideration their life styles and mental health. In this case, collaboration between the fire department, the hospital, and city administration was insufficient and their roles were unclear.

Previous literature has described factors that have the potential to affect the capabilities of administrative sectors, such as leadership or partnerships[14–16]. These studies indicate that it is necessary to clarify support system roles at the time of a disaster, and that multisector collaboration between professionals is critical.

Almost all the elderly in Area X knew their disaster evacuation point, but only half of them knew the location of the nearest fire hydrant. Moreover, very few knew how to actually use a fire hydrant. In addition, their attitudes toward disasters, such as participation in disaster training or a plan to confirm their safety with family in the event of a disaster, were in many cases non-affirmative. These results showed no significant relation to age group or family structure. It was also reported that the cooperative efforts of local residents resulted in positive psychological reactions after disasters[17], and that close relationships between the elderly residents in the same community promote such cooperation.

From the interview results, positive contexts for the collaboration system and joint activities between local citizens and the fire department were identified. However, after investigating the resident questionnaire results, it was evident that those relationships were insufficient. This inconsistency could not be identified solely by qualitative analyses of the interviews but could be ascertained through quantitative analyses of the questionnaire survey.

This study has several limitations. Since the results are primarily from one hillside residential area, it is impossible

Table 4 Factors related to disaster preparedness

		Disaster preparedness		p-value
		Yes n (%)	No n (%)	
Age category	60–79	13 (61.9)	8 (38.1)	0.486
	80 and over	13 (76.5)	4 (23.5)	
Family structure	Live alone	12 (75.0)	4 (25.0)	0.723
	Live with spouse/others	14 (66.7)	7 (33.3)	
Residential type	House	16 (64.0)	9 (36.0)	0.279
	Apartment	10 (83.3)	2 (16.7)	
Parking beside the home	Possible	20 (66.7)	10 (33.3)	1.000
	Impossible	6 (75.0)	2 (25.0)	
Self-rated economic condition	Comfortable/Enough	19 (61.3)	12 (38.7)	0.074
	Poor	7 (100.0)	0 (0.0)	
Current diseases/ailments	Yes	19 (63.3)	11 (36.7)	0.389
	No	6 (85.7)	1 (14.3)	
Need support in event of evacuation	Yes	2 (40.0)	3 (60.0)	0.301
	No	24 (72.7)	9 (27.3)	
Have emotional social support from neighbors	Yes	24 (70.6)	10 (29.4)	0.577
	No	2 (50.0)	2 (50.0)	
Self-rated health	Very good/Good	22 (68.8)	10 (31.2)	1.000
	Fair/Poor	4 (66.7)	2 (33.3)	
Know place for evacuation in disaster	Yes	19 (65.5)	10 (34.5)	0.689
	No	7 (77.8)	2 (22.2)	
Know place of fire hydrant	Yes	12 (70.6)	5 (29.4)	0.732
	No	12 (63.2)	7 (36.8)	
Know usage of fire hydrant	Yes	6 (75.0)	2 (25.0)	1.000
	No	20 (66.7)	10 (33.3)	
Participation on disaster training	Yes	13 (100.0)	0 (0.0)	0.002
	No	12 (50.0)	12 (50.0)	
Decision of safety confirmation in family	Yes	10 (100.0)	0 (0.0)	0.016
	No	15 (57.7)	11 (42.3)	

Fisher's exact test. Missing data was excluded from analysis.

to say that all hillside residential areas face the same conditions. Nevertheless, while the research areas need to be expanded, this survey area was typical of hillside residential areas in Nagasaki City. The questionnaire survey was carried out at exercise classes in the surveyed area that had small numbers of participants. Accordingly, it will be necessary in the future to obtain responses from more residents, possibly including those who are homebound.

Conclusion

This study identified several challenges related to disaster prevention preparations of a Nagasaki City hillside residential area through mixed analysis of qualitative and quantitative approaches. First, we determined that the geographic features of the hillside residential area had a large influence in expanding the damage caused by the fire. Next, we found that the support systems for evacuees were not functioning in collaboration among different professions and sectors, including both formal and informal organizations. Additionally, it was clear that elderly residents in the hillside residential area lacked knowledge on fire prevention and firefighting skills.

Due to the numerous hillside city areas in Nagasaki City, it will be important to improve local resident knowledge and abilities regarding disaster preparedness and survival in a disaster, including disaster prevention training on a regular basis. Additionally, to provide better support when a disaster occurs, multisector collaboration among professionals will be critical.

Finally, we found that the visual use of a two-dimensional framework was helpful in this study and that it can be expected to provide an effective evaluation method in future assessment of public health policy making and establishment of strategies.

Conflict of Interest: The authors declare that they have no conflicts of interest.

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