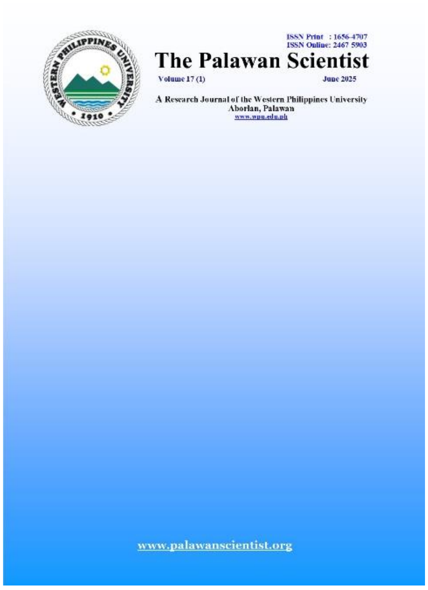

Evacuation behavior of 2020 Taal volcano eruption-affected households in Barangay Leynes, Talisay, Batangas, Philippines

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ABSTRACT

The Philippines, which is located in the western Pacific region experiences frequent and destructive disasters. Evacuation is one of the measures to reduce the impacts of disasters. Understanding evacuation behavior and incorporating this into a comprehensive evacuation plan is still needed. This study aimed to understand the evacuation behavior of households from the area at high risk of the impacts of a volcanic eruption. The type of evacuation decision, mode, and accommodation type choice behavior were assessed, and models were developed for each of these evacuation-related behaviors. Discrete choice models were used to identify significant factors to evacuation behavior using actual evacuation data collected from households in Barangay Leynes, Talisay, Batangas, Philippines. Results showed that the calculated *pseudo-R^2* for the three evacuation-related models were in the range of 0.10-0.33, indicating an acceptable level of data fit in respective models. Additionally, the calculated area under the curve (AUC) for the three models range from 0.72 to 0.85 which means that the models' level of discrimination was acceptable. Also, results of the internal validation calculated likelihood ratio (LR) were 0.83, 0.85 and 0.75, for the type of evacuation decision, mode, and accommodation type choice, respectively. These LR values are less than the critical values, indicating that model validity was established. In terms of significant factors, results showed that evacuation behavior was affected either positively or negatively by some sociodemographic and other variables such as number of household members, source of evacuation warning and vehicle ownership. The significant factors found in this study can be used in developing strategies for future evacuation operations.

Keywords: accommodation type, destination choice, emergency, evacuation decision, evacuation mode choice, evacuation plan

INTRODUCTION

The frequent occurrence of hazards is causing destruction and damage to properties, displacements of millions of people, and worsening poverty (CRED 2020). These can cause natural and anthropogenic disasters. The Philippines is highly vulnerable to natural hazards. The most common natural hazards that affect the country are typhoons, floods, earthquakes, landslides, volcanic eruptions, and fires (IFRC 2018). In January 2020, the Taal volcano, located in the province of Batangas, Philippines started showing signs of unrest after forty-three (43) years of dormancy. Alert level 4 was then raised leading to a total evacuation of people in high-risk areas within the 14-km radius and 20-km radius from Taal main crater, Taal Volcano Island, and along the Pansipit River Valley. The National Disaster Risk Reduction and Management Council (NDRRMC) in its 6 a.m. situational report of 25 January 2020, reported a total of 90,533 families were affected of which 37,445 families or 137,994 individuals took temporary shelter in 488 evacuation centers while 38,102 families or 148,271 persons stayed outside evacuation centers (NDRRMC 2020).

Evacuation is one of the countermeasures of the Philippine government to minimize loss of lives in case of no-notice disasters such as volcanic eruptions. Evacuation during the Taal volcanic eruption in the past had been completely disorganized (Barangay Official interviewed). Although evacuation plans and designated authorities in charge of evacuation management are put in place, the response of people as well as authorities when faced with sudden eruption can be unpredictable and complex. Therefore, understanding evacuation behavior and incorporating this into a comprehensive evacuation plan is still needed. Despite progress in research on evacuation behavior and modeling in the Philippines (e.g. Lim et al. 2016a; Lim et al. 2019; Lim et al. 2021), limited studies are conducted for no-notice volcanic eruptions. In addition to the risk perception, attitude, and the nature of risk communication, better evacuation compliance, socio-demographic and economic aspects should be well-understood (e.g. Favereau et al. 2018; Lechner and Rouleau 2019).

There are various aspects of household evacuation behavior such as evacuation decision, departure time choice, evacuation mode choice, and destination or specifically accommodation type choice. These decisions can be made simultaneously or sequentially and can vary depending on socio-demographic factors, hazard-related characteristics, and other factors (e.g. Lim et al. 2021; Wang et al. 2021). An evacuation decision, which is useful in estimating and modeling evacuation demand, is defined as a decision to either evacuate or stay in the area at risk of an impending hazard. The type of evacuation decision can include partial and full evacuation. Mode choice is an important logistical factor to consider in the evacuation operation. Lindell and Perry (1992) provided an early review of vehicle use during the evacuation that was later updated by Lindell and Prater (2007). More recent studies recognized and identified personal vehicles as evacuation modes (Huibregtse et al. 2010; Pel et al. 2011). Mass transit and other modes of evacuation have been explored in some evacuation studies for they can transport a considerable number of people to safety.

Another evacuation-related decision that a household should resolve is destination choice. Destination choice is the geographical location a household will go to when leaving their home located in a high-risk area. The destination often contains multiple types of accommodations. Accommodation type choice is the kind of facility where evacuees specifically go to (Bian et al. 2019). Analysis of the destination and accommodation type choice is important to be able to identify the demand for facilities in case of actual evacuations. However, past studies revealed that gaps still exist in the knowledge of the factors that influence these decisions including how these factors differ by population and disaster type (Lim et al. 2021). Another gap found in the literature is that most findings are not focused on no-notice disasters (Lechner and Rouleau 2019). Common disasters from studies are in the context of hurricanes and floods and mostly are in developed countries like the United States (e.g. Huang et al. 2016; Thompson et al. 2017).

This study aimed to understand different decision-making contexts of evacuation behavior, from evacuation decision, evacuation mode, and accommodation type choices. Using a discrete choice modeling framework, data collected from households in Leynes, Talisay Batangas, were used in calibrating and validating behavioral models. Barangay Leynes is one of the areas badly impacted by the eruption of Taal volcano in 2020. With a total population of 1,473 (396 households), it is located within the 14-km radius danger zone from the volcano. It is very near the volcano as it is located along the Taal lake in Talisay area, hence posed with high risks from volcanic eruption. It is frequently visited by tourists and bikers in the area where many business establishments are located. The results of this study can be used as a baseline for developing detailed evacuation plans for no-notice disasters due to volcanic eruptions. This is especially helpful for communities living near active volcanoes. The results in this study contribute to understanding the evacuation behavior in a developing country setting just like the Philippines due to a no-notice disaster. The impacts of disasters are not uniform when comparing disasters in developed and developing countries.

METHODS

Study Area and Data Collection

Leynes is a barangay in the municipality of Talisay, which is a 3rd class municipality in the province of Batangas, Philippines. Leynes is situated at approximately 14˚3′55.44″N, 120˚58′27.48″, on the island of Luzon. Elevation at these coordinates is estimated at 208.8 m or 685.0 ft above mean sea level. Figure 1 shows the location of Leynes, Talisay

Batangas. It shares a common border with the following barangays: Sampaloc, Caloocan, Silang Junction, and San Jose. Leynes is well known for its location on Taal Lake, providing a panoramic view of the Taal Volcano. However, it is also situated within the 14-km radius danger zone making it prone to the risks posed by Taal Volcano.

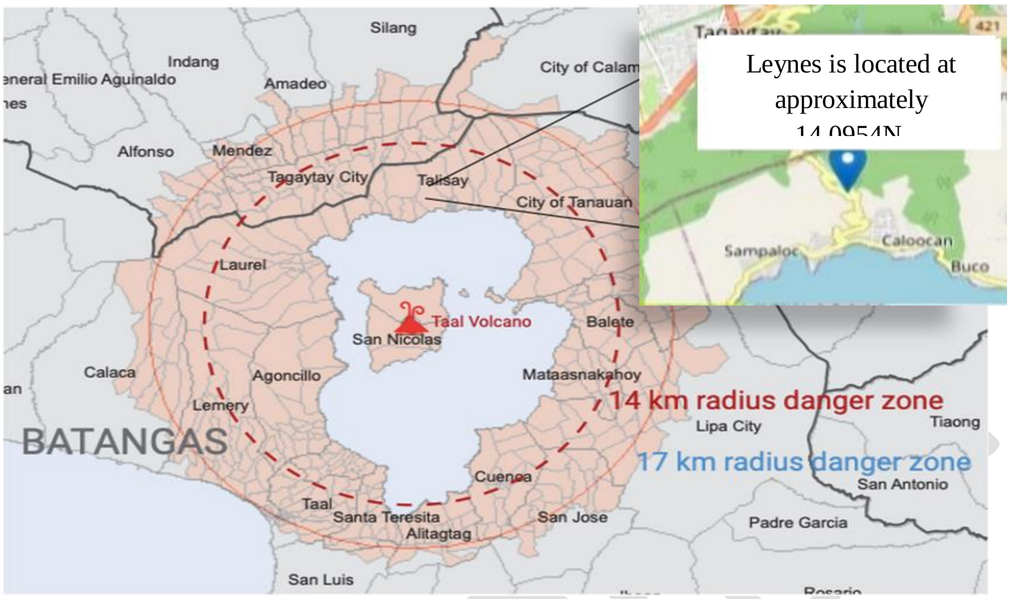

Figure 1. Location of Leynes, Talisay Batangas. Source: Open Street map (2020).

Like the method used for the data collection detailed in Lim et al. (2022a, b), the questionnaires were distributed to the households residing in the barangay through the help of the Barangay Health Workers (BHWs) from 26 June to 14 August 2021. This was done during the COVID-19 pandemic where face-to-face interviews were prohibited. Hence, the BHWs were trained in what to do while conducting limited face-to-face surveys with selected households. The survey questionnaire was designed to solicit evacuation information based on experience during the volcanic eruption in January 2020. The first portion consisted of socio-economic and household characteristics. The second portion was about their knowledge and information regarding the risk posed by the volcano. The third portion covered their evacuation experience, while the fourth section was about their re-entry experience. Lastly, the fifth portion includes households' suggestions on how to improve future evacuations.

A random sampling method was utilized in selecting household respondents. The total number of households in Leynes is 396, the number of questionnaires given was 364, and the answered questionnaires collected were 318. After the questionnaires were completed, data were summarized in a Microsoft Excel sheet. The summarized data was cleaned and checked. The cases with missing information were excluded from further data analyses. The resulting valid number of cases for analysis of evacuation-related decisions including the type of evacuation decision and evacuation mode choice is 296 (n=296). However, for the analysis of the accommodation type choice, the final valid cases used was 166 (n=166).

Modeling Framework, Parameter Estimation and Validation

The discrete choice model framework was applied in this study. In literature, discrete choice models have been used extensively in various disciplines such as social sciences, medicine, econometrics, transportation, and evacuation modeling (e.g. Mesa-Arango et al. 2013; Sadri et al. 2014). The recognized decision-makers in this study are the household heads. Equations 1, 2, and 3 show the form of the discrete choice utility function used in this study. The logit model specifies the utility function ($NEDEC_{ih}, DES_{ih}, MODE_{ih}$) for the type of evacuation decision, mode, and accommodation type choice, respectively, with terms ($\beta' X_{ih}$) and (ε_{ih}). β_s are vectors of parameters that were estimated and determined for decision i, of household h, respectively. Presented variables with Y_{ih} and Z_{ih} are the observed variables, and variables with ε_{ih} estimates variables that are not observed, underlying taste differences, and the use of proxy variables on observed choice.

$$NEDEC_{ih} = \beta_1' Y_{1ih} + \beta_2' Z_{1ih} + \varepsilon_{1ih} \quad (1)$$

$$DES_{ih} = \beta_3' Y_{2ih} + \beta_4' Z_{2ih} + \varepsilon_{2ih} \quad (2)$$

$$MODE_{ih} = \beta_5' Y_{3ih} + \beta_6' t Z_{3ih} + \varepsilon_{3ih} \ldots \quad .(3)$$

Equations 4, 5, and 6 present the probability functions for the type of evacuation decision, mode and accommodation type choice outcomes being chosen, *i*, by households, *h*, where *j* is the outcome decision, while ***e*** is Euler's number. Outcome decisions used for the type of evacuation are partial evacuation or full evacuation. In terms of mode choice, the outcomes include vehicles provided by the government, and owned/rented vehicles. While for accommodation type choice, outcome decisions include evacuation center, schools and government buildings, and friend's/relative's house or rented apartment. The decision where households partially evacuated, households with owned or rented vehicles, and the destination of a friend's/relative's house or rented apartment were the reference categories for parameter estimation of type of evacuation decision, mode choice, and destination choice, respectively.

$$P_{NEDECih} = \frac{e(\beta_1{}'Y_{1ih}+\beta_2{}'Z_{1ih}+\varepsilon_{1ih})}{\sum_i^j e(\beta_1{}'Y_{1ih}+\beta_2{}'Z_{1ih}+\varepsilon_{1ih})} \qquad (4)$$

$$P_{DESih} = \frac{e(\beta_3{}'Y_{2ih}+\beta_4{}'Z_{2ih}+\varepsilon_{2ih})}{\sum_i^j e(\beta_3{}'Y_{2ih}+\beta_4{}'Z_{2ih}+\varepsilon_{2ih})} \qquad (5)$$

$$P_{MODEih} = \frac{e(\beta_5{}'Y_{3ih}+\beta_6{}'Z_{3ih}+\varepsilon_{3ih})}{\sum_i^j e(\beta_5{}'Y_{3ih}+\beta_6{}'Z_{3ih}+\varepsilon_{3ih})} \qquad (6)$$

The coefficients β' in Equations 4, 5, and 6 are determined by the maximum likelihood estimation method with the detailed formula of the log-likelihood functions presented in Equations 7, 8 and 9 for the type of evacuation decision, mode, and accommodation type choice, respectively. In the equation, H signifies the number of households and J is the outcome type under the choice of the household, *h* being investigated.

$$LL_{NEDEC} = \sum_{i=1}^{J} \sum_{h=1}^{H} \log(P_{NEDECih}) \qquad (7)$$

$$LL_{DES} = \sum_{i=1}^{J} \sum_{h=1}^{H} \log(P_{DESih}) \;\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$LL_{MODE} = \sum_{i=1}^{J} \sum_{h=1}^{H} \log(P_{MODEih}) \;\ldots\ldots\ldots\ldots\ldots (9)$$

The null hypothesis, that coefficients in the utility functions in equations 1, 2 and 3 are zero, will be rejected statistically if any relevant model parameter is different from zero at a 0.05 significance level. The listwise deletion was used to identify variables that are included in the models. All variables were first tested for significance, then individual variables were assessed whether they should be included in the model. Insignificant variables were removed one by one. Further, the *pseudo-*R^2 was used to test the model fit. The AUC was also utilized to assess outcomes with a 0.5 cut-off point. The AUC with values ranging from 0 to 1, denotes the probability of the desired outcome and base outcome. Moreover, the correct classification rate (CCR) was used to compare the model's prediction performance to the base rate, which reflects the proportion of right classifications anticipated to occur by chance alone (Liu et al. 2014). With the addition of significant factors to the model, the CCR increased in comparison to the base rate, indicating an improvement in prediction accuracy. The sum of the squares of the percentage of outcomes in the data was used to compute the base rate.

An LR test was also used to investigate all model validity. The assumption of the method is a null hypothesis where the parameters of the model estimated using the whole data have no significant difference with that of the divided groups of two from the whole data. When the null hypothesis is not rejected, it means that the specification of the estimated models is established (Hasan et al. 2013). The LR test is as shown in equations 10, 11, and 12 for the type of evacuation decision, mode, and accommodation type choice, respectively.

In the equations shown, $LL\ (\beta_{whole})$ is the complete data model log-likelihood; $LL\ (\beta_{subsample1})$, is the log-probability estimate derived using the divided sub sample 1 of data which was randomly selected from the whole data; then $LL\ (\beta_{subsample2})$ is the log-likelihood at convergence of the model of sub sample group 2 from the whole data corresponding to the evacuation related decision being studied.

$$LR_{NEDEC} = -2[LL(\beta_{Nwhole}) - LL\ (\beta_{Nsubsample1}) - LL(\beta_{Nsubsample2})] \qquad (10)$$

$$LR_{DES} = -2[LL(\beta_{Dwhole}) - LL\ (\beta_{Dsubsample1}) - LL(\beta_{Dsubsample2})] \qquad (11)$$

$$LR_{MODE} = -2[LL(\beta_{Mwhole}) - LL\ (\beta_{Msubsample1}) - LL(\beta_{Msubsample2})] \qquad (12)$$

RESULTS

Descriptive Statistics

Table 1 details the variables and the percentage of data included for the analysis of the three evacuation-related travel behaviors. There were separate numbers of data cases used for the analysis of the evacuation travel behaviors including evacuation decision type and evacuation mode choice, as well as the accommodation type choice. The number of data cases used for the analysis of evacuation decision type and evacuation mode choice was 296 (n=296). One hundred sixty-six cases (n=166) were used for the analysis of accommodation type choice. The difference was due to the low *pseudo-*R^2 value reported for the latter using n=296. The data for the accommodation type choice analysis was reduced to find the model that provided an acceptable *pseudo-R^2* value.

The descriptive summary of the data set used for the analysis of the evacuation-related decisions (evacuation decision type and evacuation mode choice), shows that 219 households (73.99%) have fully evacuated, and 77 household respondents (26.01%) partially evacuated. Most of them (60.47%) evacuated using government vehicles while the rest (39.53%) evacuated using their owned or rented vehicles. One hundred eighty-one respondents (61.15%) evacuated to a house of friends/relatives or an apartment while 115 of them (38.85%) went to an evacuation center. Household respondents evacuated during the eruption (76.35%) and after the

Table 1. Descriptive summary of variables used for analysis of evacuation decision type, evacuation mode choice, and accommodation type choice.

Variables	Classifications	Data for NEDEC and MODE analysis		Data for DES analysis	
		N (296)	%	N (166)	%
Evacuation Decision Type (NEDEC)	Households that evacuated partially	77	26.01	44	26.51
	Households that evacuated fully	219	73.99	122	73.49
Evacuation Mode Choice (MODE)	Owned vehicle/rented vehicle	117	39.53	96	57.83
	Government vehicle	179	60.47	70	42.17
Accommodation Choice (DES)	House of friends/relatives or rented apartment	181	61.15	124	74.70
	Evacuation center (including public school, barangay hall, or church)	115	38.85	42	25.30
Departure timing (DEP)	Evacuated after the eruption	70	23.65	64	38.55
	Evacuated during the eruption	226	76.35	102	61.45
Source of Evacuation Warning (SWARN)	Media and social media	94	31.76	45	27.11
	Government official or agency	202	68.24	121	72.89
Distance traveled to the accommodation type (DIST)	≤ 25 km	126	42.57	72	43.37
	>25 km	170	57.43	94	56.63
Duration of stay in the accommodation type (DUR)	< 1 month	111	37.5	64	38.55
	≥ 1 month	185	62.5	102	61.45
Age of the respondent (AGE)	20-30 years old	62	20.95	23	13.86
	31-40 years old	74	25.00	56	33.73
	41-50 years old	65	21.96	44	26.51
	>50 years old	95	32.09	43	25.90
Marital status of the respondent (MAR)	Single	63	21.28	20	12.05
	Widow/widower	98	33.11	47	28.31
	Married/live-in	135	45.61	99	59.64
Number of household members (MEM)	≤4 members	168	56.76	95	57.23
	>4 members	128	43.24	71	42.77
Number of senior citizens in the household (NSEN)	No senior citizen present at home	191	64.53	105	63.25
	At least one senior citizen present at home	105	35.47	61	36.75
Monthly income of household (INCOME)	≤5,000 pesos	194	65.54	70	42.17
	>5,000 pesos	102	34.46	96	57.83
Vehicle ownership (OVEH)	Do not own a vehicle	106	35.81	55	33.13
	Owns vehicle	190	64.19	111	66.87
Type of Vehicle owned (TVEH)	None	106	35.81	55	33.13
	Motorcycle/tricycle	94	31.76	43	25.91
	Private car	96	32.43	68	40.96
Source of risk information related to Taal volcano (WINFO)	Media or social media	153	51.69	53	31.93
	Government official/agency	170	57.43	113	68.07
Knowledge of previous Taal eruptions (KNOW)	No knowledge of previous Taal eruption	170	57.43	74	44.58
	Have knowledge of previous Taal eruption	153	51.69	92	55.42

eruption (23.65%) since this was a no-notice disaster. Two hundred two of the respondents (68.24%) received evacuation warnings directly from a government official/agency while 94 respondents (31.76%) got their information from media/social media. Further, 57.43% of respondents got risk information about the Taal volcano directly from government officials/agencies, while the rest got information from the media/social media. Also, 51.69% of the households knew about previous Taal volcanic eruptions while 48.31% did not.

Further, for the accommodation type choice analysis which consists of 166 cases, it can be observed that most of the households fully evacuated (73.49%) and the rest partially evacuated (26.51%). Ninety-six (96) out of 166 respondents evacuated using their owned or rented vehicle while 70 of them evacuated using the designated government vehicle. Also, 42 respondents went to evacuation centers while 124 respondents stayed in their friend's/relative's house or rented apartment. Most of the respondents evacuated during the eruption (102) while 64 of them evacuated after the eruption. One hundred twenty-one respondents got their source of evacuation warning from government officials/agencies while 45 respondents got it from media outlets or social media. 56.63% of the respondents traveled more than 25 km to reach their accommodation type choice. One-hundred-two (102) household respondents stayed in their accommodation choice for a month or more while 64 of them stayed there for less than a month. For better visualization of evacuation behavior, Figure 2 shows a map of the evacuation movement of the household respondents when evacuating after the Taal volcano erupted in 2020. The map shows the type of transport mode (either government vehicle one or owned/rented vehicle) used when going by the indicated road taken from residential area in Leynes to either their friends/relatives house or rented apartment or to any designated evacuation center.

Figure 2. Evacuation mode and destination choice of household respondents in Barangay Leynes, Talisay, Batangas, Philippines.

Correlation Matrix

The correlation matrix of the variables included in the models is shown in the Appendices. Existing correlations of variables to the type of evacuation decision can be seen in the partial results. Possible determinants of the type of evacuation decision (Table

2) include the departure timing, source of evacuation warning, marital status, and knowledge of previous Taal eruption. All these variables except marital status are positively correlated to the type of evacuation decision. Furthermore, the correlation matrix to the evacuation mode choice (Table 2) indicates that distance traveled, the income of the respondents, vehicle ownership, and type of vehicle owned were significantly correlated to evacuation mode choice. It can be observed however, that the income variable was correlated with the distance traveled, vehicle ownership, and type of vehicle owned. Moreover, focusing on the correlation of accommodation type choice to other variables (Table 3), a positive correlation appeared with the source of evacuation warning, number of household members, and source of risk information about the Taal volcano. Meanwhile, the number of senior citizens in the household was negatively correlated to the accommodation type choice. The correlation matrix gives information on the effect of only one variable at a time on evacuation-related decisions being investigated. Hence, to evaluate the effects of multiple variables on evacuation-related decisions, logit models were estimated. The intercorrelation level among the independent variables implies the selection of variables that are included in the logit model.

Model Parameter Estimates and Validation

The result of the model estimation for households' evacuation behavior is shown in Table 4. The parameter estimates for decisions where households fully evacuated, households that evacuated using government vehicles and the accommodation type choice of evacuation centers are shown in the table. The range of the calculated AUC of the three models is from 0.72 to 0.85. Moreover, the model *pseudo*-R^2 ranges from 0.10 to 0.33. In terms of model validation, the value of *LR* for the type of evacuation decision is 5.12 with degrees of freedom equal to 4 and a critical value equal to 9.49. The mode choice mode has an *LR* value of 6, degrees of freedom equal to 3, and a critical value equal to 7.81. Lastly, the accommodation type choice has an *LR* value of 7.86 with degrees of freedom equal to 4 and a critical value of 9.49.

Table 4 shows that the significant variables for evacuation decision include the departure timing, source of evacuation warning, marital status, and knowledge of previous Taal eruptions. All variables have positive coefficients except for marital status. Meanwhile, the distance traveled to accommodation type choice, vehicle ownership, and the type of vehicle owned are the variables significant to the mode choice. The variables have positive coefficients. Lastly, the determinants for destination choice include source of evacuation warning, number of household members, number of senior citizens in the household, and source of information on dangers and risks of Taal volcano. Positive coefficients were denoted to all variables except the number of senior citizens in the household.

DISCUSSION

The results from this study showed different factors affecting the type of evacuation decision, mode choice, and accommodation type choice. Some of the significant factors are socio-demographic variables and are discussed in this section as presented in Table 4.

Model Parameters and Validation

The results of the logit models developed in this study capture the behavioral complexities of each decision-making covered in this study. The calculated *pseudo*-R^2 for the three evacuation-related models are in the range of 0.1-0.33, indicating acceptable level of data fit in respective models. Additionally, the calculated AUC for the three models range from 0.72 to 0.85 which means that the models' level of discrimination is acceptable. Also, results of the internal validation, *LR* tests show that calculated *LR* for the evacuation related decisions investigated are less than the critical values. These results indicate that model validity for the type of evacuation, mode choice and the accommodation type choice are established.
As shown in Table 4, all variables that determine the type of evacuation decision are significant at 0.05. Departure timing has a positive coefficient (β = 1.54) which means that the households tend to fully evacuate when doing it during the eruption. In addition, the source of evacuation warning has a positive coefficient (β = 1.01), which means that if the warning comes from government officials/agencies, households are more likely to fully evacuate. This shows that households have a high level of trust in the authorities. This complements the findings in the past literature in which the source of warning was identified as an influential predictor of evacuation decisions (Huang et al. 2016; Lim et al. 2016a; Golshani et al. 2019; Roy and Hasan 2021). Further to the results in this study, marital status has a negative coefficient (β = -0.92) which implies that households who are not single are less likely to fully evacuate. Moreover, it is important to note that knowledge of previous Taal eruptions also has a positive coefficient (β = 1.10). The more knowledgeable respondents concerning previous Taal eruptions are, the more likely that they fully evacuate.

Table 2. Correlation matrix of variables used for analysis of the type of evacuation decision and evacuation mode choice. **significant at 99%; *significant at 95%

	NEDEC	MODE	DEP	SWARN	DIST	AGE	MAR	MEM	NSEN	INCOME	OVEH	TVEH	WINFO	KNOW
NEDEC	*1*													
MODE	*-0.05*	*1*												
DEP	*0.32**	*0.09*	*1*											
SWARN	*0.19**	*-0.02*	*0.10*	*1*										
DIST	*0.05*	*0.16**	*-0.11*	*-0.04*	*1*									
AGE	*-0.11*	*0.01*	*-0.15*	*0.11*	*0.07*	*1*								
MAR	*-0.34**	*-0.07*	*-0.16**	*0.04*	*-0.08*	*0.34**	*1*							
MEM	*-0.07*	*-0.09*	*0.04*	*0.02*	*-0.03*	*-0.03*	*0.06*	*1*						
NSEN	*-0.03*	*-0.06*	*-0.04*	*0.01*	*0.07*	*0.32**	*0.02*	*0.15**	*1*					
INCOME	*-0.12*	*0.21**	*-0.13*	*0.02*	*0.22**	*-0.02*	*-0.07*	*0.04*	*-0.02*	*1*				
OVEH	*-0.05*	*0.62**	*0.01*	*0.08*	*0.10*	*0.02*	*-0.05*	*-0.09*	*-0.05*	*0.24**	*1*			
TVEH	*0.08*	*0.60**	*0.08*	*0.05*	*0.14*	*0.03*	*-0.12*	*-0.07*	*-0.01*	*0.25**	*0.85**	*1*		
WINFO	*0.14*	*0.12*	*0.03*	*0.30*	*0.11*	*0.07*	*-0.02*	*0.06*	*0.08*	*0.04*	*0.01*	*-0.02*	*1*	
KNOW	*0.37**	*0.02*	*0.04*	*0.06**	*0.14*	*-0.01*	*-0.29**	*-0.01*	*0.01**	*0.14*	*0.07*	*0.13*	*0.04*	*1*

Table 3. Correlation matrix of data used for analysis of accommodation type choice. **significant at 99%; *significant at 95%

	DES	NEDEC	MODE	DEP	SWARN	DIST	DUR	AGE	MAR	MEM	NSEN	INCOME	OVEH	TVEH	WINFO	KNOW
DES	*1*															
NEDEC	*0.10*	*1*														
MODE	*-0.05*	*-0.10*	*1*													
DEP	*-0.07*	*-0.17*	*-0.03*	*1*												
SWARN	*0.11**	*0.22**	*-0.13*	*-0.06*	*1*											
DIST	*-0.13*	*0.05*	*-0.09*	*0.13*	*-0.07*	*1*										
DUR	*-0.02*	*0.17*	*0.08*	*-0.01*	*0.10*	*0.01*	*1*									
AGE	*0.14*	*0.01*	*-0.15*	*0.10*	*0.13*	*0.10*	*-0.01*	*1*								
MAR	*0.06*	*-0.36**	*-0.02*	*0.15*	*-0.02*	*-0.08*	*-0.10*	*0.01*	*1*							
MEM	*0.16**	*-0.09*	*0.06*	*-0.04*	*-0.08*	*-0.01*	*-0.07*	*-0.09*	*0.02*	*1*						
NSEN	*-0.13**	*-0.02*	*-0.05*	*-0.11*	*-0.01*	*0.01*	*0.08**	*0.15*	*-0.03*	*0.12*	*1*					
INCOME	*-0.07*	*0.12*	*0.05*	*0.03*	*-0.05*	*0.18*	*0.01*	*-0.02*	*-0.05*	*-0.03*	*0.12*	*1*				
OVEH	*-0.06*	*-0.04*	*-0.02*	*0.01*	*0.15*	*0.06*	*-0.10*	*0.01*	*0.17*	*-0.17*	*-0.05*	*0.18*	*1*			
TVEH	*-0.05*	*0.05*	*-0.01*	*-0.02*	*0.10*	*0.15*	*-0.05*	*-0.01*	*0.07*	*-0.15*	*0.10*	*0.16*	*0.87**	*1*		
WINFO	*0.19**	*0.02*	*0.11*	*-0.01*	*0.34*	*0.13*	*-0.09*	*-0.12*	*-0.03*	*0.04*	*0.10*	*0.17*	*0.15*	*0.87*	*1*	
KNOW	*-0.06*	*0.04*	*-0.09*	*0.02*	*0.05*	*0.14*	*0.04*	*0.05*	*-0.11*	*-0.05*	*0.11*	*0.16*	*0.06*	*0.15*	*0.13**	*1*

Table 4. Result of the logit model parameter estimation for households that fully evacuated by government vehicle and went to evacuation centers. **significant at 99%, *significant at 95%

Variables	Type of Evacuation Decision		Mode Choice		Accommodation Type Choice	
	Coefficient (β)	P>|z|	Coefficient (β)	P>|z|	Coefficient (β)	P>|z|
DEP indicator variable for departure timing (1 for evacuation timing during the Taal eruption, 0 otherwise)	1.54**	0.000				
SWARN indicator variable for source of evacuation warning (1 for government official/agency, 0 otherwise)	1.01**	0.002			1.12*	0.028
MAR indicator variable for marital status (1 for married/live-in/widow/widower, 0 for single)	-0.92**	0.000				
KNOW indicator variable for knowledge on previous Taal eruption (1 for the presence of knowledge about Taal, 0 otherwise)	1.10**	0.000				
DIST indicator variable for distance traveled to accommodation type choice (1 for > 25 km, 0 for ≤ 25 km)			0.55	0.081		
OVEH indicator variable for vehicle ownership (1 for households that own a vehicle, 0 otherwise)			1.68**	0.002		
TVEH indicator variable for the type of vehicle owned (1 for private car/motorcycle/tricycle, 0 otherwise)			0.94**	0.008		
MEM indicator variable for the number of household members (1 for more than 4 members, 0 otherwise)					0.81*	0.045
NSEN indicator variable for the number of senior citizens in the household (1 for the presence of senior citizen, 0 for none)					-0.79*	0.047
WINFO indicator variable for source of information on dangers and risks of Taal volcano (1 for government official/agency, 0 otherwise)					1.38**	0.001
Constant	-0.49	0.369	-1.68	0.000	-1.06	0.024
Number of Observations	*296*		*296*		*166*	
LR chi^2	*91.13*		*131.85*		*19.52*	
Prob > chi^2	*0.00*		*0.00*		*0.00*	
Pseudo-R^2	*0.27*		*0.33*		*0.10*	
CCR	*80.41*		*81.76*		*76.51*	
CCR Base Rate	*61.51*		*52.19*		*62.20*	
AUC	*0.83*		*0.85*		*0.72*	

It can be observed from the results in Table 2 that the distance traveled to accommodation type choice has a positive coefficient (β = 0.55) implying that respondents are more likely to use a government vehicle if they are going to travel for more than 25 km. The critical range value of more or less than 25km distance was set because the study area is situated within the 14-km danger zone and designated evacuation centers are within the provinces of Cavite, Laguna, and Quezon. It is also worth noting that although the distance traveled is significant at 90% as shown in Table 2, it is still included in the model due to previous studies and consistent with other findings. Longer distances traveled result in a higher probability of using vehicles compared to walking (e.g. Lim et al. 2016b).

Moreover, vehicle ownership and type of vehicle owned has positive coefficients, β = 1.68, 0.94, respectively. The result of vehicle ownership indicates that households that own a vehicle are more likely to evacuate using a government vehicle. This can be explained by the type of vehicle most households own, which is also a significant variable in the model. Also, from the descriptive data in Table 1, only 32.43% of them owned a private car and the remaining more than 67% either owned a motorcycle or tricycle while others had none. Those respondents who have motorcycles or tricycles have resorted to using government vehicles because their capacity cannot accommodate all evacuating family members. Also, during the context of evacuation, the ashes on the road were so thick with mud causing the need for bigger vehicles for evacuation. This result in the current study is contrary to the results of Chen et al. (2021) where vehicle ownership is a determinant of personal vehicle use. This difference is plausible as in the case of Chen et al. (2021), where there would be no opportunity for government agencies to provide transportation for evacuation in a local tsunami setting.

The source of warning has a positive coefficient (β = 1.12) which means that warnings that came from government officials/agencies are more likely to encourage respondents to go to designated evacuation centers. Similarly, past studies reported that mandatory evacuation notices coming from government officials encouraged respondents to stay in the designated evacuation centers (Golshani et al. 2019; Lim et al. 2021; Nagarajan and Shaw 2021). Further, the number of household members has a positive coefficient (β = 0.81), which means that households with more than 4 family members are more likely to go to the evacuation centers. This is complementary to the findings of Wu et al. (2012) in which they also found out that larger household sizes have a higher probability of staying in public shelters. Moreover, the presence of senior citizens in the household indicated a negative coefficient (β = -0.79) which signifies that those households with elderly members are less likely to go to evacuation centers. This result is according to Golshani et al. (2019) who found that retired household members tend to stay with their family because they typically rely on their family members or relatives for emergency evacuation. Moreover, the source of information related to Taal volcano, and its risks is positively correlated to destination choice (β = 1.38). This indicates that respondents whose source of risk information regarding Taal volcano is the government official/agency will be more likely to go to an evacuation center.

The above findings can lead to several policy and operational recommendations and ramifications. Evacuation planners should think about the entire evacuation process, from the choice to leave to the availability and capacity of evacuation modes, shelter, and return. The term "evacuation" does not merely mean "withdrawal." Furthermore, withdrawal is not the most difficult part of the evacuation process. It is more effective for operational personnel to think of evacuation as a roundtrip process including the four interrelated stages, rather than just a movement away from danger. Indeed, Siebeneck et al. (2020) and Manandhar and Siebeneck (2021) have studied this issue extensively. Also, rather than being homogeneous, the phenomena should be viewed as diverse. The evacuee population is composed of several segments that will not all be present at the same time at any given location. Some could be just beginning to flee, while others have arrived at their chosen accommodations. Further, there are others who may have returned home due to frustration of traffic jams along the way. Another implication is that future message, order language, and timing in communicating warnings and disaster risks to residents should be considered and strengthened. The required evacuation resources, such as evacuation vehicles and rescue automobiles, should always be provided and readily available in the study's community environment. Additionally, agencies should explore boosting the number of public and alternative shelters available to alleviate evacuees' anxieties about locating and paying for accommodation.

Although models have been developed and evaluated as discussed, this study has some limitations. A bigger sample size can be taken from other barangays. Pooled data from different barangays might result in a better understanding of the volcanic travel behavior of Talisay, Batangas. The study area might be expanded for a more robust understanding of the evacuation decision, mode, and accommodation type choices for the city and municipal level. Also, other factors aside from the factors considered in this study can be investigated and contextualized in the research. Utilizing evacuation intentions or a combination of this and actual evacuation intentions for modeling might also be useful in future research.

Lastly, this study only addressed two warning sources, so the effects of other sources such as peers—as well as warning channels (e.g. Lindell and Perry 1987) and message content (e.g. voluntary vs. mandatory evacuation (Baker 1991)— should be addressed as directions for future research.

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ETHICAL CONSIDERATIONS

In the conduct of interviews, participants' informed consent was ensured. Only those who were willing to participate were interviewed. The personal information of participants is kept confidential. Only the results of the data analysis are published in this paper.

DECLARATION OF COMPETING INTEREST

We declare no competing interests in this work.

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