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Wellbeing After a Managed Retreat: Observations from a Large New Zealand Program

Abstract

Managed retreat programs aim to relocate households or remove homes and other infrastructure out of harm's way. Managed retreats are most typically considered for coastal areas or floodprone zones. In New Zealand, as elsewhere, managed retreat initiatives generate a highly polemical and emotional discussion within affected communities, and between them and the government. Given the difficult and controversial implementation of managed retreats, understanding what happens to residents who are displaced by these programmes is of immense importance. We examine the wellbeing of the people who were forced to move as part of a large managed-retreat program that was implemented in Christchurch, New Zealand, after the 2011 earthquake the city experienced. We consider three indicators for the measurement of subjective (surveyed) wellbeing: quality of life, stress, and emotional wellbeing. Our aims are: (1) to describe the wellbeing of the relocated residents after they were forced to move, and identify which factors are correlated with their well-being having already moved to new places (2) to describe the subjective experience of the residents in their communication with the government and in their relation with the community: (3) to identify the effect of economic factors (household annual income, home ownership, and financial impacts) on their wellbeing; and (4) to relate these findings to possible lessons for policy makers when designing managed retreat programs.

JEL-Codes: Q540.

Keywords: managed retreat, wellbeing, shock, relocation, climate change.

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1. Introduction

Managed retreat programs aim to relocate households or remove homes and other infrastructure out of the reach of hazards. They are most typically considered for coastal areas when coastal erosion is made worse by ongoing sea level rise, and where the future feasibility of continuing habitation looks bleak (Alexander et al, 2012). It is sometimes also considered because of other known coastal hazards such as tsunamis or hurricane storm surges (e.g., Ingram et al., 2006). In New Zealand, as elsewhere, managed retreat initiatives generate highly polemical and emotional discussions, as these programs affect people and their communities dramatically (Hanna et al., 2017; Hino et al., 2017).

Given the controversial and difficult implementation of managed retreat programs, it is clear that understanding what happens to residents who get displaced is of immense importance. An improved understanding of the factors that characterise how the retreat process is related to residents' wellbeing in its aftermath can have significant impact on the design of managed retreat policies. This knowledge can help planners design programs more effectively and avoid some of the well-intentioned failures that often beset such efforts.

In this paper, we examine the large managed-retreat program that was implemented in Christchurch, New Zealand, after the 2011 earthquake the city experienced. In this program, the government re-zoned several areas of the city, and moved about 20,000 people (around 8000 households) by buying their homes at their pre-earthquake assessed value. This is an unusually large program; possibly the largest in a high-income country. Admittedly, most managed retreat programs are associated with coastal and flooding hazards, but the motivation for the Christchurch Residential Red Zone (RRZ) program was not very different. Ultimately, the motivation was to reduce future risk—both mortality and morbidity risks and risk to assets.

Here, we examine the wellbeing of the people who were forced to move by the RRZ program, using a comprehensive survey, and describe how this program affected their well-being.

Although the term wellbeing is frequently used, there is no widespread agreed definition and it is often used as an all-encompassing concept to describe the quality of people's lives (Dodge et al. 2012). Terms such as happiness, quality of life, and life satisfaction have been used interchangeably to mean wellbeing (Allin, 2007; Robine and Jagger, 2003). In this study, we consider three indicators for the measurement of wellbeing: (1) quality of life; (2) stress level; and (3) emotional wellbeing (measured with the WHO-5 indicator).

Generally, two ways to measure wellbeing have been used in previous research: objective and subjective. The objective measure identifies an individual's requirements and how these requirements are satisfied (for example, in terms of caloric intake), while the subjective measure is based on surveys which ask individuals directly (Veenhoven 2000; Diener and Lucas, 2002). Here, we use the subjective measurement approach, based on survey questionnaires, to evaluate the well-being of re-located people after the implementation of a managed retreat program.

Evidence from previous studies demonstrates that subjective well-being is related to multiple factors (Pinquart and Sörensen, 2000; Peterson et al.,2014). It is now recognized, for example, that social relations (the bonding, linking and bridging connections within and between communities) affect well-being in several ways. As such, the personal impact of the breakup of communities that is associated with managed retreats needs to be evaluated (e.g., Prezza and Costantini, 1998; Pretty et al., 2006).

Some researchers also emphasize the importance of social capital in enhancing resilience and reducing the potential impacts of disasters (Aldrich, 2012a, 2012b; Aldrich and Sawada, 2015). Thus, unintentionally, the drive to reduce risk by instituting managed retreat programs might also be increasing risk as a community's collective ties are severed.

The aims of this study are: (1) to describe the (subjective) wellbeing of the RRZ residents after they were forced to move, and identify which factors affect their well-being having

already moved to new places. (2) to describe the subjective experience of the residents in their communication with the government and in their relation with the community, (3) to identify the effect of the economic factors (household annual income, home ownership, financial impacts) on their wellbeing; and (4) to relate these findings to possible lessons for policy makers when designing managed retreat programs.

To address these aims, we use a survey that specifically targeted the RRZ residents in their new homes, and whose direct aim was to gauge what happened to them (CERA, 2016). The rest of the paper is organized as follows: Section 2 gives an overview of the study area and the financial offers that RRZ residents were given for their re-settlement. Section 3 describes how the data was collected, and what they include. Section 4 details the empirical models used to evaluate the determinants of wellbeing. The results of the statistical analysis are described in section 5, and section 6 concludes with some further observations.

2. The RRZ area and the Crown offers

Figure 1 shows the map of Christchurch. Greater Christchurch includes Christchurch City, and the Waimakariri and Selwyn districts. The population of Christchurch City pre-earthquake was approximately 348,000 people, while that of Waimakariri and Selwyn districts together was just about 77,000 residents. The Christchurch earthquake on 22nd February 2011 was the worst natural disaster in New Zealand history, as it caused the death of 185 people, and a reconstruction cost estimated at around 40 Billion NZD (Wood et al., 2016).

East of the city centre, in the flat area between the centre and the coast, along the Avon river, the earthquake caused severe damage to buildings, and significant liquefaction. In the hillside suburbs south-east of the centre, the earthquake destabilised cliffs, and many houses remained at risk from landslides and rock falls. The damage in both these areas was the most severe in the city. In June 2011, the Government announced an emergency policy which aimed

to designate some of the worst affected areas as "red zones". Red zones were eventually declared in parts of Waimakariri District to the north of Christchurch City around the Waimakariri River, parts of the flat land in Christchurch City along the Avon River, and parts of the Port Hills.

The residents in this Residential Red Zone were told that these areas were no longer zoned for residential use, and the Crown offered to purchase their homes and land. The government offered homeowners two options: (1) The Crown Option: the government buys both the building and land at their 2007 assessed values, and in return it owns any outstanding insurance claim for damage from the earthquake(s). (2) The Insurance Option: the Crown will only purchase the land at its 2007 assessed value, and the homeowner will retain the remaining claim against their insurer for any damage. The final date for accepting these offers was 10th December 2015. By that deadline, 7,724 of 8,060 property owners in the residential red zone had accepted one of the government offers; 1,695 homeowners had accepted the Crown option and 6,029 properties chosen the insurance option (Nguyen, 2019).

3. Data and variables selection

3.1. The Survey

The CERA Residential Red Zone Survey was conducted by the independent polling company Nielsen under contract from the New Zealand Government. The survey was conducted in Christchurch, during October and November 2015, almost five years after the earthquake. At that time, the vast majority of the RRZ households had already moved to new locations. Respondents were contacted using the contact information held by the Canterbury

Earthquake Recovery Authority (CERA) – the ministerial-level authority which was implementing the RRZ program.[1]

The survey, and consequently our analysis, was restricted to the former residential red zone property owners who accepted one of the government's offers for their properties. The sample size is 1890 homeowners, out of 7,724 (25%); it was designed to represent the population of the RRZ households. A total of 136 questions included both categorical and ordinal questions. Most questions were based on the five-points Likert scale, with 1 classified as 'strongly disagree' and 5 as 'strongly agree'. We re-code all variables so that a higher score represents a higher level of wellbeing.

Table 1 provides a snapshot of the respondents to the survey. Among them, 41% were males and 59% were female. Only about 4% of the respondents were between the ages of 18 and 34, 62% were between 35 and 64; and 34% were older than 64. A high proportion, 80%, answered that they do not have any health problem at the time they were interviewed.

Regarding their quality of life, 75% participants rated their overall quality of life as good or extremely good. Only 7% reported that their quality of life is extremely poor or poor. About their stress level, 22% answered they were stressed 'always' or 'most of the time,' and 23% replied they 'rarely' or 'never' experienced adverse emotional wellbeing, while many respondents answered they experienced "most of the time" five positive emotional aspects during the two weeks before they were surveyed (table 2).

3.2. Dependent variables

We examined three dependent variables. *Quality of life* is a categorical variable where respondents were asked to report their overall quality of life ranging from 1 (extremely poor) to 5 (extremely good). *The stress level* was assessed with the following question "In the past

[1] We were provided access to the survey data by the Department of Prime Minister and Cabinet (DPMC) – the body that took over CERA's programs after the latter was dismantled in 2016. Regrettably, we were not given access to the geo-spatial identifiers, so we cannot distinguish between respondents in the three RRZ areas.

12 months, how often have you experienced stress that has had a negative effect on you." Answers were: 1 (always), 2 (most of the time), 3 (sometimes), 4 (rarely), and 5 (never). We estimated the determinants of both of these dependent variables with ordered-logit regression models.

Finally, *emotional wellbeing* was evaluated by the WHO-5 wellbeing index (the World Health Organisation 5 items index). Respondents were asked to rate their experience over the last two weeks, ranging from 0 (at no time), 1 (some of the time), 2 (less than half of the time), 3 (more than half of the time), 4 (most of the time), and 5 (all of the time), in terms of five aspects " I am cheerful and in good spirits", "I woke up feeling fresh and rested", "My daily life has been filled with things that interest me", "I have felt calm and relaxed", and "I have felt active and vigorous". The raw scores were summed up to a score from 0 to 25, with 0 being the lowest level of emotional wellbeing. We use factor analysis to measure *emotional wellbeing* and estimate it as a continuous variable.

3.3. Independent variables

In this study, we examined several demographic factors including age (grouped into 18-34, 35-64, 65 and older with the second group as the reference category), ethnicity, gender, having children and having a partner (as a binary variable).

Regarding the health factor, respondents were asked to report whether they have health condition or disability that has lasted six months or more and that restricts their everyday activities (as a binary variable).

In terms of economic factors, we included the household annual income (in NZ$ – less than 30,001; 30,001-60,000; 60,001-100,000; 100,001-200,000; and 200,001 and up; with the first group as the reference category), home ownership (as a binary variable), and financial impact due to being in the Red Zone. The financial impact was measured through four questions. Respondents were asked to describe their financial position – specifically, in

negative, no impact, or positive way, in terms of : (1) Their mortgage size, (2) The amount of equity they have in their property, (3) the amount of their available savings, and (4) the size/quality/value of their property.

In terms of social relations, participants were asked to rate the extent to which they feel a sense of community with others in the neighbourhood they live in now, and feel the general area or neighbourhood their house/apartment is in now suits their needs and the needs of others in their household.

Our study is focusing on the wellbeing of residents after they were forced to move by the government's policy. Hence, we included in our model the government's interactions, the government offers, which are the Crown/Insurance option (with the Crown option as the reference category), and the time when a property was confirmed as being in the Red zone areas. The government's interactions with the homeowners were measured based on five questions. Participants were asked to rate whether: (1) they were given sufficient time to make decisions about the offers, (2) they were provided with the best possible information to help them to make a decision about the offers, (3) they were treated respectfully and fairly, and (4) the red zoning and offer processes were clear, and (5) they have confidence in the Government agencies involved.

4. Empirical model

4.1. Factor analysis

As we have a large set of observed variables, we use factor analysis to obtain a more limited set of predictors that can be conceptualized as: government communication, the financial impacts, and emotional wellbeing. Factor analysis is a statistical technique for reducing the dimensionality of the data by describing linear combinations of the variables that contain most of the information and that permit meaningful interpretation of these groups.

An advantage of a factor score over a mean or total score is that the factor scores weights each of the items differently, based on how central it is to the true value. By contrast, when we generate a mean or total for the set of items, each item counts as if it were equally central to the concept.

4.2. Wellbeing model

The model of subjective wellbeing follows that of Brown et al. (2012). Given that the first two dependent variables (*quality of life* and the *stress level*) are ordinal, the empirical analysis is based on ordered logistic regressions. We can use ordered logit regression if the proportional odds (PO) assumption is satisfied. To test whether the PO assumption is met, we use the Brant test (Brant, 1990). The test result for the *quality of life* variable revealed that $\chi^2(42)= 49.22$ and p=.21, indicating that the proportional odds assumption cannot be rejected. However, for the stress level, the Brant test is $\chi 2\ (42) =60.5$; and p=.03, indicating that the PO assumption is rejected. Therefore, fitting a partial PO model rather than a PO model might be a better option.

We estimate the following model:

$$\log\left(\frac{P(WB_i \leq j)}{P(WB_i > j}\right) = \log\left(\frac{\gamma_i^j}{1-\gamma_i^j}\right) = \beta_1 D + \beta_2 X + \beta_3 E + \xi \qquad (1)$$

The ordered logit model can be expressed in terms of an underlying latent variable y*. Here this could be interpreted as the individual's "true well-being". The higher the value of y*, the more likely they are to report a higher category of self-assessed well-being. In our case, there are five categories, so the range of values y* should be divided into five intervals, each one corresponding to a different category of self-assessed well-being. To make interpretation of the results easier, we report the odd ratio (OR), which is a ratio of two odds. In logistic regression, the odd ratio is also known as the exponentiated logit coefficient. When OR is greater than 1, the odds of success or of having an event for one group are larger than the odds for the other group. When OR is less than 1, the odds of success or of having an event decrease for one

group are smaller than the odds for the other group. Finally, the OR equals to 1 indicates that there is no relationship between the predictor and the odds of success.

We treat the emotional wellbeing measure as a continuous variable. To evaluate the emotional wellbeing, we estimate the following linear model:

$$WB = \beta_1 D + \beta_2 X + \beta_3 E + \xi \qquad (2)$$

In equation (1) and (2) WB is individual wellbeing; D is a vector containing the individual's demographics; X is a vector of observed or reported values of the social variables (the economic factors, the health factors, social relations, and the government policy) that affect individual wellbeing; E is a vector containing unobserved individually specific factors; ξ is an error term

We have cross-sectional data that do not allow us to estimate *E*. However, many researchers accept the assumption of no correlation between *E* and *X, E* and *D*. We attempted to only use objective variables as predictor variables in this model to avoid shared-method variance. However, this was not always possible, so coefficients for the social relations and the government communication should be interpreted with additional caution.

5. Results

5.1. Factors extracted from the factor analysis

Reliability analysis was measured by calculating the Cronbach's alpha. The alpha is the proportion of the observed variance that represents true variance. If alpha equals to 80%, it means that 80% of the variance in the scale represents the true score on the variable. The minimum proposed Cronbach's alpha should be above 0.6 and one should keep items when item-total correlation is greater than 0.3.

In our study we obtained three latent variables from the sets of items, which are effective government communication, the financial impacts, and emotional wellbeing. The

Cronbach's alpha coefficients of these latent variables are 0.89, 0.71, and 0.91, respectively. All are greater than 0.7, meaning that the measurement of these latent variables is acceptable (in terms of reliability; i.e., our measurement values represent a large proportion of true values).

The Bartlett's test results for the three groups of items are all statistically significant, indicating there is sufficient intercorrelation to conduct the factor analysis. For each group, all the factor loadings are greater than 0.6, and there is only one factor having an eigenvalue greater than 1. Therefore, we scored and obtained one factor for each group to represent effective government communication, the financial impact, and emotional wellbeing variable.

5.2. Estimation results: Quality of life

Table 4 shows the result of the ordinal logistic regression for quality of life. A positive coefficient corresponds to an odds ratio (OR) greater than 1, and a negative logit regression coefficient corresponds to an OR between 0 and 1. First, we estimate the model with objective measure variables only (column 1). Then, we run regression with subjective measures variables included (column 2). The inclusion of the subjective variables does not significantly alter the coefficients of the objective variables. Therefore, we conclude that including subjective variables does not lead to a substantial measurement error.

In terms of demographics, for the age predictor, the reference category is age ranging from 35 to 64. We expected to observe a u-shaped relationship for age (Brown et al, 2012), meaning the elderly and the youth have a higher average (subjective) quality of life compared to those who are middle-aged. We observe that older respondents (>65) indeed reported higher quality of life than their younger middle-aged counterparts. However, the younger age group (18 to 34) has no statistically significant difference, indicating no difference in the quality of life level between the two age groups (18-34 and 35-64).

The coefficient on quality of life for Maori is not statistically different from that of European respondents (the default category) once holding all other variables constant.

However, people identifying as others (in New Zealand, that category mostly includes Asians and Pacific Islanders) had lower subjective quality of life compared to those identifying as European. Females reported a higher average level of quality of life compared to males (OR=1.21, p=.06). Having children and having a partner also contributed positively to quality of life. Maybe not surprisingly, reporting a health condition is associated with a significantly negative impact on reported quality of life.

In terms of the economic factors, the expected relationships also hold. For the annual household income predictor, the reference category is households having an annual income less than $30,000. For the higher income groups ($30,001-$60,000, $60,001-$100,000, and 100,001-$200,000) the odds ratio of three categories are 1.5; 2.1; and 3.0. For the last group, income which is greater than $200,001, the estimated OR is not statistically significant.[2] Furthermore, households that reported less adverse financial impacts from being Red zoned and who own their home also reported higher quality of life.

The analysis confirms the importance of factors associated with social relations and government policy. It is noteworthy that feeling a sense of community with others in the neighbourhood and having a strong satisfaction with the neighbourhood are both statistically significant and positively associated with quality of life. The OR of the government communication is greater than 1 and statistically significant (OR= 1.57), indicating that when the government communication is better, residents tend to report their quality of life as better. Furthermore, choosing the Insurance Option has a negative association with the reported quality of life (p=.003, OR=0.74).

5.3. Estimation results: Stress levels

Regarding the stress level, a partial proportional odds model was fitted to estimate the ordinal outcome variable with the set of predictor variables. This model was used since it allows

[2] This finding might provide a modest support for of the well-documented Easterlin paradox (Easterlin, 1974).

the effects of some predictor variables to vary when the proportional odds assumption (PO) does not hold ($\chi 2$ (42) =60.5; p=.03).

With the question "In the past 12 months, how often have you experienced stress that has had a negative effect on you", 3% of respondents answered "always", 19% reported " most of the time", 55% answered "sometimes", 20% responded "rarely", and 3% answered "never". Because only a small proportion of respondents have always or never experienced stress, we combine "always" and "most of the time" into a single category; and combine "rarely" and "never" into a single category. We also estimated regression with the original categories; these results are included in the appendix (table 2)

Examining each predictor variable, we found that having a health condition violated the PO assumption, while it was tenable for the other predictor variables. Therefore, we fit a partial PO model rather than a PO model. Table 5 reports the correlates of the stress level variable. Older respondents (>=65) have less perceived stress than their younger counterparts (34 to 64). Ethnicity does not show any significant effect on the stress level of residents. This finding suggests that the observed bivariate relationship between ethnicity and stress is due to inequalities in the distribution of other variables (e.g. wealth or home ownership), rather than there being a direct effect of ethnicity on the stress level. Females experienced more stress than males (OR=0.7). Having kids also increases stress while having a partner does not appear to have a significant impact on the reported stress level.

In term of the economic factors, the regression analyses revealed that while the financial impact of the red zoning appeared to have a negative significant impact, income and home ownership were not associated significantly with reported stress.

In both model A comparing "most of the time" vs. "sometimes" and model B comparing "sometimes" vs. "rarely", having health condition has a statistically significantly impact on the stress level. The ORs of having health condition variable in these models are 0.35 and 0.57,

indicating that those having a health condition have experienced stress more frequently compared to those without.

Strongly feeling a sense of community with others in the neighbourhood and having a high satisfaction in the neighbourhood are highly significant and positively related to lower frequency of stress. Choosing the Insurance offer leads to more stress compared to the Crown offer, but this effect is not significant when controlling for the social relations and the government communication variables.

Taken together, being female and having children are significantly associated with higher stress. However, being older, having positive financial impact, feeling a sense of community and experiencing effective government communication are associated with less stress.

5.4. Estimation results: Emotional wellbeing

Table 6 shows the result of regression for emotional wellbeing obtained from factor analysis. We also ran regression with the dependent variable - emotional wellbeing calculated by simply adding the five scores as suggested by the WHO (table 7). The results reveal that the correlations between predictor variables and emotional wellbeing are similar, with some differences in the coefficient values.

Older respondents (>=65) have higher levels of emotional wellbeing than their younger counterparts (34 to 64). Females reported having lower levels of emotional wellbeing. Having children does not show any significant effect on the levels of emotional wellbeing. Having a partner leads to a higher emotional wellbeing, but this effect is not significant when controlling social relations and the government communication variable. Ethnicity does not show any significant effect on the wellbeing of residents. This finding again suggests that the bivariate relationship between ethnicity and emotional wellbeing is due to inequalities in the distribution of other variables, such as social relations or income, rather than there being a direct effect of

ethnicity on emotional wellbeing. Not surprisingly, having a health condition is significantly associated with the lower levels of emotional wellbeing.

For the income measure, the reference category is households having an annual income less than $30,000. Generally, when the annual household income increases, residents tend to report their emotional wellbeing as better. Similarly, financial impact correlated significantly and positively with emotional wellbeing. As expected, the coefficient for social relations (feeling a sense of community with others in the neighbourhood, and having a strong satisfaction in the neighbourhood) and the government communication are all positive and statistically significant.

In terms of the government offers, those who chose the Insurance Option reported lower emotional wellbeing than those with the Crown Option. Moreover, those whose property was confirmed as being in the red zone areas later (in 2012) have better emotional wellbeing than those having their property was rezoned earlier (in 2011).

6. Discussion and conclusions

The aim of this paper was to analyse, quantitatively, the determinants of wellbeing for a population that was affected by a *de facto* involuntary relocation associated with a large managed retreat program. The Residential Red Zone program was implemented in New Zealand after the Christchurch 2010-2011 earthquake sequence and affected about 8,000 households (about 20,000 people). As far as we are aware, there has been little follow-up on populations that have been forced to relocate in managed retreat programs, globally, in spite of the obvious and increasing importance of these programs as an adaptation tool for climatic change.

Specifically, we focused on the relationship between three measures of wellbeing – quality of life, stress, and emotional wellbeing. We investigated the determinants of these

measures, using econometric tools, by focusing on the demographic characteristics, the economic circumstances, social relations, and the ways in which government policy was perceived by the affected households.

Generally, having to relocate did not mean residents reported low wellbeing measures. Demographic factors, health condition and the type of government compensation offer the residents accepted all were important to their levels of wellbeing. Social relations, the financial circumstances, and the government communication were all associated significantly and positively with a higher quality of life, less stress, and higher emotional wellbeing. Although the results presented here cannot imply causation, because of the limitation of the cross-sectional nature of the survey and the subjective nature of the wellbeing measurement, they do give some indications of those area where improvements could potentially contribute to greater wellbeing of relocated households.

For example, Pretty et al (2006), found that social capital contributes to the psychological wellbeing of the affected individuals. Furthermore, it is noteworthy that when this data was collected in 2015, the respondents had recently moved to new communities. Therefore, in other circumstances it is plausible that social relations can show more powerful impacts on wellbeing once the relocated have established themselves in their new communities. From a policy perspective, that suggests that the designers of managed retreat policies should design their programs in ways that encourage the establishment and strengthening of social capital (broadly defined).

Three further findings stand out as important in the managed retreat context. The significance of effective government communication is of obvious interest to the central and local governments who usually design these involuntary or voluntary managed retreat programs. It lends support to the inclusion of closer consultation between the government and residents as a special characteristic of the design of these programs. Some insights about what

constitutes effective government communication – for example with regards to the timing of re-zoning announcements – can also be arrived at.

The finding for the Insurance Option is also noteworthy. Choosing the Insurance Option, rather than the Crown Option, had an adverse impact on the residents' quality of life and emotional wellbeing. In practice, and maybe surprisingly, the majority of Red Zone residents chose the Insurance Option (about 70%). Retroactively, this was a puzzling choice, as the insurance claim resolution process in Christchurch faced some significant hurdles and delays – hurdles and delays that could have been expected (Nguyen and Noy, 2019). Our work here confirms that choosing the Crown Option could have been a 'better' choice, as it allowed residents to settle their claims quickly and at pre-determined prices.

Why so many homeowners chose the Insurance Option remains, in our view, a mystery, and suggests a room for a more active policy by the regulatory and planning bodies. Nguyen (2019) found that opting for the Insurance option was to some extent a result of peer pressure (or herd behaviour). It is important to observe that, after the fact, these households also reported lower quality of life. This specific finding suggests room for a more proactive management of household choice, by governments, in a post disaster managed retreat circumstances. The New Zealand Red Zone program was unique in that it was *de jure* voluntary but was widely perceived to be, *de facto,* as mandatory – which may explain why take up rate was so high. This last finding may suggest that other components of that program, such as the option choice, could have been better designed to lead to better outcomes for the affected households as well.

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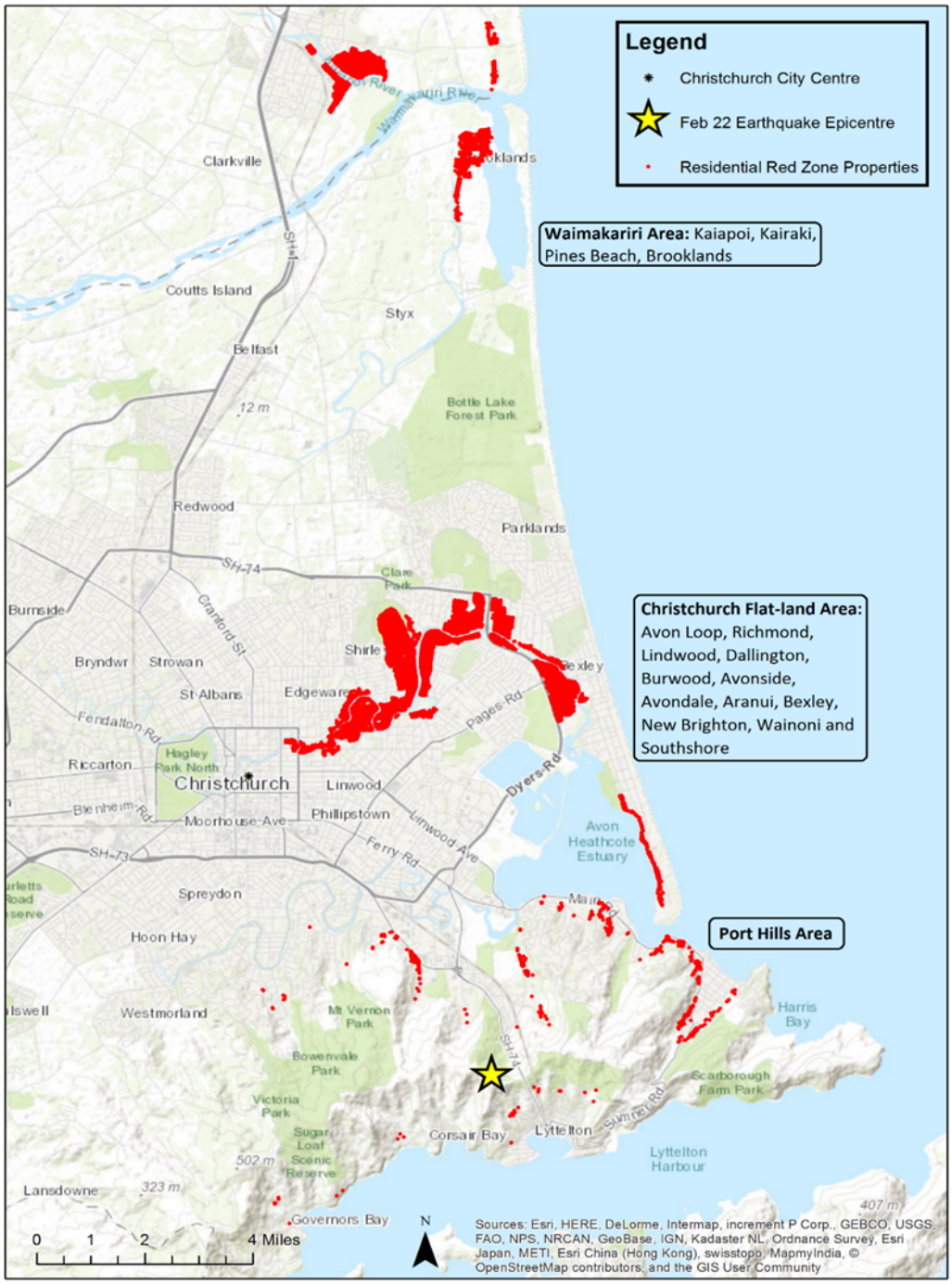
Figure 1- Residential Red Zone Properties



Source: Nguyen (2019)

Table 1- Characteristics of the sample (N=1890)

Variables	Level	Rate (%)
Gender	Male	41
	Female	59
Age	18-34	4
	35-64	62
	+65	34
Household annual income	<$30000	11
	$30001-$60000	27
	$60001-$100000	38
	$100001-$200000	21
	>$200001	3
The Crown offers	The crown option	30
	The insurance option	70
Having health condition	Yes	18
Overall quality of life	Extremely poor	1
	Poor	6
	Neither poor nor good	19
	Good	56
	Extremely good	18
The stress level	Always	3
	Most of the time	19
	Sometimes	55
	Rarely	20
	Never	3

Table 2: WHO-5 emotional well-being index

	0	I	II	III	IV	V
I have cheerful and in good spirits	1	12	11	25	44	6
I woke up feeling fresh and rested	3	15	15	25	36	5
My daily life has been filed with things that interest me	8	17	21	24	27	3
I have felt calm and relaxed	12	19	22	23	22	3
I have felt active and vigorous	2	18	12	26	34	8

Experience during the last two weeks: 0= At no time; I= Some of the time, II= Less than half of the time; III= More than half of the time; IV= Most of the time; V= All of the time. Rate (%)

Table 3: Indicators for factor analysis

Effective government communication	
Item1	I was given sufficient time to make decisions about the Crown offer
Item2	I was provided with the best possible information help me to make decisions about the Crown offer
Item3	I was treated respectfully and fairly in my dealings with the Crown
Item4	The red zoning and Crown offer process was clear
Item 5	Did you have confidence in the Government agencies involved
Financial impacts: financial position in a negative way, no impact, or positive way, in terms of	
Item6	Mortgage size
Item7	The amount of equity they have in their property
Item8	The amount of their available savings.
Item9	The size/quality/value of their property
Item10	Overall financial position
Emotional wellbeing	
Item 11	I have cheerful and in good spirits
Item 12	I have felt calm and relaxed
Item 13	I have felt active and vigorous
Item 14	I woke up feeling fresh and rested
Item 15	My daily life has been filled with things that interest me

Table 4. Model estimation results (LHS: quality of life)

VARIABLES	(1)	(2)
Age (base:35-64 years old)		
24 to 35	1.153	1.196
	(0.199)	(0.210)
>= 65	1.537***	1.324**
	(0.188)	(0.166)
Ethnicity (base: European)		
Maori	1.128	1.284
	(0.265)	(0.308)
Others	0.763*	0.760*
	(0.124)	(0.126)
Female	1.191*	1.211**
	(0.111)	(0.115)
Having children	1.376***	1.424***
	(0.158)	(0.167)
Have a partner	1.467***	1.344**
	(0.167)	(0.155)
Having health condition	0.495***	0.541***
	(0.0599)	(0.0670)
Economic factors		
Household annual income ($ 1000)		
$30.1-60	1.401**	1.497**
	(0.232)	(0.252)
$60.1-$100	2.105***	2.113***
	(0.348)	(0.354)
$100.1-$200	3.450***	3.070***
	(0.644)	(0.582)
>$200.1	2.176**	1.658
	(0.731)	(0.567)
Home ownership	2.139***	1.615**
	(0.422)	(0.321)
Financial impact	2.210***	1.687***
	(0.113)	(0.0928)
Social relations		
Felling a sense of community		1.287***
		(0.0676)
Neighbourhood suitability		1.821***
		(0.123)
The government offers		
Time being Red zone	0.929	1.064
	(0.111)	(0.131)
Insurance option	0.661***	0.740***
	(0.0675)	(0.0771)
Government communication		1.576***
		(0.0826)
Observations	1,890	1,890

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Table 5. Model estimation results (LHS: the stress level)

VARIABLES	(1)	(2)
Age (base:35-64 years old)		
24 to 35	0.906	0.896
	(0.160)	(0.160)
>= 65	1.956***	1.742***
	(0.241)	(0.218)
Ethnicity (base: European)		
Maori	0.967	1.033
	(0.224)	(0.247)
Others	0.870	0.894
	(0.142)	(0.147)
Female	0.725***	0.704***
	(0.0681)	(0.0672)
Having kids	0.800*	0.794**
	(0.0923)	(0.0931)
Have partner	1.200	1.102
	(0.136)	(0.127)
Economic factors		
Household annual income ($ 1000)		
$30.1-60	1.187	1.219
	(0.199)	(0.207)
$60.1-$100	1.260	1.194
	(0.209)	(0.201)
$100.1-$200	1.301	1.118
	(0.242)	(0.211)
>$200.1	1.252	1.040
	(0.426)	(0.363)
Home ownership	1.391*	1.064
	(0.275)	(0.214)
Financial impact	1.612***	1.281***
	(0.0774)	(0.0673)
Social relations		
Felling a sense of community		1.265***
		(0.0657)
Neighbourhood suitability		1.370***
		(0.0913)
The government offers		
Time being Red Zone	0.880	0.966
	(0.106)	(0.119)
Insurance option	0.802**	0.893
	(0.0814)	(0.0923)
Government communication		1.463***
		(0.0757)
Model A- most of the time vs. sometimes		
Health condition	0.323***	0.345***
	(0.0446)	(0.0496)
Model B- sometimes vs. rarely		
Health condition	0.536***	0.565***
	(0.0882)	(0.0953)
Observations	1,890	1,890

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Table 6. Model estimation results (LHS: emotional wellbeing)- OLS

VARIABLES	(1)	(2)
Age (base:35-64 years old)		
24 to 35	0.0486	0.0464
	(0.0826)	(0.0790)
>= 65	0.252***	0.177***
	(0.0589)	(0.0568)
Ethnicity (base: European)		
Maori	0.0244	0.0274
	(0.111)	(0.106)
Others	-0.0554	-0.0475
	(0.0774)	(0.0740)
Female	-0.145***	-0.139***
	(0.0450)	(0.0431)
Having kids	-0.0131	-0.00795
	(0.0551)	(0.0528)
Have a partner	0.112**	0.0771
	(0.0545)	(0.0523)
Having health condition	-0.458***	-0.401***
	(0.0581)	(0.0558)
Economic factors		
Household annual income ($ 1000)		
$30.1-60	0.139*	0.147*
	(0.0806)	(0.0771)
$60.1-$100	0.275***	0.248***
	(0.0797)	(0.0763)
$100.1-$200	0.377***	0.303***
	(0.0888)	(0.0851)
>$200.1	0.497***	0.406***
	(0.162)	(0.155)
Home ownership	0.144	0.00658
	(0.0933)	(0.0901)
Financial impact	0.229***	0.118***
	(0.0225)	(0.0237)
Social relations		
Felling a sense of community		0.145***
		(0.0235)
Neighbourhood suitability		0.159***
		(0.0297)
The government offers		
Time being Red Zone	0.0904	0.128**
	(0.0572)	(0.0551)
Insurance option	-0.224***	-0.167***
	(0.0489)	(0.0470)
Government communication		0.138***
		(0.0229)
Observations	1,890	1,890
R-squared	0.127	0.203

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Table 7. Model estimation results (LHS: the WHO-5 wellbeing)- OLS

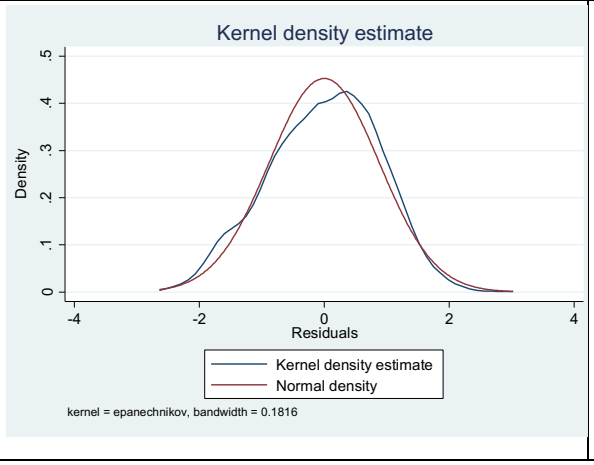
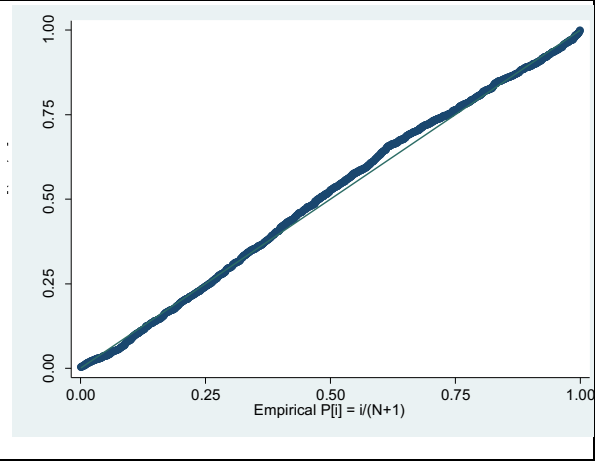
VARIABLES	(1)	(2)
Age (base:35-64 years old)		
24 to 35	0.265	0.252
	(0.463)	(0.443)
>= 65	1.420***	0.997***
	(0.330)	(0.318)
Ethnicity (base: European)		
Maori	0.148	0.163
	(0.621)	(0.596)
Others	-0.294	-0.249
	(0.434)	(0.415)
Female	-0.809***	-0.776***
	(0.252)	(0.242)
Having kids	-0.0848	-0.0558
	(0.309)	(0.296)
Have a partner	0.620**	0.426
	(0.305)	(0.293)
Having health condition	-2.567***	-2.250***
	(0.325)	(0.313)
Economic factors		
Household annual income ($ 1000)		
$30.1-60	0.789*	0.833*
	(0.452)	(0.432)
$60.1-$100	1.542***	1.392***
	(0.446)	(0.427)
$100.1-$200	2.129***	1.715***
	(0.497)	(0.477)
>$200.1	2.817***	2.311***
	(0.910)	(0.871)
Home ownership	0.809	0.0388
	(0.523)	(0.505)
Financial impact	1.283***	0.658***
	(0.126)	(0.133)
Social relations		
Felling a sense of community		0.814***
		(0.132)
Neighbourhood suitability		0.891***
		(0.166)
The government offers		
Time being Red Zone	0.527	0.735**
	(0.320)	(0.309)
Insurance option	-1.266***	-0.947***
	(0.274)	(0.263)
Government communication		0.768***
		(0.129)
Observations	1,890	1,890
R-squared	0.128	0.203

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Appendix A: Testing the normality of residuals, heteroskedasticity, and multicollinearity for the emotional wellbeing model.

We checked for the normality of residuals (graph 1 and graph 2 below). In the first graph, we produce a kernel density plot with the normal option requesting that a normal density be overlaid on the plot. The second graph shows a standardized normal probability (P-P) plot. There are no indications of non-normality, and we can accept that the residuals are close to a normal distribution.

We used Breusch-Pagan test with Ho: Constant variance and White's test with Ho: homoskedasticity to test the heteroskedasticity problem. The results for both Breusch-Pagan test and White's test with p=0.19 and p=0.36, respectively, indicate that we cannot reject Ho (there is no evidence of an heteroskedasticity problem). Furthermore, we computed Variance Inflation Factor (VIF) which is the degree that the variances in the regression estimates are increased due to multicollinearity. The largest VIF was 3.6 which is lower than the threshold of 10 and the mean of VIF was 1.84, indicating that there is no sign of serious multicollinearity.

Graph 1. Kernel density estimate	**Graph 2. Standardized normal probability plot**
	

Appendix B: Oster (2019) sensitivity analyses for selection effects for Table 6

Because of the cross-sectional nature of the survey, we cannot observe individually specific factors such as genetic characteristics. When we add subjective variables in the model (e.g., "Felling a sense of community", "Neighbourhood suitability", and "Government communication"), the shared method variance may occur. In order to explicitly model selection effects, some studies use treatment or Heckman models, which require the inclusion of at least one instrumental variable, or a variable that is truly endogenous. However, finding a strong instrumental variable is not always possible.

Oster (2019) developed a post-estimation test to evaluate the degree to which model coefficients are potentially affected by omitted variable bias. Oster's approach is based on the idea that if all variables affecting the outcome of interest were included in the regression, any possible selection effects would be controlled for and the remaining effect of the variable of interest would be the true effect. Oster assumes that such a model would explain 100% of the variation in the outcome variable and hence have an $R^2=1$.

If the known variables are at least as important for explaining the outcome as the omitted variables, Oster suggests a procedure for calculating the expected change in the coefficient size of the variable of interest that would occur if $R^2=1$. If the coefficients change very little, this is an indication that selection bias is not significantly affecting the results.

We examine if the findings presented in Table 6 are robust to correcting for omitted variable bias using Oster's (2019) method, and found that the coefficients for "Felling a sense of community", "Neighbourhood suitability", and "Government communication" are indeed robust.

Appendix table 1. Treatment effect estimates of subjective variables

	Coefficient original table 6	Treatment effect estimate after Oster sensitivity analyses
Felling a sense of community	0.145	0.153
Neighbourhood suitability	0.159	0.12
Government communication	0.138	0.156

Appendix table 2: Model estimation results (LHS: the stress level) with five categories 1 (always), 2 (most of the time), 3 (sometimes), 4 (rarely), and 5 (never)

VARIABLES	(1)	(2)
Age (base:35-64 years old)		
24 to 35	0.893	0.886
	(0.157)	(0.156)
>= 65	2.019***	1.793***
	(0.245)	(0.220)
Ethnicity (base: European)		
Maori	0.975	1.045
	(0.223)	(0.245)
Female	0.726***	0.702***
	(0.0674)	(0.0660)
Having kids	0.775**	0.766**
	(0.0886)	(0.0886)
Have partner	1.209*	1.103
	(0.136)	(0.125)
Economic factors		
Household annual income ($ 1000)		
$30.1-60	1.144	1.167
	(0.190)	(0.196)
$60.1-$100	1.228	1.147
	(0.202)	(0.190)
$100.1-$200	1.262	1.072
	(0.232)	(0.200)
>$200.1		
Home ownership	1.491**	1.172
	(0.293)	(0.233)
Financial impact	1.639***	1.289***
	(0.0782)	(0.0669)
Social relations		
Felling a sense of community		1.262***
		(0.0648)
Neighbourhood suitability		1.394***
		(0.0910)
The government offers		
Time being Red zone	0.882	0.973
	(0.105)	(0.118)
Government communication	1.473***	1.473***

	(0.0750)	(0.0750)
Model 1 (Y>1 vs. Y≤ 1)		
Ethnic (Others)	0.366***	0.344***
	(0.136)	(0.131)
Having health condition	0.221***	0.244***
	(0.0630)	(0.0717)
Insurance option	0.282***	0.322***
	(0.116)	(0.133)
Income >$200.1	1.187	0.270*
	(0.410)	(0.184)
Model 2 (Y>2 vs. Y≤ 2)		
Ethnic (Others)	0.828	0.828
	(0.167)	(0.171)
Having health condition	0.312***	0.336***
	(0.0432)	(0.0483)
Insurance option	0.731**	0.839
	(0.0967)	(0.115)
Income >$200.1	1.187	0.665
	(0.410)	(0.279)
Model 3 (Y>3 vs. Y≤ 3)		
Ethnic (Others)	0.921	0.944
	(0.188)	(0.196)
Having health condition	0.521***	0.555***
	(0.0858)	(0.0936)
Insurance option	0.864	0.964
	(0.109)	(0.124)
Income >$200.1	1.187	1.149
	(0.410)	(0.448)
Model 4 (Y>4 vs. Y≤ 4)		
Ethnic (Others)	1.709	1.776
	(0.635)	(0.668)
Having health condition	0.628	0.679
	(0.229)	(0.250)
Insurance option	0.555**	0.585**
	(0.144)	(0.154)
Income >$200.1	1.187	2.967*
	(0.410)	(1.750)
Observations	1,890	1,890

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses