Effects of Socio-demographic Factors on Evacuation Decision-making Under an Imminent Threat of Volcanic Eruption: Case Study Auckland.

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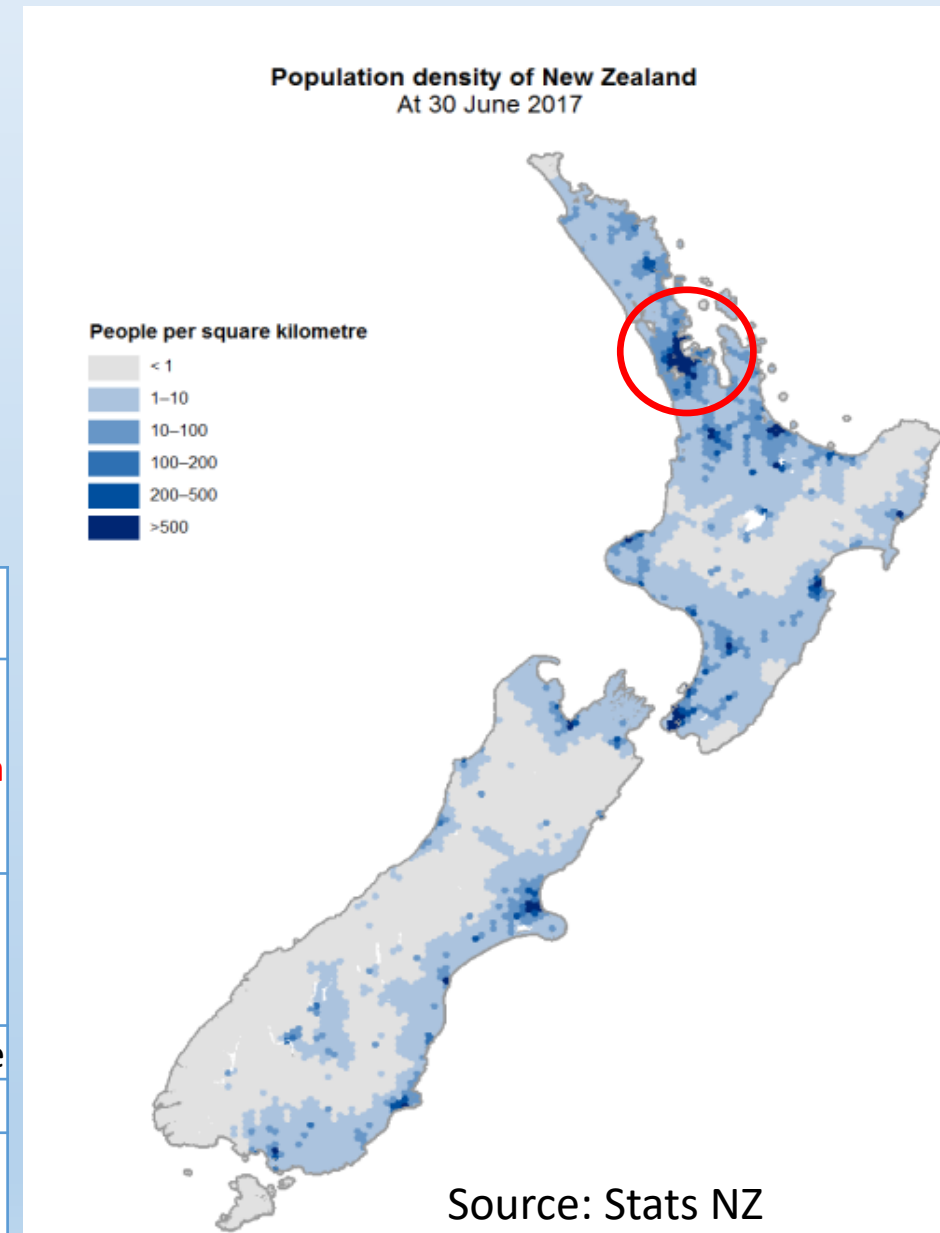
University of Auckland

Auckland?

❖ *One third of New Zealand population resides*

❖ *Generates 37.5% of the country's GDP (Statistics New Zealand, 2018)*

What are the emergency situations?

❖ *Prone to a number of natural hazards*

S.N	Natural Hazard	Likelihood	Impact	Number of Evacuees	Priority
1	**Volcanic Eruption (AVF)**	**Rare**	**Catastrophic**	**100,000+**	
2	Volcanic Eruption (Distant Source Eruption)	Likely	Major	-	**Very High**
3	Cyclone	Likely	Major	1000+	
4	Earthquake	Unlikely	Major	10,000+	
5	Flooding Tsunami(Regional/Local)	Unlikely	Moderate	100,000+	High
6	Erosion (Landslide /Land instability)	Almost Certain	Moderate	1000+	
7	Flooding (River / Rainfall /Storm Surge)	Possible	Moderate	1000+	Moderate
8	Fire (Urban)	Possible	Minor	1000+	Low
9	Fire (Rural)	Likely	Insignificant	1000+	Very Low
10	Tornado	Likely	Insignificant	-	

Source: Auckland Natural Hazards (AC & CDEM,2014)

Population density of New Zealand
At 30 June 2017

People per square kilometre
< 1
1–10
10–100
100–200
200–500
>500

Source: Stats NZ

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What can be the expected behaviour of Aucklanders after the warning is announced

Answers may be

People assess the risk

How ?

look for more information

Where?

How they come to the decision to evacuate?

Call friends and family

Important for simulation modelling and behaviour predictions

Route to evacuate?

Mode to evacuate?

Collect family members and pets

Preference to go after evacuating the place?

Officials need to understand these to create the most effective plans

Factors affecting evacuation decision making

Contributing factors

❏ *Literature Review:*
  identify different influential factors and research gaps

❏ *Influence of socio-demographic factors:*
  descriptive statistics & logistic regression (this paper)

❏ *Influence of socio-psychological factors:*
  (socio-psychological) modelling tools and techniques
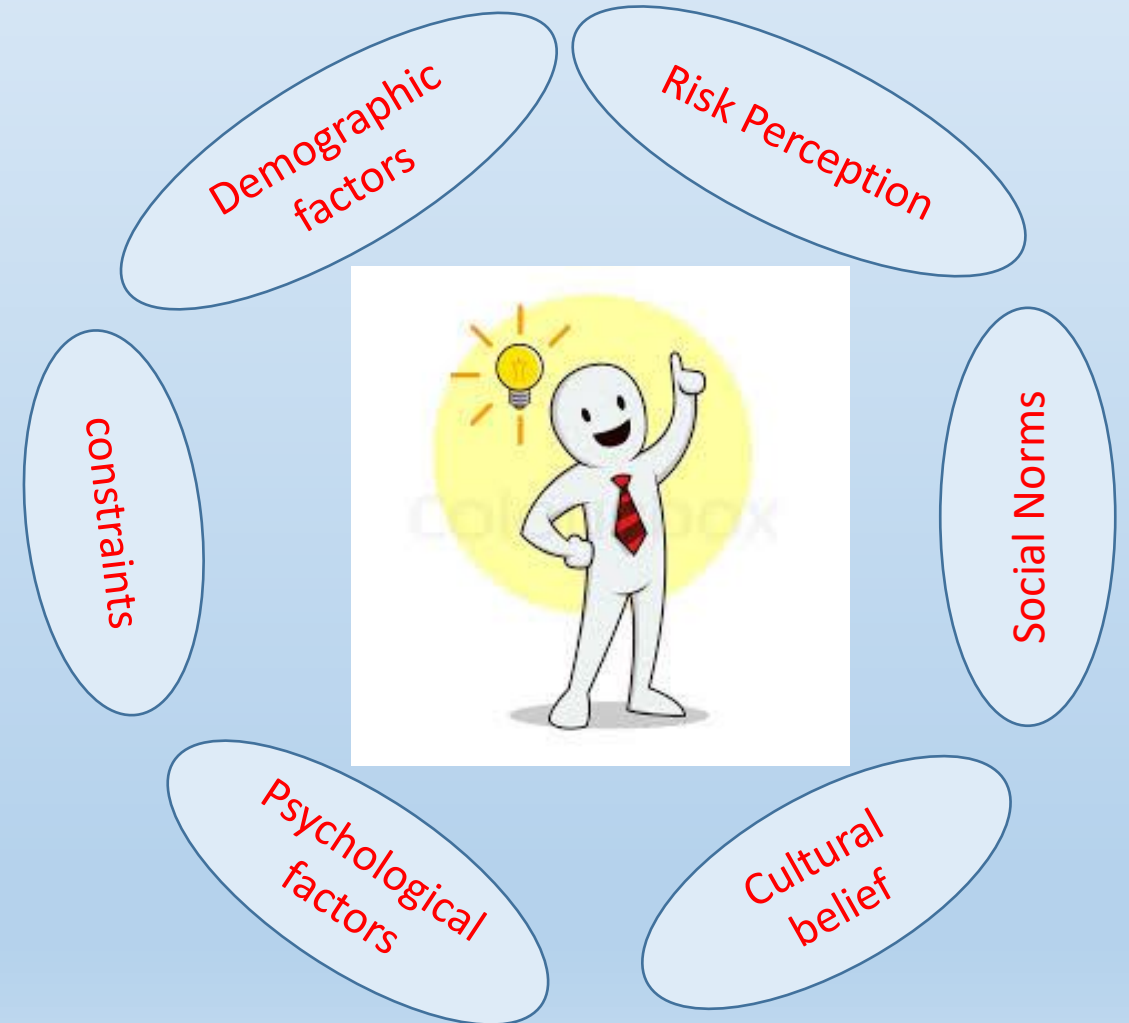
Introduction to Paper

ELSEVIER

safety science

Check for updates

Investigating evacuation behaviour under an imminent threat of volcanic eruption using a logistic regression-based approach

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ARTICLE INFO

ABSTRACT

With natural hazard events increasing globally, it is important to establish an effective evacuation procedure to mitigate their impacts. This paper investigates factors contributing to individuals' evacuation decision-making under an imminent threat of volcanic eruption based on the data collected from a stated preference survey conducted in Auckland, New Zealand. Several factors are analysed using a logistic regression approach, including socio-demographic factors and factors related to risk, awareness, preparedness, evacuation warning and order, evacuation route choice, evacuation mode choice and evacuation destination choice. The results revealed that some of these factors are influential for individuals' evacuation decision-making, including ethnicity, choice of destination, mode of transport, length of residency, risk awareness, annual household income and household with children. These findings will be useful for planners and policymakers in managing risks and planning to improve the safety of the vulnerable community by identifying appropriate evacuation strategies and reducing risk-increasing evacuation behaviour.

Contributions of Paper

1. *A stated preference questionnaire survey is conducted in Auckland, New Zealand*
   Questions related to individuals' perceptions of volcanic hazards and their evacuation decision-making process under a hypothetical volcanic eruption scenario

2. *Data collected analyzed using descriptive statistics and a logistic regression approach*

3. *Influential factors contributing to individuals' evacuation decisions are identified and evaluated*

Questionnaire Survey

➤ Pilot survey conducted during March 2019 followed by a detailed questionnaire survey from November 2019 to April 2020 using Qualtrics online survey tool

➤ The questions related to the pre-evacuation actions are based on the hypothetical scenario of a volcanic eruption warning. It was stated in the survey

"Imagine that scientists have started to detect small earthquakes deep in the earth that suggest a volcanic eruption might be building. The earthquakes are not able to be felt at the surface but are detected using scientific instruments and visible on the GeoNet web page. Auckland Emergency Management and GeoNet have issued a statement through the media and through their alerting systems (text message, emails etc.) advising that an eruption is LIKELY and asking people in an area that includes YOUR HOME SUBURB to prepare for an evacuation that will take place in a week time".

Questionnaire Survey

➢ The questions dealing with the factors affecting decision-making after the authorities issued an evacuation order is based on the following hypothetical scenario. It was stated in the survey

"Imagine now that earthquakes and other warnings of a volcanic eruption have grown and are now being felt at the surface. Auckland Emergency Management has issued a MANDATORY evacuation notice that includes the suburb WHERE YOU LIVE. Everyone must evacuate from your suburb within the next 24 h. It is noon (12:00hrs) on a weekday."
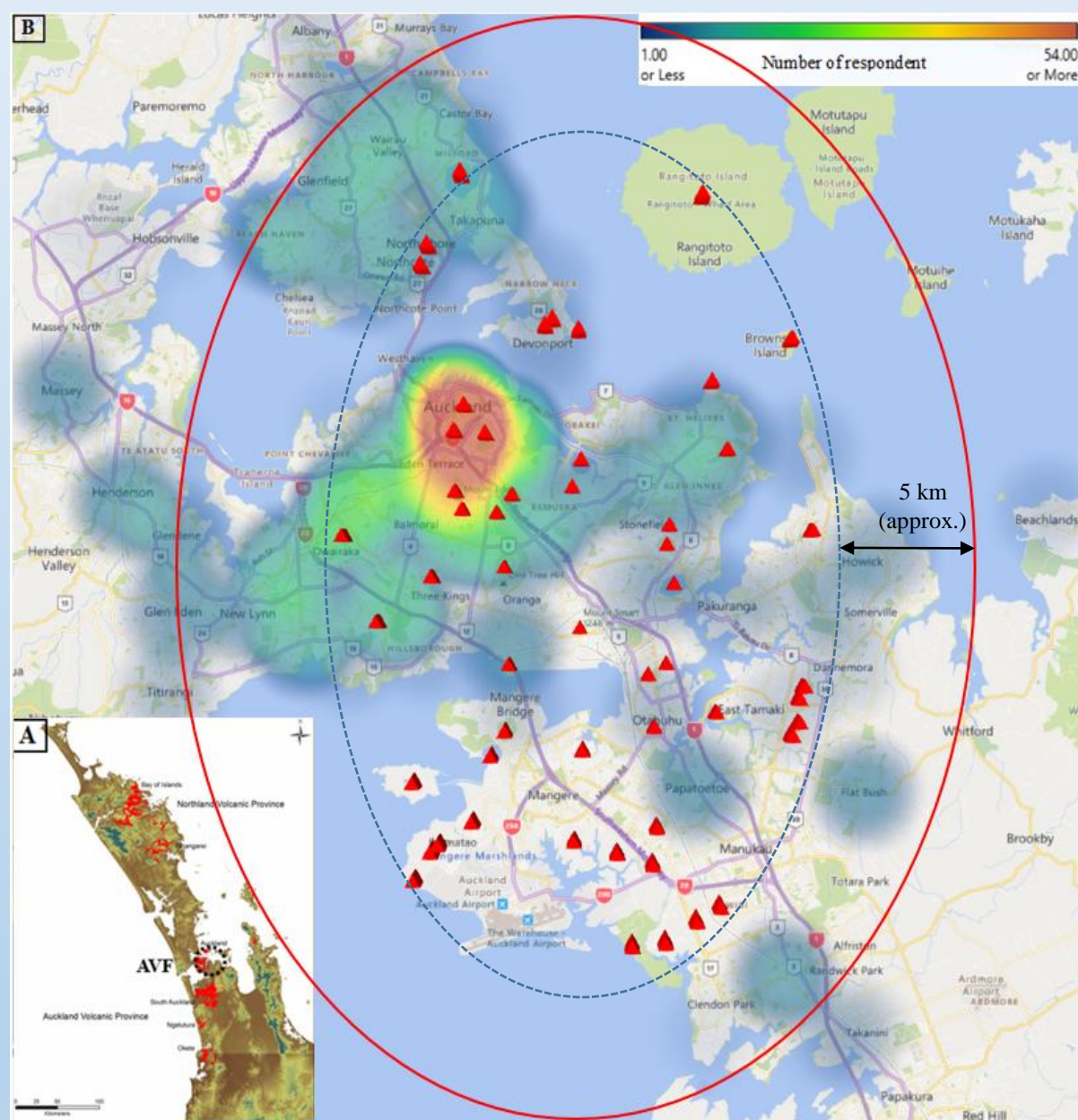
Fig. A) Spatial distribution of volcanoes in the upper North Island of New Zealand, B) The AVF (the area inside dotted blue line), spatial distribution of volcanoes (represented by red triangles ▲), the survey area (the area inside solid red line) superimposed with a heat map (coloured patches) of the residential locations of the online survey respondents (modified from Wild et al., 2020)

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Descriptive statistics

Socio-demographic characteristics		Survey respondents (%)	Auckland census 2018 (%)
Gender	Male	50.6	49
	Female	48.0	51
	Gender diverse	0.7	-
	Prefer not to say	0.7	-
Age	16-20	5.6	7
	21-30	33.4	18
	31-40	31.0	16
	41-50	15.5	15
	51-60	10.1	13
	60+	4.4	31
Ethnicity	European	52.4	47.8
	Asian	21.6	25.1
	Middle Eastern/Latin American/African	7.1	2.0
	Pacific people	4.2	13.8
	Maori	2.5	10.3
	Others	12.2	1.0
Occupation	Employee (full time)	55.6	-
	Student	23.4	-
	Student & employee (part-time)	5.7	-
	Employee (part-time)	2.9	-
	Self-employed	2.7	-
	Others	9.7	-
Length of residency	Less than a year	8.9	-
	1 to 5 years	26.3	-
	More than 5 years	64.8	-

Socio-demographic characteristics		Survey respondents (%)	Auckland census 2018 (%)
Do you have a partner/ spouse	Yes	61	-
	No	39	-
Accommodation type	Owned by myself or family	45.7	-
	A short-term rental or hotel	3.9	-
	A mid- to long-term rental	50.4	-
Number of adults in the household	1	8.8	-
	2	36.2	-
	3	20.4	-
	4+	34.6	-
Number of children in the household	None	65.9	-
	1	17.2	-
	2	12.3	-
	3	2.9	-
	4+	1.7	-
Total annual household income	$100,001 or more	51.9	-
	$70,001 - $100,000	18.2	-
	$50,001 - $70,000	11.7	-
	$30,001 - $50,000	4.4	-
	$20,001 - $30,000	5.4	-
	$20,000 or less	8.4	-
Number of vehicles in the household	None	11.6	-
	1	28.7	-
	2	34.2	-
	3+	25.5	-

➢ *20 questions were analyzed which includes; 11 questions related to socio-demographics*

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Descriptive statistics

➢ *5 questions related to knowledge about volcanic eruptions and pre-evacuation actions*

| Variables		Survey respondents (%)
Risk awareness	A lot	24.8
	I've heard a little bit	62.9
	I've never heard about the risk of a volcanic eruption in Auckland	12.3
Preparedness	Yes	15
	No	85
Evacuation mode choice	Personal car	74.8
	Transportation arranged by Civil Defence/Government	12.9
	Bus	2.3
	Train	1.4
	Ferry	0.5
	Other	8.1
Evacuation route choice	Towards south (e.g., Coromandel, Tauranga, Hamilton, Rotorua)	48.4
	Towards north (e.g., Whangarei)	29.5
	Others	22.1
Destination choice	A hotel or guesthouse	7.4
	Friend's/Relative's/Whanau's house	34.8
	Marae	0.3
	Emergency shelter provided by the authorities	26.6
	Don't know where to go	21.6
	Others	9.3

Descriptive statistics
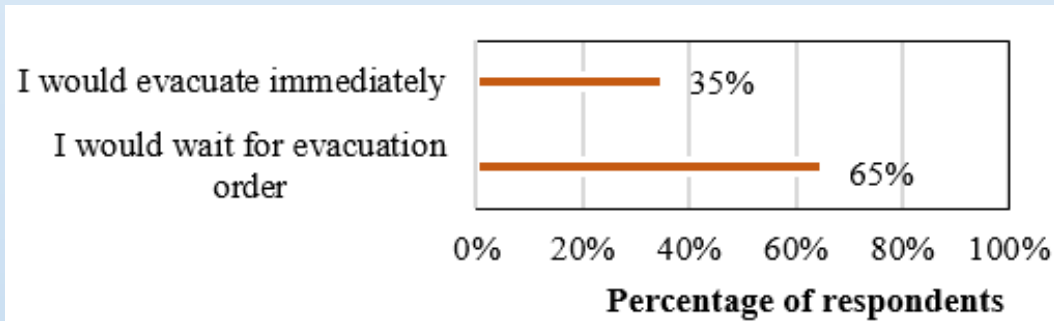
(a) Q: After getting the advisory warning message, what would you do?
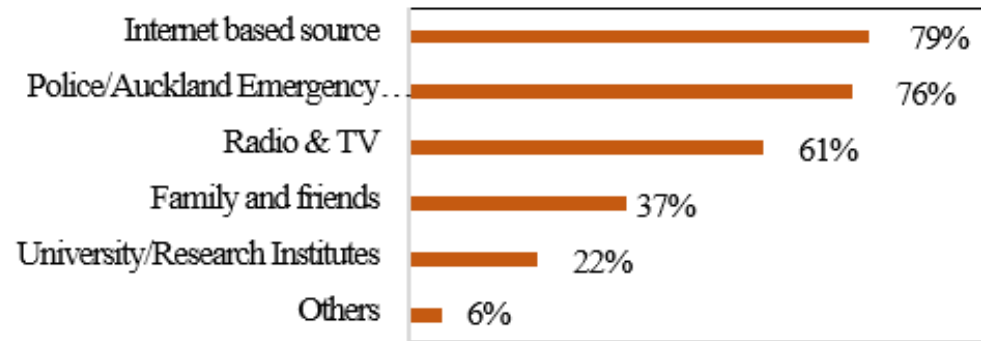
(b) Q: Where would you look for more information on the evacuation? (multiple selection was available)
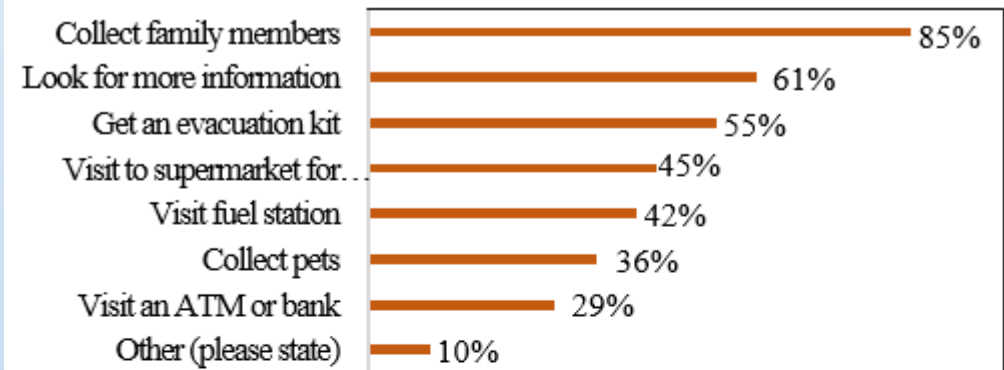
(c) Q: What would be your actions after the mandatory order is issued? (multiple selection was available)
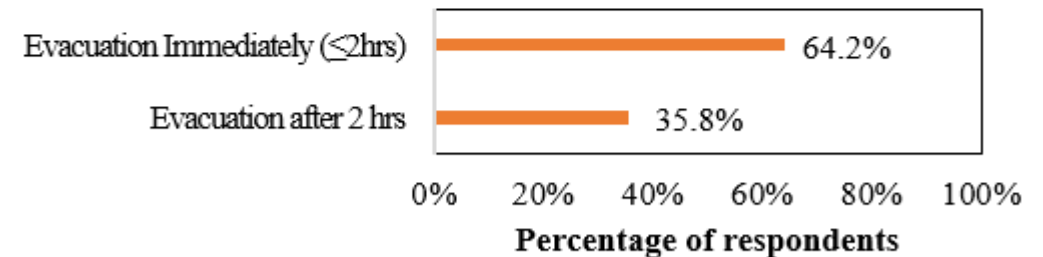
(d) Q: How soon would you evacuate after the mandatory order is issued during daytime?

➢ *2 questions related to pre-evacuation actions after receiving advisory warning message (presented in Fig. (a) and (b))*

➢ *2 questions related to individual's decision after an evacuation order is issued (presented in Fig. (c) and (d)).*

Logistic regression

➢ Binary Logistic regression using SPSS version 25

➢ Dependent variable: Decision to evacuate with two choices

(immediate/delayed evacuation behaviour).

    1. Evacuate immediately i.e. within the first two hours of receiving an evacuation order

    2. Wait for further information and evacuate after two hours of receiving an evacuation order

➢ Independent variables: Initially considered 14, final used for analysis 8 after further check

Logistic regression

➢ VIF were below the cut-off value of 3.3, no Multicollinearity.

➢ Accommodation type, number of adults in the household, gender and age were not significant.

➢ As most of the respondents (85%) seemed to be not prepared for the disaster so, the preparedness variable was also not considered for further analysis.

➢ Stepwise backward Akaike Information Criterion (AIC) values were calculated and variables were dropped further for a better model.

Table 3
Explanatory variables with their respective F-values, VIF.

Variables	Description	One way ANOVA F-Value	VIF
Preparedness	Yes (15%), No (85%)	4.89*	1.06
Destination choice	Emergency shelter provided by the authorities (26.6%), Friend's house/Relative's house/Whanau's house (34.8%), Others (38.6%-A hotel or guest house; Marae; Don't know where to go; others)	16.12***	1.10
Evacuation mode	Personal car (74.8%), Transportation arranged by Civil Defence/ Government (12.9%), Others (12.3%-Bus; Train; Ferry; others)	19.03***	1.22
Route choice	Towards south direction (e.g. Coromandel, Tauranga, Hamilton, Rotorua) (48.4%), Towards the north direction (e.g. Whangarei) (29.5%), Others (22.1%)	10.38***	1.12
Number of children in household	None (65.9%), greater than equal to 1 (34.1%)	22.15***	1.20
Ethnicity	European (52.4%), Maori and Pacific (6.7%), Asian (21.6%), Others (19.3%-Middle East/Latin America/Africa, others)	7.12**	1.10
Risk awareness	Little bit or No (75.2%), A lot (24.8%)	41.04***	1.14
Age	20 to 50 (79.9%), 50+ (14.5%)	0.43	1.10
Partnership status	Yes (61%), No (39%)	4.46*	1.17
Length of residency	<5 years (35.2%), More than 5 years (64.8%)	7.77**	1.33
Number of adults in household	Less than equal to 4 (65.4%), Greater than 4 (34.6%)	1.47	1.06
Annual household income	<$50,000 (18.2%), $50,000 to $100,000 (29.9%), $100,001 or more (51.9%)	10.98***	1.06
Accommodation type	Owned by myself or family (45.7%), Others (54.3%-A short term rental or hotel; A mid to long-term rental)	1.55	1.37
Gender	Male (50.6%), Female (48%), Gender diverse (0.7%), Prefer not to say (0.7%)	1.45	1.02

Note: *p < 0.050; **p < 0.010; ***p < 0.001

Logistic regression

Table 4
Logistic regression model output.

Predicted probability of people evacuating immediately (x/xxᵃ)	B (coefficient)	S.E.	Wald	Sig.	Odds Ratio	95% C.I. for Odds Lower	Upper
Destination choice (Friend's/relative's house vs. Emergency shelter)	−1.30	0.31	17.8	0.000***	0.27 (1/3.67)	0.15	0.50
Destination choice (Others vs. Emergency shelter)	−1.25	0.28	19.7	0.000***	0.29 (1/3.47)	0.17	0.50
Evacuation mode (Arranged transport e.g., by Civil Defence vs. Personal car)	−0.55	0.33	2.8	0.096†	0.58 (1/1.73)	0.30	1.10
Evacuation mode (Others vs. Personal car)	−1.36	0.32	17.7	0.000***	0.26 (1/3.87)	0.14	0.49
Evacuation route choice (Towards North vs. Towards South)	−0.56	0.23	5.8	0.016*	0.57 (1/1.74)	0.37	0.90
Evacuation route choice (Others vs. Towards South)	−0.70	0.27	7.0	0.008**	0.50 (1/2.00)	0.30	0.84
Number of children in household (1 + vs. None)	0.64	0.22	8.5	0.003**	1.89	1.23	2.91
Ethnicity (Maori and Pacifica vs. European)	−0.01	0.41	0	0.983	0.99	0.44	2.22
Ethnicity (Asian vs. European)	−1.44	0.27	28.7	0.000***	0.24 (1/4.20)	0.14	0.40
Ethnicity (Others vs. European)	−0.47	0.27	3.1	0.077†	0.62 (1/1.59)	0.37	1.05
Risk awareness (A lot vs. Little bit or no)	1.21	0.27	21.0	0.000***	3.35	2.00	5.64
Annual household Income ($50,000 to $100,000 vs. <$50,000)	0.71	0.30	5.7	0.017*	2.04	1.13	3.66
Annual household Income ($100,000 or more vs. <$50,000)	0.76	0.29	7.1	0.008**	2.14	1.22	3.75
Length of residency (<5 years vs. More than 5 years)	1.28	0.24	29.0	0.008*	3.59	2.26	5.74
Constant	0.93	0.42	4.9	0.026	2.54		

Note: †p < 0.100; *p < 0.050; **p < 0.010; ***p < 0.001.
Factors showing in parenthesis (x/xxᵃ), where xxᵃ = baseline/reference category.

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Conclusions

✓ People with European ethnicity are more likely to evacuate immediately when compared to those with Asian ethnicity (4.2 OR)

✓ People with a shorter length of residency (less than five years) are more likely to evacuate immediately when compared to those with a longer length of residency (3.59 OR)

✓ People with a high annual household income (($50,000 to $100,000) are more likely to evacuate immediately when compared with those with lower annual household income (2.04 OR)

✓ People residing in a household with one or more children are more likely to evacuate immediately when compared to those who live without any children (1.89 OR)

✓ People who are aware of the risk are more likely to evacuate immediately when compared to those who are not (3.4 OR)

Conclusions

✓ People choosing to go to emergency shelters are more likely to evacuate immediately when compared to those going to friends' and relatives' houses (3.7 OR) and other destinations (3.5 OR)

✓ People using their personal car are more likely to evacuate immediately when compared to those using other transportation options (3.9 OR)

✓ People choosing to evacuate towards the south direction are more likely to evacuate immediately when compared to those evacuating towards other directions (2.0 OR)

✓ The number of adults in the household, age, gender, and partnership status and accommodation type did not have any significant effect on evacuation decision making

Conclusion

➤ Results in this study show that evacuation decisions can be determined by a combination of socio-demographic factors (ethnicity, length of residency, annual household income and household with children) and factors related to risk awareness, evacuation route choice, evacuation mode choice and evacuation destination choice.

➤ These findings will be useful for planners and policymakers in managing risks and planning to improve the safety of the vulnerable community by identifying appropriate evacuation strategies and reducing risk-increasing evacuation behaviour.

Recommendations

➢ Risk awareness is important in immediate evacuation compliance; special attention needs to be paid to improve the risk awareness in people.

➢ Further attention should be given to other ethnic groups (including Asian, Middle Eastern / Latin American / African, Pacific people, Maori) and those with less annual income and longer length of residency.