

## Article

# Factors Contributing to Disaster Evacuation: The Case of South Korea

Dongkwan Lee <sup>1</sup>, Soyeon Yoon <sup>1</sup>, Eun-Seon Park <sup>1</sup>, Yuseung Kim <sup>2</sup> and D.K. Yoon <sup>1,\*</sup>

<sup>1</sup> Department of Urban Planning and Engineering, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea; matoto@yonsei.ac.kr (D.L.); syoon100@yonsei.ac.kr (S.Y.); parkeunseon@yonsei.ac.kr (E.-S.P.)

<sup>2</sup> Masters Program in Policy, Planning, and Management, University of Southern Maine, 34 Bedford St., Portland, ME 04104, USA; yuseung.kim@maine.edu

\* Correspondence: dkyoon@yonsei.ac.kr; Tel.: +822-2123-5893

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**Abstract:** There has been increasing interest in effective evacuation in response to natural disasters, particularly in understanding human evacuation behavior. It is important to determine the factors affecting evacuation decision making to promote prompt evacuation. This study focuses on the effects of past experiences on evacuation behavior in South Korea, especially the evacuation drill experience. Additionally, the influence of demographic and socio-economic characteristics on evacuation behavior is considered. After collecting data through telephone surveys, *t*-tests and logit regression models were used to evaluate the data. The results reveal that an evacuation drill experience is positively related to making a decision to evacuate. The results also confirm that certain demographic factors, such as age and household size, as well as socio-economic factors, such as household income and housing type, influence evacuation decisions. Besides these, knowing the location of a shelter is another factor that improves the chances of evacuation. Finally, discussions and suggestions for increasing participation in evacuation drills are provided.

**Keywords:** natural disasters; evacuation behavior; evacuation drill; demographic and socio-economic factor; Korea

## 1. Introduction

In recent years, there have been unprecedented efforts to reduce the increasing risks associated with natural disasters caused by rapid climate change and global warming. As a countermeasure to decrease the amount of damage caused by natural disasters, especially bodily injuries and deaths, authorities have provided people with proper guidelines on how to evacuate in emergency situations. Rapid evacuation is important, as can be seen from global examples in the past. Before the flooding due to Hurricane Katrina, authorities issued a mandatory evacuation of the city, but many people remained in their homes or could not leave. In the Great East Japan Earthquake, there was a warning although it appeared only a minute before the disaster. However, it ended up with a huge loss of life and property. More recently, an earthquake and a tsunami hit the city of Palu, Indonesia, with devastating consequences. Thousands of people died and the lack of a warning siren urging evacuation before the disaster was criticized.

To promote rapid and effective evacuation in the event of disasters, nonstructural measures such as increasing awareness and experience are important [1]. While the structure of evacuation systems is relatively well known, there is still room for in-depth research on people's evacuation behavior. Previously, the effectiveness of past evacuation experiences has been found to be dependent on people's evacuation behaviors [2–4]. Several questions arise from the relationship between

individual experience and evacuation behavior, such as: Is drill experience an important factor for evacuation from natural disasters? What are the crucial factors that lead people to evacuate? Why do people not evacuate? Are there any differences between people from different demographic and socio-economic characteristics regarding evacuation behavior? Although these issues have been continuously discussed and evaluated for decades in prior literature, few studies provide clear answers.

One of the main questions regarding people's behavior during disasters is about the determinants of evacuation decision making. Researchers have conducted surveys to identify these determinants since the 1960s [5]. Much of the prior literature deals with evacuation behavior during natural disasters. Researchers have identified critical determinants affecting evacuation decisions based on region, type of disaster, as well as the respondents' demographics, socio-economic conditions, and experience. Table 1 lists significant factors documented in previous studies on natural disaster evacuation behavior and impacts. These factors are classified under three headings: Demographic characteristics, Socio-economic characteristics, and Experience and Knowledge.

**Table 1.** Significant factors affecting decision to evacuate shown in prior research.

Category	Factor	Reference	Disasters
Demographic characteristics	Gender	[3,6–15]	Cyclone, Hurricane, Natural disasters
	Age	[9,16–24]	Hurricane, Nuclear power plant accident
	Ethnicity	[3,9,11,18,25]	Hurricane
	Health	[3,9,26]	Hurricane
	Household size	[9,17]	Nuclear power plant accident, Hurricane
	Family composition	[3,6,9,12,17,18,26–28]	Cyclone, Hurricane, Nuclear power plant accident, Natural disasters, Fire
	Pet	[3,7,9]	Hurricane, Natural disasters
Socio-economic characteristics	Income (Financial condition)	[9,11,19,26,29]	Hurricane
	Education	[9]	Hurricane
	Job constraint	[17,30]	Nuclear power plant accident, Hurricane
	Homeownership	[3,8,9,15]	Hurricanes
	Housing type	[9]	Hurricane
	Duration of residency	[3,9,31]	Hurricane
Experience/Knowledge	Disaster Experience	[1,3,6,31]	Tsunami, Hurricane, Cyclone
	Prior evacuation experience	[2–4,13]	Hurricane
	Evacuation drill experience	[1,32]	Tsunami, Tornado
	Disaster Awareness/Knowledge	[1,16,17,26,32,33]	Tsunami, Hurricane, Cyclone, Nuclear power plant accident, Tornado

The literature on disaster evacuation behavior has found that demographic (gender, age, ethnicity, health condition, household size, and family composition, especially the presence of children, elderly, and pets in the home) and socio-economic characteristics (income, education, occupation, homeownership, housing type, and duration of residency) affect people's decision to evacuate [3,6–18,25–30]. Researchers have tested diverse demographic and socio-economic characteristics to determine who fails to evacuate and why. Many of these factors are significantly related to evacuation behavior. For example, females show a tendency to evacuate more often than males in a disaster situation [3,8–10,12–15]. However, homeownership shows an inconsistent effect. In the paper by Riad et al. [3] and Smith and McCarty [9], homeownership has a negative correlation with evacuation, while homeowners are more likely to evacuate rapidly in the result of a survey on Black Americans [8]. Smith and McCarty [9] find that several demographic variables such as gender,

age, race, family composition, and household size have an impact on evacuation behavior during hurricanes. In contrast, Stein et al. [16] and Aguirre [29] note that none of their social and demographic control variables (gender, age, and race) have a significant effect on evacuation during hurricanes.

Another important determinant of evacuation decision making is evacuation and drill experience. Prior evacuation and drill experience can influence people's awareness and response to risks. Burnside et al. [2] investigated whether citizens who have evacuation experience are more likely to evacuate. Their results confirm that people who have evacuation experience in the past are more likely to evacuate from upcoming natural disasters than people without the experience. This result is consistent with studies conducted by Riad et al. [3] and Murray-Tuite et al. [4]. Murray-Tuite et al. [4] find that people are likely to make the same decisions to evacuate in a similar disaster situation. Meanwhile, Chaney and Weaver [32] suggest the positive effect of experiencing a tornado drill on shelter-seeking behavior. In this paper, the evacuation rate of people with drill experience is 23% higher than that of those without.

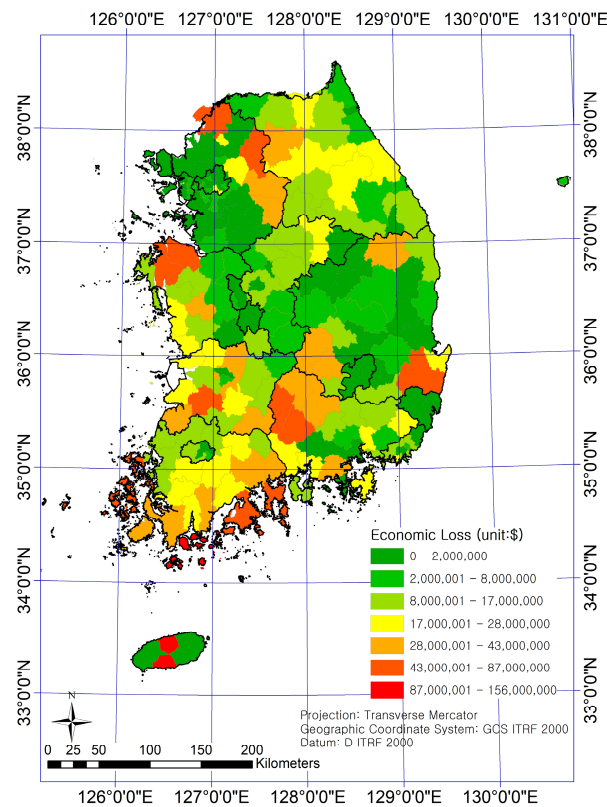
Considering the extensive literature review above, this study's contribution to the literature on disaster evacuation becomes clearer. Firstly, the factors mentioned in previous studies are inconsistent in relation to evacuation behavior, depending on the region and types of disasters due to differences in disaster experience and knowledge. This implies that a regional-based approach reflecting local residents' experience and awareness of natural disasters helps in promoting effective evacuation in the event of disasters. This study identifies the major factors and explains each factor's influence on evacuation behavior specifically in South Korea. Secondly, in previous studies, there has been an emphasis on evacuation decisions and their relationship with demographic and socio-economic characteristics. Few cases focus on the impact of evacuation drills on evacuation behavior [1,32]. Considering the nature of factors that people can control or those that they cannot, identifying the effect of evacuation drill experience on behavior may be crucial in planning for effective decision making in an evacuation.

This study addresses the impact of people's previous experience in making effective evacuation decisions in the context of natural disasters, particularly flooding, in South Korea. The main aims of this study are as follows: (1) to evaluate whether demographic characteristics affect evacuation behavior; (2) to examine what kind of socio-economic characteristics influence evacuation behavior; and (3) to discover whether previous disaster drills (or education) experience contribute to disaster evacuation. This study classifies the potential factors affecting evacuation decisions into three categories: demographic factors, socio-economic factors, and experience and knowledge of evacuation. In addition to answering the above-mentioned questions, this study deals with several research questions about people's evacuation behaviors. An individual's past experiences have been suggested to affect evacuation decisions, especially experience with evacuation drills.

## 2. Study Area

A questionnaire survey related to demographic and socio-economic characteristics, experience with evacuation drills, and expected evacuation behavior in future disasters was conducted in South Korea (See Appendix A). The study area is South Korea. As illustrated in Figure 1, South Korea is located on the southern part of the Korean Peninsula, which lies between longitudes 125° and 131° and latitudes 33° to 39° N. South Korea is surrounded by water on three sides and land on the other. It faces North Korea across the DMZ (Demilitarized Zone). Japan is about 200 km to the south across the Korean Strait, while China lies 190 km to the west. Its total area is 100,363 km<sup>2</sup> and the population is 51.4 million as of 2017. Almost half the total population (24.5 million) lives in the Seoul Metropolitan area including the capital of South Korea, Seoul, Incheon metropolitan city and Gyeonggi province, which has a population density (509 inhabitants/km<sup>2</sup>) [34] higher than the global average (57 inhabitants/km<sup>2</sup>) [35]. Its major cities are Pusan, Incheon, Daegu, Gwangju, and Ulsan. South Korea is now generally considered as having joined the developed world with its strong GDP, low infant mortality rate, high life expectancy, and quality health care and higher education systems.

Its largest industries include electronics, automobiles, telecommunications, shipbuilding, chemicals, and steel with an estimated GDP of \$1.5 trillion and \$29,743 per capita as of 2017, ranked in the world as 12th and 30th [36], respectively. Average rainfall is over 1000 mm per year but about two-thirds of the precipitation occurs during the short monsoon season [37].



**Figure 1.** Property damage by natural disasters in South Korea (2007–2016).

South Korea has been affected by numerous natural disasters, such as torrential rains [38], typhoons [39], heavy snow [40], and landslides [41], with flooding caused by the annual monsoon season in July and August being one of the main natural disasters. Moreover, concerns about earthquakes have increased due to the recent earthquake events in the southeast area. The average annual damage caused by natural disasters was US \$3.3 billion (calculated based on the exchange rate: \$1 = 1100 won), and the average annual casualty was 16 between 2007 and 2016. According to South Korea's Ministry of the Interior and Safety, in 2016 18 natural disasters (12 heavy rainfalls, 3 heavy falls of snow, 2 typhoons, and 1 earthquake) occurred in South Korea, and damages worth US \$2.6 billion were reported.

### 3. Methodology

#### 3.1. Research Design

This study concerns human behavior and uses the survey method, which is one of most common methodologies. The survey questionnaire was structured to focus on three topics: individual information including demographic and socio-economic characteristics, and experience with evacuation drills. Overall, respondents were questioned about their evacuation behavior. The survey was reviewed and approved by the Institutional Review Board (IRB). Telephone surveys were conducted targeting adults (at least 20 years old) residing in South Korea between 1 September and 15 September 2017, and during June 2018. The responses, numbering 541, were collected and utilized as the dataset for analyses. A total of 54 questions were created among which most were multiple choice

questions. Table 2 illustrates the structure of the questionnaire and the factors addressed in the survey. Gender, age, household size, and family composition were selected to investigate the respondents' demographic characteristics, and options for each question were created. In the same way, occupation, education, marital status, monthly household income, homeownership, and housing type were included in the questionnaire for investigating respondents' socio-economic status. Regarding disaster experience and evacuation experience, the questionnaire asks about people's disaster experience in the past. It was understood that a respondent who had not experienced a disaster situation would not have faced an evacuation situation. Hence, we had to distinguish the valid samples from all other samples by asking whether the respondent had any previous disaster experience, and if the respondent chooses "yes" in the question, the survey moves on to ask him/her about the evacuation experience in the emergency caused by the disaster. Although the total number of samples was 541, by eliminating those who had not faced a disaster, we could only obtain 292 valid samples in which respondents had to make a decision regarding evacuation to escape from a natural disaster. It turned out that 292 respondents answered the question asking whether he/she had any evacuation experience and 124 (42.5%) of them had undergone evacuation in an emergency.

**Table 2.** Description of respondents' answers.

Factor	Parameter	Respondents (%) (N = 541)
Gender	male	269 (49.7%)
	female	272 (50.3%)
Age	20 s	95 (17.6%)
	30 s	98 (18.1%)
	40 s	108 (20.0%)
	50 s	111 (20.5%)
	over 60	129 (23.8%)
Occupation	student	39 (7.2%)
	housewife	100 (18.5%)
	career man or woman	297 (54.9%)
	self-business owner	61 (11.3%)
	no job	15 (2.8%)
	other	29 (5.3%)
Education attainment	middle school	9 (1.7%)
	high school	118 (21.8%)
	bachelor's degree	324 (59.9%)
	master's degree	90 (16.6%)
Marital status	single	200 (37.0%)
	married	337 (62.3%)
	other	4 (0.7%)
Household income (monthly)	less than 1800 dollars	73 (13.5%)
	1800–5399 dollars	305 (56.4%)
	over 5000 dollars	163 (30.1%)
Homeownership	housing owned	372 (68.8%)
	Rent (monthly or yearly)	166 (30.7%)
	other	3 (0.6%)
Housing type	apartment	365 (67.5%)
	single-family detached housing	66 (12.2%)
	multi-family housing	106 (19.6%)
	other	4 (0.7%)
Disaster experience	Yes	292 (54.0%)
	No	249 (46.0%)
Evacuation drill experience	Yes	107 (36.6%)
	No	186 (63.4%)
<i>Among people who have disaster experience (N = 292)</i>		
Evacuation	Yes	124 (42.5%)

### 3.2. Categories of Factors

This study classified potential factors affecting evacuation decision mainly into 3 categories (demographic, socio-economic, and experience/information) and all the parameters in the questionnaire are transformed into dummy variables and checked for their correlation.

One of the research aims is to show the influence of demographic factors on evacuation behavior. To examine the effects of demographic factors on evacuation behavior, the information provided by survey participants was utilized and tested according to several factors that are in the questionnaire, as listed in Table 3. Gender, age, occupation, education, marital status, household size, and family composition are included as demographics. These factors contain information exclusively about individuals or households.

**Table 3.** Variables and their expected effects on evacuation decision.

Category	Variable	Definition	Expected Effects
Dependent Variable	Evacuation	Respondent has evacuated in an emergency caused by a natural disaster in the past	No sign
Demographic characteristics	Gender	Respondent's gender: male (+) or female (−)	+
	Age	Respondent's age range: less than 20, in the 30s, 40s, 50s, and over 60	−
	Occupation	Respondent's occupation including student, housewife, businessman/woman, self-business owner, and having no job, etc.	Case-by-case basis
	Marital status	Respondent is currently married (+) or not (−)	+
	Household size	Number of family members in the household	−
	Family composition	Percent of children (aged less than 12), seniors (aged over 60), or disabled persons who might have trouble moving to escape to a safe place.	Case-by-case basis
Socio-economic characteristics	Household income	Based on the proportion of yearly household income in the country, four classes are suggested. Less than 1800 dollars is the lowest option, and over 5400 dollars is the highest option in the questionnaire.	+
	Education	Respondent's educational level is identified. Middle school, high school, bachelor's degree, and beyond master's degree	+
	Homeownership	Status of respondent's homeownership. If the respondent lives in his/her own house, homeownership is 'housing owned', if he/she is a tenant, homeownership is 'monthly or yearly rent'	+
	Housing type	Housing type in which occupants live such as multi-family housing, single-family detached housing, and apartment	Case-by-case basis
Experience/Knowledge	Evacuation drill experience	Respondent's experience in participating in an evacuation drill or program related to natural disasters	+
	Location of shelter	Respondent's knowledge about the route to or location of the shelter	+

It is widely known that people's socio-economic status can affect their decision making, and the same logic can be applied to decision making regarding evacuation in an emergency caused by a natural disaster. This study assumes that people's socio-economic status has a significant relationship with their evacuation decision during the disaster situation. To clarify the relationship between decision making and these factors, we considered several socio-economic factors in the survey questionnaire such as education, household income, home ownership, housing type, job, and so on. Table 3 shows the definition of each variable and the direction of the expected effects. We made several assumptions regarding the expected effects of each variable. Being male, having a high level of education, being married, having a high household income, own housing, drill experience, and knowledge about the location of the shelter could increase the probability of evacuation during the



disaster. On the other hand, older age and large family size have the opposite effect. Some variables with inconsistency in the effect of choices such as occupation, family composition, and housing type are classified as “case-by-case basis”.

One of the critical parts of this study is to determine the effectiveness of evacuation drills on evacuating during disasters. In the preliminary analysis, the *t*-test results indicate that the mean value of the two groups is significantly different at 1% confidence level, and thus the null hypothesis, “there is no difference in the evacuation behavior between a group with drill experience and a group without it” is rejected. The results also show that more people evacuated in the group with drill experience than in the group without drill experience. We also assume that if people have information about the evacuation such as the location of the shelter, it could motivate more people to evacuate to a safe place. Thus, related questions have been constructed and added to the questionnaire.

### 3.3. Logit Regression Analysis

To analyze the relationship between the tendency of people to evacuate and demographic and socio-economic characteristics, and drill experience, logit regression analyses are conducted because the dependent variable is dichotomous. We developed three logit regression models to figure out the influential factors on people’s evacuation behavior focusing on making decisions to evacuate among individual factors and drill experience in depth. Table 4 shows the results of the three models. Variables are selected considering their significance and explanatory power. For each model, 292 samples were used. The overall model satisfies the significant confidence level and a total of 14 variables were eventually chosen for the final model.

**Table 4.** Results of logistic models.

Description	Model1		Model2		Model3	
	Coeffi.	Odd Ratio	Coeffi.	Odd Ratio	Coeffi.	Odd Ratio
<b>Demographic characteristics</b>						
Less than 30 years	−0.552 ** (0.277)	0.576			−0.0988 ** (0.339)	0.372
Over 60 years	−0.481 (0.362)	0.618			−0.588 (0.425)	0.555
Married	0.301 (0.256)	1.351			0.275 (0.303)	1.317
Household size over 3	0.535 * (0.290)	1.708			0.244 (0.363)	1.277
At least one child in the family	0.196 (0.304)	1.217			0.050 (0.353)	1.051
At least one senior in the family	−0.326 (0.348)	0.722			−0.308 (0.435)	0.735
<b>Socio-economic characteristics</b>						
Equal to or lower than high school graduate			−0.463 (0.333)	0.629	−0.327 (0.382)	0.721
Less than 1800 dollars per month			−0.891 * (0.535)	0.410	−1.610 ** (0.691)	0.200
Household income is over 5400 dollars per month			0.542 ** (0.264)	1.719	0.541 * (0.311)	1.718
Rent (monthly or yearly)			−0.360 (0.285)	0.698	−0.363 (0.340)	0.695
Single-family detached house			−0.463 (0.376)	0.630	−0.400 (0.471)	0.670
Multi-family house			0.580 * (0.346)	1.787	0.980 ** (0.425)	2.663



Table 4. Cont.

Description	Model1		Model2		Model3	
	Coeffi.	Odd Ratio	Coeffi.	Odd Ratio	Coeffi.	Odd Ratio
<b>Experience/Knowledge</b>						
Evacuation drill experience					<b>1.747 ***</b> (0.301)	5.739
Knowledge of location of the shelter					<b>1.405 ***</b> (0.393)	4.076
Constant	−0.521 (0.348)	0.594	−0.264 (0.201)	0.768	−1.447 (0.48)	0.342
Number of Observation	292		292		292	
Nagelkerke R-square	0.066		0.085		0.367	
Likelihood ratio	383.377		379.128		304.938	
$\chi^2$ test	0.022		0.004		$9.3 \times 10^{-14}$	

\*  $p < 0.10$ , \*\*  $p < 0.05$  and \*\*\*  $p < 0.01$ . Standard errors are in the parentheses.

## 4. Results

Three logit regression models are fitted based on the categories of factors and the results provide useful information to find appropriate predictors for people's evacuation behavior during emergencies.

### 4.1. Results of Demographic Characteristics Model

Model 1 consists of six demographic variables. Among the demographic factors, age, marital status, household size, and family composition are identified as factors influencing evacuation, as shown in Table 4. Age and household size are significant variables. In the case of age, it is proved that people below 30 are less likely to evacuate than people in other age groups when a natural disaster occurs. A variable representing seniors aged over 60 also shows a negative sign but it is not statistically significant. According to Cutter and Barnes [17], seniors are less likely to evacuate. However, the results of Model 1 do not provide clear evidence showing that seniors are reluctant to evacuate and are less likely to leave for evacuation points than other age groups.

It is found that the household size is also an influential factor when an evacuation decision is made. If there are over three members in a household, people are more likely to evacuate during emergencies. This result is in accordance with Cutter and Barnes [17] while it is different from that of Smith and McCarty [9]. Besides these three variables, marital status, and family composition are included in the model but they are not statistically significant. Specifically, marital status and child in the family show a positive sign, while having a 'senior in the family' shows a negative sign.

### 4.2. Results of the Socio-Economic Characteristics Model

Model 2 is composed of six variables. Education, household income, home ownership, housing type are included in the model. This model indicates that household income is a critical condition affecting the evacuation decision. If household income is less than \$1800 per month, people are less likely to evacuate, while people are more likely to evacuate when their household income is over \$5400 per month. It is also revealed that people living in multi-family housing evacuate more than people living in detached housing. Besides these three variables, low education level, living in a leased home, and living in single detached housing show a negative tendency, but they are not statistically significant in the model.

### 4.3. Results of the Final Model

Model 3 was created by adding factors of demographic and socio-economic characteristics and drill experience to examine the dangerous situation caused by a natural disaster. Six variables are found to be significant in the final model. Age, income, housing type, drill experience, and knowledge of the shelter location are statistically significant in the final model. Most of all, this model clearly proves that drill experience in the past is helpful in encouraging people to evacuate during a disaster situation. Moreover, knowledge of the location of the shelter can lead people to evacuate to the safe place by escaping from the dangerous environment. Both these variables are strongly significant and show a positive relationship to evacuation. With regard to demographic variables, age is the only significant variable and it is found that people aged below 30 are less likely to evacuate than those in other age groups. On the other hand, other variables in demographics are not statistically significant. In terms of socio-economic variables, the result is the same as that of model 2. Household income and housing type are significant. From the significance of household income variables, we suggest that there is a strong relationship between people's household income and the tendency for evacuation during a disaster situation. People with low household income are less likely to evacuate, while people with a high household income show the reverse tendency. Housing type confirms that people living in a multi-family house are more likely to evacuate than people living in single-family detached houses.

Based on the results of the analyses thus far, several noticeable findings exist. One of the main findings is that evacuation drill experience has a strong effect on evacuation decision making.

People with evacuation drill experience tend to evacuate. Furthermore, having information about the shelter location can be an influential factor in making people more likely to evacuate.

Some influential demographic and socio-economic factors, particularly, age, household income, and housing type, were also found to be important in evacuation decision making. Regarding demographics and socio-economic factors, all the significant variables in the final model are socio-economic factors, except age.

## 5. Discussion

In the case of South Korea, when a natural disaster such as flooding or heavy rainfall followed by a typhoon occurs, a vast amount of damages are incurred. In this survey study, it was found that only a few respondents had experienced other natural disasters such as a tsunami, heavy snow, earthquakes, and landslides. Hence, this study focused on flooding, but the findings from this may encompass other natural disasters as well.

The results of the analysis section address the three research aims listed in the introduction. Demographic and socio-economic factors and evacuation drill experience clearly proved to be important in evacuation decision making.

Firstly, we determined that there is a significant relationship between evacuation decision making and evacuation drill experience, which is similar to the findings of Chaney and Weaver [32]. Riad et al. [3] also find that there is a significant relationship between people's experience in the past and people's evacuation decisions.

Our results demonstrate that past evacuation drills affect prompt evacuation and provide knowledge on how to evacuate during the disaster. Drill experience and educational programs are important because people often do not evacuate even though they are aware of the natural disaster. From the answers to the other questions, we learned that a majority of respondents did not realize the magnitude and seriousness of the natural disaster. Although people experience occasional flooding due to the annual monsoon season in South Korea, most were unaffected by it and safe. This could explain people's propensity to ignore the risk of natural disasters, causing them to lower their guard against disaster risks, and resulting in more human injuries and casualties in the future. Hence, the evacuation drill and education could help remind people of the perilous nature of a future disaster.

Although the drill experience is an important factor, people often do not clearly remember what they learned during the drill. Over 70% of respondents answered that they do not remember the contents of the evacuation drill; some barely remembered them. This suggests that changes in the evacuation drill curriculum or program need to be considered. The results also indicate that people depend on knowledge factors when they make evacuation decisions. The importance of knowing the location of the shelter has been emphasized in prior studies [6,26,33].

Secondly, the results confirm that some demographic factors are closely related to evacuation decisions. Although there are not as many significant variables as were expected, noticeable findings were drawn from the results. Particularly, age affects people's tendency to evacuate. Prior studies [9,16,19–24] argue that age has a negative effect on evacuation decision and the findings from Aguirre [29] about the effect of age are inconsistent with our results. The results of this study suggest that people below the age of 30 are less likely to evacuate than people in other age groups, and those over 60 show a lower tendency to evacuate. Smith and McCarty [9] list two reasons why older people are less likely to evacuate. These are mobility limitations caused by physical impairments, medical conditions of seniors, and lack of knowledge of disaster threats, caused by their social isolation. Older people are also reluctant and incapable of responding to the possibility of evacuation, and hence less likely to evacuate [17]. However, it is not statistically significant. The reason for the inconsistency in the results among studies might be due to the difference in the region. As Stein et al. [16] emphasize, people's evacuation behavior may be influenced by the location where they live, and this might be the cause for inconsistent results from other studies. The plausible reasons why young people are less likely to evacuate might be explained in two ways. First, they believe in their youth and strong body and

they want to help someone older and weaker if the time comes. Second, they have a lack of experience and knowledge of natural disasters. These reasons might make them stayers rather than leavers. The number of family members might be related to evacuation: households over three members are more likely to evacuate as shown in Model 1, although it is not significant in the final model. According to Cutter and Barnes [17] a household with more members, especially preschool-aged children or a pregnant woman, is more likely to evacuate. On the other hand, Smith and McCarty [9] argue that the rate of evacuation decreases as household size increases. They find that large households are less likely to evacuate than small households because of logistical constraints.

Thirdly, this study discovered that socio-economic status, such as household income and housing type, could be critical factors associated with making evacuation decisions; high-income earners are more likely to evacuate when a natural disaster occurs, while low-income earners are less likely to evacuate. Regarding income, the results are consistent with Adeola [31], Brodie et al. [19], and Eisenman et al. [26]. According to Brodie et al. [19], there are three possible explanations for people not evacuating: (1) unclear instruction on how to find a shelter; (2) lack of one's own transportation to leave for a safe place; (3) not having enough money to stay in other places, especially people in low-income areas. Also, the fear of losing their job among people in the low-income areas is suggested by Elliot and Pais [11]. Smith and McCarty [9] find that high income increases the probability of people going to a hotel or motel rather than to a public shelter. Besides income, multi-family housing could contribute to evacuation in emergencies according to the results of this study, which is consistent with the findings of Smith and McCarty [9]. Possible explanations for this could be that multi-family housing life could provide more opportunities to communicate with each other and easily share information during emergencies, as a small community. These areas usually have a good alert system. Furthermore, multi-family homes located in basement floors of buildings or flood-prone areas such as lowlands are very vulnerable to flooding, property damage, and even suffering casualties in the past. On the other hand, living in a single detached house is not a helpful predictor for evacuation behavior, as its effect is not significant.

## 6. Conclusions

This study explores the relationship between people's individual characteristics including demographic and socio-economic factors, experience with evacuation drills, and evacuation behavior, specifically evacuation decision making. Researchers have debated whether people's past experience with evacuation expedites escaping from dangerous situations caused by natural disasters [4,32]. This study clearly provides evidence that different experiences have different effects on evacuation behavior, particularly past participation in an evacuation drill, which affects evacuation decisions: people with evacuation drill experience are more likely to evacuate than people without such experience. This result indicates the effectiveness of evacuation drills.

This study also demonstrates that, in addition to evacuation experience, demographic and socio-economic factors can influence evacuation decision making. Age, family size, household income, and housing type are influential factors. The current evacuation systems and evacuation drill programs can be improved based on these results. As for evacuation drill programs, efforts should be made to attract more people to participate in drills and to ensure that people remember what they learn in the drills.

Policymakers should implement programs and strategies to increase participation in evacuation drills. One possible proposal is to develop notification or warning systems that are tailored to different socio-economic groups. Demographic characteristics must also be considered, such as household size. Families with three or more members may need more time to gather and may experience difficulties getting in touch with each other during disasters due to heavy network traffic or mobile communication failure [42]. Hence, it is recommended that premade plans be established with family members of a large household, including designated meeting locations. Policymakers may be able to attract larger households and families to evacuation drills by promoting and providing opportunities to create such

plans. As a socio-economic factor, housing type might be considered when the evacuation warning is issued. People who live in a single-family detached house might miss more important information than those who live in a multi-family dwelling. More attention is needed when it comes to alerting and urging people to evacuate. Differentiated notifications of upcoming evacuation drills based on demographic and socio-economic status may be helpful in getting more people to participate in drills as well.

The study also has some limitations. Firstly, respondents who have experienced natural disasters at least a couple of times in the past may make different evacuation decisions each time. Secondly, the disasters experienced can be different among respondents, and people's behavior might be influenced by the type of disaster as well. These shortcomings provide opportunities for further research. Above all, there should be additional research regarding establishing evacuation plans based on people's experience and creating strategies to implement these countermeasures against future natural disasters.

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## Appendix A

### Survey Questionnaires

#### I. Personal Information

1. Please indicate your gender.  
① Male ② Female
2. Which age-range do you belong to?  
① 20–29 ② 30–39 ③ 40–49 ④ 50–59 ⑤ 60–69 ⑥ Over 70
- 2-1. Where do you live?  
( ) City/Province ( ) si/gun/gu
3. What is your occupation?  
① Professional ② faculty ③ manager ④ Office worker  
⑤ Self-employed ⑥ Retail sales worker ⑦ Student ⑧ housewife ⑨ Unemployed
4. What is your highest level of education?  
① Middle school graduate ② High school graduate ③ Bachelor's degree  
④ Beyond Master's degree
5. Are you married?  
① Yes ② No ③ Not applicable
6. How many family members are there in your family including you?  
① One ② Two ③ Three ④ Four ⑤ Over five
7. Are there any of the following in your family? (multiple responses available)  
① Child(ren) (aged less than 12) ② Senior(s) (aged over 65) ③ Disable person(s)  
④ Pregnant woman/women ⑤ None
8. Which is the range of the average monthly household income of your family?  
① less than \$1800 ② \$1800~\$3599 ③ \$360~\$5399 ④ Over \$5400
9. Does your family own a house or live on rent?  
① Monthly rent/Yearly rent ② Own house
10. What kind of housing do you currently live in?  
① Apartment ② Single family housing ③ Multi-family housing ④ Other (\_\_\_\_\_)
11. What floor do you live on?  
(\_\_\_\_\_) floor

## II. Natural Disaster Experience

1. Have you ever experienced a natural disaster in the past?
  - ① Yes (☞ go to question 2) ② No (☞ end survey here)
2. What kind of natural disaster have you experienced? (multiple responses available)
  - ① Storm and typhoon ② Heavy rainfall and flood ③ Earthquake
  - ④ Heavy snow ⑤ Tsunami ⑥ Other (\_\_\_\_\_)
3. Have you ever evacuated in the event of a natural disaster?
  - ① Yes (☞ go to question 4) ② No (☞ go to question 7)
4. In what kind of disaster did you evacuate? (multiple responses available)
  - ① Storm and typhoon ② Heavy rainfall and flood ③ Earthquake
  - ④ Heavy snow ⑤ Tsunami ⑥ Other (\_\_\_\_\_)
5. What was the reason for you to evacuate from the most recent natural disaster you faced? (multiple responses available)
  - ① Because I realized the dangers involved in the disaster
  - ② Because other people were evacuated
  - ③ Because the mass media (Internet/sns/broadcast) asked us to evacuate
  - ④ Because friends asked us to evacuate
  - ⑤ Other (\_\_\_\_\_)
6. With whom did you evacuate? (multiple responses available)
  - ① Family ② Friend ③ Fellow ④ Alone ⑤ Other (\_\_\_\_\_)
 (☞ go to question 8)
7. Please tell us why you did not evacuate in the event of a disaster?
  - ① Because the magnitude of the disaster did not look big
  - ② Because I misjudged that the danger is not serious enough to evacuate
  - ③ Because there was no emergency alert or announcement
  - ④ Because I did not know the location of the shelter
  - ⑤ Because there was no one to help me deal with it
  - ⑥ Judged the disaster as not a problem based on past experience
  - ⑦ Other ( )
 (☞ end survey here)
8. Have you participated in any disaster evacuation practice or drill?
  - ① Yes ② No
- 8-1. Do you remember what you learned from the disaster evacuation practice or drill?
  - ① I remember most of it ② I remember a little ③ I barely remember
9. Did you know the location of the shelter at the time of evacuation?
  - ① Yes ② No

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