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# Deprived yet healthy: Neighbourhood-level resilience in New Zealand

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ABSTRACT

Geographical inequalities in health are omnipresent with health and related behaviours typically worse in socioeconomically deprived places. However, this is not always true. Deprived places with unexpectedly good health outcomes, or what might be considered 'resilient' places, have been noted. Few studies have quantitatively examined resilience in neighbourhoods or investigated potential explanations for this resilience. This paper examines the paradox of low mortality despite high social deprivation in New Zealand neighbourhoods and considers possible neighbourhood characteristics that contribute to unanticipated positive health outcomes. Using area-level mortality (2005–2007) and socioeconomic data, we developed the Resilience Index New Zealand to quantify neighbourhood levels of resilience across the country. We then examined relationships between this measure and a suite of built, physical and social characteristics. We found that resilient places tended to be densely populated, urban areas. We observed gradients and increases/decreases in the most resilient groups in access to or levels of physical environment factors (environmental deprivation, safe drinking water, air quality) and unhealthy living infrastructure (alcohol and gambling outlets). Since these factors are amenable to change, these findings are the strongest evidence that such improvements may lower mortality in similarly deprived places. The social environment of resilient areas was characterised by high levels of incoming residents. We also found some surprising associations and observed *U*-shaped relationships for a number of the neighbourhood factors. Such findings suggest the need to develop a better proxy of community cohesion and a better understanding of the interactions between people and their neighbourhoods, rather than simply the presence of certain factors. We argue that this study has identified amenable neighbourhood characteristics and highlighted the importance of 'place-specific' resilience factors that may be effective in reducing mortality in some neighbourhoods, but be less effective in others.



## Introduction

Geographical and social inequalities in health have been identified in many countries, including New Zealand (Pearce, Witten, & Bartie, 2006). Socioeconomically deprived places tend to have less favourable health outcomes and health-related behaviours (Chan et al., 2008; Haynes, Pearce, & Barnett, 2008; Richardson, Blakely, Young, Graham, & Tobias, 2009; Tobias & Cheung, 2003). Evidence also suggests that the gradient in health is growing (Pearce & Dorling, 2009; Wilkinson, 2005). It is argued that much of the socio-spatial distribution to health inequalities relates to rising social and economic inequalities within neoliberal economics which not only directly affect population health, but have also resulted in rising social segregation, decreased social capital, and the increasingly uneven distribution of environmental goods and bads (Wilkinson & Pickett, 2009).

Despite rising inequalities, it has been posited that there are neighbourhoods with unexpectedly good health outcomes regardless of their disadvantageous settings, or what might be considered 'resilient' neighbourhoods. Although sometimes a nebulous concept, resilience has been defined as the internal ability or coping capacity to recover from or adapt to harmful stressors to a system (Kasperson, Turner, Schiller, & Hsieh, 2002). Resilience entails both a level of adversity and an unanticipated, positive result. Psychology has long employed the concept of resilience and studies have argued that resilience at individual and group levels can be a key factor in managing significant stressors (Hegney et al., 2007), including deprivation. In this way, deprivation acts as a source of adversity to overcome. Research has identified characteristics that make individuals more likely to be healthy, despite living in deprived areas, including cognitive skills (Garmezy, 1991), family and community support, self-esteem

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(Canvin, Marttila, Burstromb, & Whitehead, 2009), and optimism (Connor & Davidson, 2003). In addition, researchers are beginning to explore the neighbourhood characteristics that influence area-level resilience. Theoretically, one might be resilient through two pathways: 1) the neomaterial; and 2) the psychosocial. Through the neomaterial perspective, even very deprived areas may be rich in access to amenities, social capital, and environmental resources which lead to health benefits. Through the psychosocial perspective, some deprived groups may avoid comparison with more advantaged groups in society, and thereby sidestep associated poor health such as depression and chronic stress (Sweet, 2011). These pathways are not mutually exclusive. Drawing on an 'assets-based' model of health, it is feasible that some socially deprived neighbourhoods may, despite their otherwise poor social circumstances, provide a 'healthy' environment such as better access to health care facilities, healthy food options, an urban infrastructure that is supportive for physical activity, cohesion and integration, and high levels of voting or volunteering. Neighbourhoods with a particular combination of population groups may also provide a positive social context, in that they lack segregation or fragmentation. We theorise that these neighbourhood characteristics may strengthen resilience.

Neighbourhood resilience research represents a small proportion of the broader neighbourhoods and health literature and work to date has been restricted to the United Kingdom (UK). These studies define resilience or 'overachieving' in terms of better mental health, lower mortality or better life expectancy than estimated given the level of deprivation. One study identified significantly lower age-specific mortality rates in places with persistent economic disadvantage, relative to places with similarly deprived histories (Tunstall, Mitchell, Gibbs, Platt, & Dorling, 2007). Other studies have identified associated characteristics of resilient neighbourhoods such as low percentages of non-western immigrants, low percentages of elderly people (van Hooijonk, Droomers, van Loon, van der Lucht, & Kunst, 2007), low community turnover, low percentages of single-parent households (Wandersman & Nation, 1998), attracting new residents (Mitchell, Gibbs, Tunstall, Platt, & Dorling, 2009) and not being located in major urban fringe (Doran, Drever, & Whitehead, 2006). A weakness of these studies was the large population size of the area units investigated, with one study having as many as one million people per unit and others having an average of 90,000 people. While this scale may be suitable for assessing population health impacts of policy, this level of aggregation discounts smaller-scale characteristics of the built, physical or social environments, thus missing more localised processes of resilience. Our study fills an important gap by evaluating resilience at a finer geographic scale, where processes and practices that are rooted in neighbourhoods may be more pertinent in explaining resilience.

Research on the health-promoting or health-hindering aspects of areas of residence has expanded dramatically over the last decade. Aspects of the neighbourhood which may impact the ability of residents to live healthy lives have been conceptualized as 'opportunity structures' (Macintyre & Ellaway, 2000). The geographical locations of such public goods are often determined by local planning and policy. Implicit in the provision of such public goods is a belief that they are beneficial to residents' well-being (Witten, Exeter, & Field, 2003). Thus, modifications to these neighbourhood characteristics are often seen as a way to reduce poor health outcomes and health inequalities, particularly in poor areas.

A wide range of neighbourhood characteristics have been identified which affect individual or community health, although not consistently. There are three broad (and overlapping) areas of investigation, the built, physical and social environments. These features may directly impact health via harmful exposures or by influencing health-related behaviours. Often degraded or harmful environments within these three realms coincide with deprived areas. For example, deprived groups are exposed to higher levels of air pollutants (Næss, Piro, Nafstad, Smith, & Leyland, 2008), contaminated waste sites (Salmond, Howden-Chapman, Woodward, & Salmond, 1999), and poorer drinking water quality (Hales, Black, Skelly, Salmond, & Weinstein, 2003), which are associated with poor health. While this may be true in a number of deprived neighbourhoods, the question is whether some features of the built, physical and social environment have the potential to bolster health despite high levels of deprivation. For example, social conditions of neighbourhoods may be beneficial, especially in poor areas, to respond to or sidestep some of the negative effects of deprivation including access to social support systems and social contexts which nurture healthy behaviours and prevent psychosocial stress (Congdon, 1996; Everson-Rose et al., 2011). Thus, using the neomaterial perspective, features of neighbourhood built, physical and social environments may be positive influences on, or create opportunities for, health even in very deprived places.

Our research examines the apparent paradox of low mortality despite high deprivation in neighbourhoods in New Zealand and considers associated neighbourhood characteristics. First, we identified areas with better or worse health than expected, to create a Resilience Index New Zealand (RINZ) that quantifies levels of resilience for each neighbourhood. Then, we used the RINZ to examine relationships with neighbourhood characteristics of the built, physical and social environments.

## Data and methods

This study evaluated resilience in small areas in New Zealand, utilising 2006 census area units (CAUs), which are suitable approximates of a neighbourhood ($n$ = 1919; mean population c.2000), and the spatial unit for which health data are routinely released. To quantify a Resilience Index New Zealand (RINZ), we identified CAUs which have unexpectedly high to low mortality, given levels of deprivation, percentage Māori and the number of aged care facilities. We fitted regression models and detected areas of model under- and over-prediction. Then, we used the RINZ to examine relationships with neighbourhood characteristics.

### *Deprivation data*

Our area-level indicator of deprivation was the New Zealand Deprivation Index (NZDep) which comprised nine variables (e.g. employment, home and car ownership, and uptake of government assistance programs) taken from the 2006 census (Crampton, Salmond, & Kirkpatrick, 2004). NZDep has been associated with a number of health outcomes including cardiovascular disease (Chan et al., 2008), lower life expectancy (Tobias & Cheung, 2003), increased cervical cancer (McFadden, McConnell, Salmond, Crampton, & Fraser, 2004), and diabetes in New Zealand Europeans (Joshy et al., 2009). The NZDep scores were ranked to create deciles (1 = least deprived 10% of CAUs).

### *Health, population and confounder data*

To generate mortality rates, we compiled 2006 census data for the usually resident population and all-cause mortality counts (smoothed by averaging 2005–2007) by six age-sex groups (males and females aged 0–4, 5–24, 25–44, 45–64, 65–84, and 85 years and over). As these data are publicly available, anonymised records, no ethical approval was required. In addition, we obtained CAU census-based percentage Māori and address locations for all aged care facilities from the Ministry of Health. Addresses were

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geocoded and the number of facilities per CAU computed. These variables were added as independent variables to regression models. CAUs without population, NZDep, or covariate data were omitted from analysis, leaving 1435 CAUs.

*Neighbourhood characteristics data*

Neighbourhood characteristics were selected according to a review of the New Zealand literature relating to environmental and neighbourhood effects on health as well as pragmatic considerations relating to data availability. Health-related neighbourhood characteristics of the built, physical and social environment were then compiled from a variety of data sources (Table 1). All measures were calculated or compiled by CAU, except those relating to access to safe drinking water and population change which are routinely compiled at the territorial authority level for jurisdictional purposes. We used pre-calculated measures relating to access (high = 1 to low = 5) to health care, healthy living infrastructure, educational facilities, cultural centres (Pearce, Day, & Witten, 2008; Pearce, Mason, Hiscock, & Day, 2008; Pearce et al., 2006), levels of social fragmentation (Ivory, Collings, Blakely, & Dew, 2011), environmental deprivation (Pearce, Richardson, Mitchell, & Shortt, 2011) and air pollution (Kingham, Fisher, Hales, Wilson, & Bartie, 2008). Additionally, we calculated access to unhealthy living infrastructure by measuring distances along the road network from population-weighted centroids of each CAU to the nearest gambling and alcohol outlets. We also calculated variables characterising the social environment within CAUs, such as percentages of volunteerism, population change, long-term residents, rural-urban status (1 = most urban) and population density using census data. Plunket is a postnatal and early childhood service offered in New Zealand. A *marae* is a cultural meeting place important for maintaining language and cultural practices and connections to values and philosophies in Māori society.

*Calculating the Resilience Index New Zealand (RINZ)*

To develop the Resilience Index New Zealand (RINZ), we fitted regression models and detected areas of model over- and under-prediction. To select the appropriate model, we first examined the mean and variance of the dependent variable (death counts) and observed a variance over seven times the value of the mean. Further evidence of over-dispersion was identified after fitting a Poisson model and goodness-of-fit test, which confirmed our choice to use negative binomial regression models (Deviance chi-square = 57,607, $p < 0.001$, Pearson chi-square = 97,652, $p < 0.001$). Next, we examined the likelihood ratio test for the over-dispersion parameter alpha and found an alpha significantly different from zero, thus reinforcing our decision to use a negative binomial model (chi-square = 24,000, $p < 0.001$, over-dispersion factor = residual deviance/residual degrees of freedom = 1.10). In order to rule out the potential for our regression analyses to lead to spatially correlated errors, we calculated the Moran's *I* statistic and determined that the estimation of spatial models was not warranted (Moran's *I* Statistic = 0.011, $p = 0.390$).

Since we were interested in identifying areas which 'over-achieve' in the face of socioeconomic adversity, we did not want the relationship to be influenced by potential confounders, such as particular sub-populations known to have higher mortality rates (Tobias & Yeh, 2006). Areas with higher numbers of aged care

**Table 1**
Health-related neighbourhood characteristics.

| Neighbourhood characteristics | | | Mean | Median | Sd | Min | Max | Data source | Year |
|---|---|---|---|---|---|---|---|---|---|
| **Built** | *Healthcare* | GP distance | 10 | 3 | 23 | 1 | 278 | Ministry of Health | 2011 |
| | | Pharmacy distance | 12 | 3 | 27 | 1 | 278 | Ministry of Health | 2003 |
| | | Plunket distance | 18 | 6 | 37 | 0 | 290 | White pages, internet | 2004 |
| | | Accident & emergency distance | 27 | 14 | 47 | 1 | 280 | Ministry of Health | 2003 |
| | | Ambulance distance | 27 | 12 | 36 | 1 | 174 | Ministry of Health | 2002 |
| | | Fire station distance | 20 | 7 | 32 | 1 | 175 | Ministry of Health | 2002 |
| | *Healthy living infrastructure* | Park distance | 4 | 1 | 17 | 0 | 362 | Department of conservation | 2004 |
| | | Beaches distance | 23 | 17 | 19 | 1 | 198 | Land information New Zealand | 2005 |
| | | Sports/Leisure facility distance | 15 | 6 | 31 | 0 | 278 | ACC Pool Safe | 2005 |
| | | Supermarket distance | 12 | 4 | 27 | 0 | 246 | TLA, websites | 2004 |
| | | Dairy, fruit/vegetables & service station distance | 8 | 2 | 20 | 0 | 245 | TLA, websites | 2004 |
| | *Unhealthy living infrastructure* | Gambling outlet distance | 2 | 1 | 5 | 0 | 61 | Department of Internal Affairs | 2003 |
| | | Off licence alcohol outlet distance | 2 | 1 | 4 | 0 | 47 | Liquor Advisory Council | 2005 |
| | | On licence alcohol outlet distance | 2 | 1 | 4 | 0 | 44 | Liquor Advisory Council | 2005 |
| | *Education* | Kindy/daycare/play centre distance | 9 | 2 | 23 | 0 | 247 | Ministry of Education | 2004 |
| | | Primary school distance | 6 | 2 | 16 | 1 | 223 | Ministry of Education | 2002 |
| | | Intermediate school distance | 6 | 2 | 16 | 1 | 223 | Ministry of Education | 2002 |
| | | Secondary school distance | 13 | 5 | 28 | 1 | 274 | Ministry of Education | 2002 |
| **Physical** | *Air Quality* | $PM_{10}$ annual average | 9 | 11 | 7 | 2 | 33 | Kingham et al. | 2008 |
| | *Water Quality* | % TLA pop with drinking water compliance - bacteria | 76 | 87 | 26 | 0 | 100 | Ministry for the Environment | 2007 |
| | | % TLA pop with drinking water compliance - protozoa | 46 | 48 | 40 | 0 | 100 | Ministry for the Environment | 2007 |
| | *Overall* | Environmental deprivation index | 0 | 0 | 0 | −2 | 2 | Pearce et al. | 2011 |
| **Social** | *Culture* | Marae distance | 16 | 8 | 29 | 0 | 223 | Takoa directory | 2005 |
| | *Participation* | % Volunteerism | 11 | 11 | 3 | 0 | 32 | Statistics NZ | 2006 |
| | | % Childcare service | 33 | 34 | 5 | 1 | 69 | Statistics NZ | 2006 |
| | | % Any unpaid service | 29 | 29 | 5 | 1 | 78 | Statistics NZ | 2006 |
| | *Rurality* | Urban-rural status | 2 | 1 | 2 | 1 | 7 | Statistics NZ | 2006 |
| | | Population density, per $km_2$ | 1164 | 703 | 1253 | 0.04 | 8136 | Statistics NZ | 2006 |
| | *Cohesion* | Social fragmentation index | 5 | 5 | 3 | 1 | 10 | Ivory et al. | 2011 |
| | | % Lived in area 30 + years | 5 | 4 | 3 | 0 | 15 | Statistics NZ | 2006 |
| | | % TLA pop lost or gained (1996–2006) | 9 | 7 | 13 | −19 | 61 | Statistics NZ | 2006 |

NOTE: All distances in kilometres; TLA = Territorial Land Authority; Urban-rural status (1 = most urban, 7 = most remote); Social fragmentation index (10 = high, 1 = low); Environmental deprivation index (2 = high, −2 = low).

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facilities were expected to have higher mortality rates, unrelated to the level of NZDep. Since it could be argued that smoking levels themselves could be both influences on and outcomes of resilience and due to the high correlation between smoking and NZDep and percentage Māori (Barnett, Pearce, & Moon, 2005), we chose not to include smoking in the model. We also investigated whether interaction terms improved the model fit, using the likelihood ratio test. Thus, the final model assumed a negative binomial distribution and included age- and sex-specific counts of death as the dependent variable, the age- and sex-specific population count as an offset, and NZDep deciles, age, sex, quintiles of percentage Māori, number of aged care facilities and interaction terms (age.sex and age.Māori) as the independent variables. Note that NZDep deciles and quintiles of percentage Māori were treated as categorical variables.

In order to quantify areas of model under- (non-resilient) and over-prediction (resilient), we generated deviance residuals for each CAU. These residuals were then used to generate the RINZ. Raw values were assigned quintiles of high (5) to low (1) resilience. All analyses were conducted using Stata 11.1 software (College Station, TX).

*Evaluation of neighbourhood characteristics by the Resilience Index New Zealand (RINZ)*

A suite of variables pertaining to the built, physical and social neighbourhood environments was selected which have been shown to protect or hinder health. Priority was given to characteristics previously investigated in the New Zealand context. These were selected to understand relationships between resilience and neighbourhood characteristics, for each CAU. For example, we calculated travel time and distance to aspects of the built environment which create opportunities for better health. We also calculated levels of environmental goods and bads and factors which might bolster social and cultural capital or provide a positive context for health. For each non-categorical variable characterising the built, physical and social environment, we then calculated average values by RINZ quintile, ratios, and Spearman's rank correlation coefficients and *p*-values (using raw deviance residuals). For categorical variables, we calculated percentages by RINZ quintiles and ratios.

## Results

The fitted regression model yielded the anticipated statistically significant, positive associations between mortality and NZDep (Table 2). There was a general upward trend in Incidence Rate Ratios (IRRs) as NZDep increased, with a peak at decile 7 and a slight decrease in deciles 8 to 10. The co-variates including age, Māori and number of aged care facilities were statistically significant. Most of the categorical levels of the interaction terms were statistically significant, but sex was not. There is also an indication that when controlling for NZDep, age and sex, there may be a protective effect of Māori density. This relationship existed before and after adding interaction terms, and appears to vary by age. These estimates were then used to detect areas of model under- and over-prediction and to develop RINZ from the standardised deviance residuals. Residuals were ranked and classed into quintiles of high (5) to low (1) resilience, each group containing 287 CAUs. Fig. 1 shows the spatial distribution of RINZ nationally and within major cities. The most resilient areas are predominantly in rural areas in the central south island. Within each of the three major cities in New Zealand, each has a fairly even spatial distribution of highly resilient areas.

*Relationship between resilience and neighbourhood characteristics*

In order to understand the characteristics of resilient neighbourhoods, we examined a suite of built, physical and social factors found to hinder or bolster health in other research (Tables 3–5). We observed a *U*-shaped relationship between RINZ and many of these factors. Still, the built environment of resilient neighbourhoods can be characterised as having decreased access to healthcare infrastructure and being at greater distances from gambling facilities and alcohol outlets. All Spearman's rank correlation coefficients were significant and modest. Note that raw deviance residuals were used where higher resilience was represented by negative values.

The physical environment of resilient neighbourhoods can be characterised by lower environmental deprivation, and by better access to safe drinking water and slightly higher average annual $PM_{10}$ levels. These areas are often warm, built-up areas. All correlations were significant but modest.

The social environment of resilient neighbourhoods can be characterised as main urban areas, having higher social fragmentation, more new and incoming residents and lower access to *marae*. Average population density in the most resilient areas was over twice that of the non-resilient areas. Resilient areas can also be characterised by having fewer people engaged in volunteerism

**Table 2**
Regression results – used to calculate the resilience index (RINZ).

| Dependent var: Death count | | | | |
|---|---|---|---|---|
| Independent var: | IRR | SE | *p* value | Likelihood ratio test *p* value |
| NZDep 2 | 1.10 | 0.04 | 0.015* | <0.001* |
| NZDep 3 | 1.11 | 0.04 | 0.007* | |
| NZDep 4 | 1.29 | 0.05 | <0.001* | |
| NZDep 5 | 1.36 | 0.05 | <0.001* | |
| NZDep 6 | 1.53 | 0.06 | <0.001* | |
| NZDep 7 | 1.61 | 0.07 | <0.001* | |
| NZDep 8 | 1.59 | 0.07 | <0.001* | |
| NZDep 9 | 1.50 | 0.07 | <0.001* | |
| NZDep 10 | 1.53 | 0.07 | <0.001* | |
| Age group: 5–24 years | 0.20 | 0.01 | <0.001* | <0.001* |
| Age group: 25–44 years | 0.17 | 0.01 | <0.001* | |
| Age group: 45–64 years | 0.17 | 0.01 | <0.001* | |
| Age group: 65–84 years | 0.35 | 0.02 | <0.001* | |
| Age group: 85 + years | 2.06 | 0.14 | <0.001* | |
| Sex: Female | 0.93 | 0.04 | 0.069 | <0.001* |
| % Maori, Quintile 2 | 0.67 | 0.04 | <0.001* | <0.001* |
| % Maori, Quintile 3 | 0.59 | 0.04 | <0.001* | |
| % Maori, Quintile 4 | 0.45 | 0.03 | <0.001* | |
| % Maori, Quintile 5 | 0.38 | 0.03 | <0.001* | |
| Number aged care facilities | 1.41 | 0.01 | <0.001* | <0.001* |
| Age2.Sex | 0.97 | 0.05 | 0.635 | <0.001* |
| Age3.Sex | 1.15 | 0.06 | 0.011* | |
| Age4.Sex | 1.10 | 0.06 | 0.086 | |
| Age5.Sex | 1.20 | 0.07 | 0.001* | |
| Age6.Sex | 2.24 | 0.13 | <0.001* | |
| Age2.Maori2 | 1.10 | 0.10 | 0.249 | <0.001* |
| Age2.Maori3 | 1.14 | 0.10 | 0.143 | |
| Age2.Maori4 | 1.12 | 0.10 | 0.198 | |
| Age2.Maori5 | 1.31 | 0.12 | 0.002* | |
| Age3.Maori2 | 0.96 | 0.08 | 0.666 | |
| Age3.Maori3 | 1.20 | 0.11 | 0.038* | |
| Age3.Maori4 | 1.50 | 0.13 | <0.001* | |
| Age3.Maori5 | 1.67 | 0.15 | <0.001* | |
| Age4.Maori2 | 1.26 | 0.11 | 0.007* | |
| Age4.Maori3 | 1.47 | 0.13 | <0.001* | |
| Age4.Maori4 | 1.68 | 0.14 | <0.001* | |
| Age4.Maori5 | 2.20 | 0.19 | <0.001* | |
| Age5.Maori2 | 1.23 | 0.11 | 0.015* | |
| Age5.Maori3 | 1.38 | 0.12 | <0.001* | |
| Age5.Maori4 | 1.67 | 0.15 | <0.001* | |
| Age5.Maori5 | 2.46 | 0.22 | <0.001* | |
| Age6.Maori2 | 1.30 | 0.12 | 0.005* | |
| Age6.Maori3 | 1.89 | 0.17 | <0.001* | |
| Age6.Maori4 | 2.23 | 0.20 | <0.001* | |
| Age6.Maori5 | 3.60 | 0.34 | <0.001* | |

* Lowest deprivation (NZDep 1), age group 1 (0–4 years), lowest Maori quintile, and male used as reference populations.

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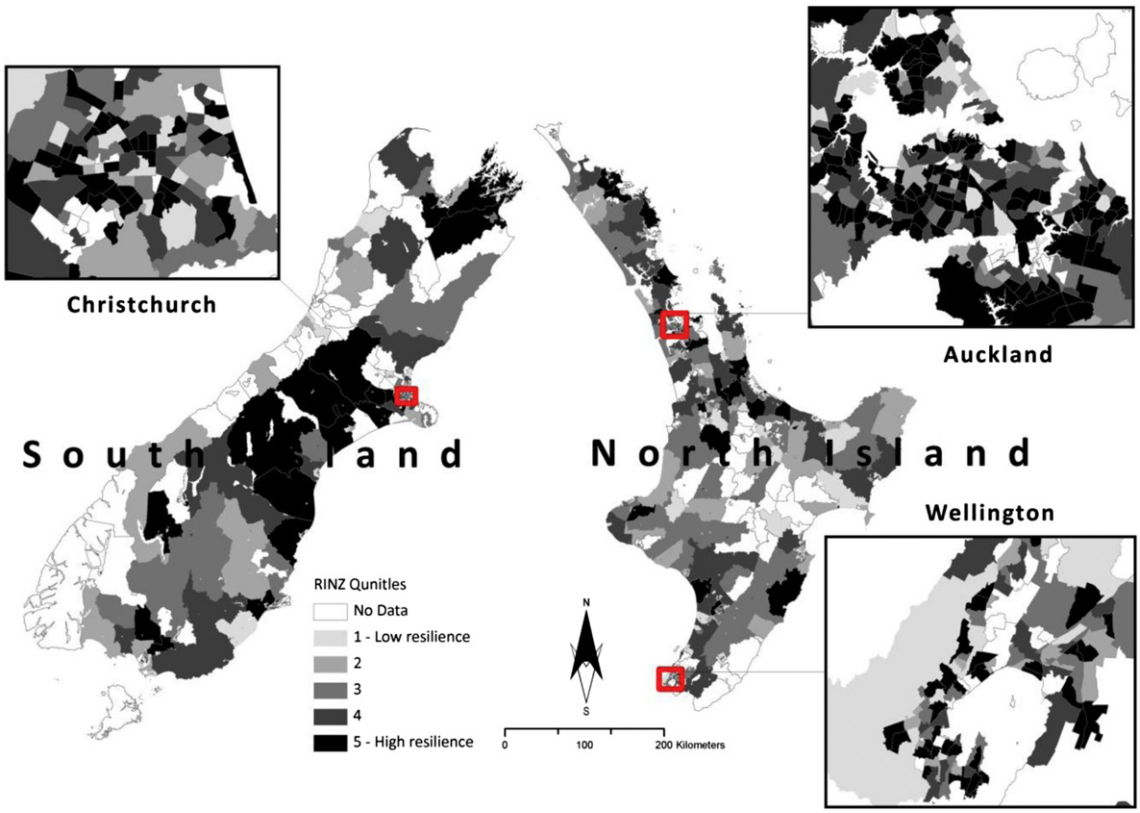


**Fig. 1.** Map of resilience index values across New Zealand.

or unpaid services. All correlations were significant and most were modest. The strongest correlations were found for population density, volunteerism, and unpaid services.

## Discussion

While deprived places in society tend to suffer poorer health outcomes than more advantaged groups, this is not always true. In this study, we constructed an index of health resilience to deprivation and tested its relationship with built, physical and social neighbourhood characteristics. Our study adds to the sparse amount of resilience research which has rarely been investigated in a quantitative, systematic way, and not at all in New Zealand. We provide evidence of resilience in areas of New Zealand, where mortality is lower than expected given the level of deprivation, as found in other recent research (Tunstall et al., 2007). In doing this, we also identified pivotal and amenable factors to potentially improve health in similarly deprived places. This is not to say the structural causes of poverty and inequality should be ignored. In fact, resilience research is under scrutiny for being a nebulous

**Table 3**
Neighbourhood built environment characteristics by the resilience index (RINZ).

| Neighbourhood characteristics – built environment | | Low | | | | High | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RINZ 1 | RINZ 2 | RINZ 3 | RINZ 4 | RINZ 5 | R5: R1 | $r^2$ | *p* value |
| *Healthcare* | GP travel time, mean | 3.1 | 3.2 | 3.1 | 3.0 | 2.7 | 0.84 | 0.13 | <0.001 |
| | Pharmacy travel time, mean | 3.2 | 3.2 | 3.1 | 3.0 | 2.7 | 0.84 | 0.14 | <0.001 |
| | Plunket travel time, mean | 3.3 | 3.3 | 3.2 | 2.9 | 2.7 | 0.81 | 0.16 | <0.001 |
| | Accident & emergency travel time, mean | 3.0 | 3.0 | 3.1 | 2.9 | 2.8 | 0.90 | 0.07 | <0.001 |
| | Ambulance travel time, mean | 3.0 | 3.1 | 3.2 | 2.9 | 2.8 | 0.94 | 0.06 | <0.001 |
| | Fire station travel time, mean | 3.2 | 3.1 | 3.1 | 2.9 | 2.6 | 0.81 | 0.15 | <0.001 |
| *Healthy living infrastructure* | Parks travel time, mean | 2.9 | 3.0 | 3.0 | 2.9 | 2.7 | 0.93 | 0.06 | <0.001 |
| | Beach travel time, mean | 3.0 | 3.1 | 3.1 | 2.9 | 2.7 | 0.90 | 0.09 | <0.001 |
| | Sports/leisure facility travel time, mean | 3.1 | 3.0 | 3.2 | 3.0 | 2.8 | 0.91 | 0.05 | <0.001 |
| | Supermarket travel time, mean | 3.1 | 3.1 | 3.0 | 3.0 | 2.8 | 0.91 | 0.07 | <0.001 |
| | Dairy, fruit/vegetables & service station travel time, mean | 2.9 | 3.1 | 3.1 | 3.0 | 2.7 | 0.92 | 0.06 | <0.001 |
| *Unhealthy living infrastructure* | Gambling outlet dist, mean | 1.8 | 2.7 | 3.6 | 2.4 | 2.0 | 1.11 | 0.04 | <0.001 |
| | On licence alcohol outlet dist, mean | 1.3 | 2.0 | 2.7 | 2.1 | 1.6 | 1.22 | 0.01 | 0.063 |
| | Off licence alcohol outlet dist, mean | 1.4 | 2.1 | 2.8 | 2.1 | 1.7 | 1.21 | 0.05 | <0.001 |
| *Education* | Kindy/daycare/play centre travel time, mean | 3.1 | 3.1 | 3.1 | 2.9 | 2.7 | 0.87 | 0.09 | <0.001 |
| | Primary school travel time, mean | 2.8 | 2.9 | 3.1 | 3.0 | 2.8 | 1.00 | −0.02 | 0.001 |
| | Intermediate school travel time, mean | 2.9 | 2.9 | 3.1 | 3.0 | 2.8 | 0.99 | −0.16 | 0.041 |
| | Secondary school travel time, mean | 3.2 | 3.0 | 3.1 | 3.0 | 2.7 | 0.86 | 0.10 | <0.001 |

NOTE: Travel time (5 = low access, 1 = high access); Dist = distance in km, from population-weighted centroid.

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**Table 4**
Neighbourhood physical environment characteristics by the resilience index (RINZ).

| Neighbourhood characteristics - physical environment | | Low | | | | High | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RINZ 1 | RINZ 2 | RINZ 3 | RINZ 4 | RINZ 5 | R5: R1 | $r^2$ | *p* value |
| *Air quality* | Average annual PM10, mean | 8.1 | 8.9 | 9.6 | 11.3 | 12.6 | 1.57 | −0.22 | <0.001 |
| *Water quality* | % TLA pop access to safe drinking water[a], mean | 71.7 | 76.5 | 75.8 | 80.6 | 83.8 | 1.17 | −0.19 | <0.001 |
| | % TLA pop access to safe drinking water[b], mean | 38.7 | 41.0 | 47.5 | 52.5 | 60.8 | 1.57 | −0.21 | <0.001 |
| *Overall* | Environmental dep. index, mean | 0.1 | 0.1 | −0.1 | 0.0 | −0.1 | −0.53 | 0.10 | <0.001 |
| | Class: Clean, Green and Warm, % | 25.8 | 23.0 | 21.3 | 20.1 | 9.8 | 0.38 | | |
| | Class: Clean, Green and Temperate, % | 26.5 | 25.6 | 27.9 | 11.2 | 8.8 | 0.33 | | |
| | Class: Warm and Built-up, % | 12.1 | 15.2 | 17.5 | 25.2 | 29.9 | 2.46 | | |
| | Class: Settled, green and temperate, % | 21.2 | 20.2 | 19.2 | 18.7 | 20.7 | 0.98 | | |
| | Class: Cool, built-up and polluted, % | 19.0 | 19.5 | 18.5 | 20.5 | 22.5 | 1.18 | | |
| | Class: clean, rural and cold, % | 31.7 | 26.0 | 17.3 | 13.5 | 11.5 | 0.36 | | |

NOTE: TLA = Territorial Land Authority; Environmental deprivation index (2 = high, −2 = low).
[a] bacteriologically-compliant.
[b] protozoal-compliant.

concept under which political and structural failings to prevent or protect the public turn to community and individual-level responsibility. In contrast to blaming poor health on neighbourhoods, we argue that: 1) identification of neighbourhood features associated with resilience can serve as a guide for planners and policy makers to alter environments and provide spaces which support health; but 2) further investigation is needed to refine proxies of cohesion, understand the protective effects of ethnic density in New Zealand and examine 'place-specific' resilience factors.

To support our first argument, we underscore our findings, which demonstrate a gradient across resilience quintiles or larger inclines/declines in the most resilient group as these findings provide stronger evidence to support the notion that modifications in these domains may lead to changes in mortality. Specifically, we found resilient places tend to have poorer access to potentially harmful aspects of the built environment, better access to safe drinking water and lower levels of environmental deprivation. We then trace potential pathways through which they might lower mortality.

We found that resilient neighbourhoods had poorer access to aspects of unhealthy living like gambling and alcohol outlets. A study in New Zealand found that individuals with better access to gambling outlets were more likely to be a gambler or problem gambler, after controlling for age, sex, socioeconomic status and rurality (Pearce, Mason, et al., 2008). This is a public health concern, as problem gambling has been associated with violence (Muelleman, DenOtter, Wadman, Tran, & Anerson, 2002), alcohol and substance abuse (Welte, Barnes, Wieczorek, Tidwell, & Parker, 2001), suicidality, and poor mental health (Ledgerwood & Petry, 2004).

Within the physical environment, we observed a general upward gradient in access to safe drinking water and resilience, which is likely related to better infrastructure of main urban areas, as resilient places were often built-up, densely populated places. Surprisingly, resilient areas also had slightly higher average annual $PM_{10}$ levels, which likely relates to increased vehicle traffic due to their urban locations. Even with higher $PM_{10}$ levels, we observed a downward gradient for overall environmental deprivation, with the lowest values in the most resilient places, which has been found to decrease respiratory diseases and mortality in other research (Pearce et al., 2011).

The social environment of resilient places was characterised by high numbers of incoming residents, echoing findings from other resilience research (Mitchell et al., 2009). The qualitative research

**Table 5**
Neighbourhood social environment characteristics by the resilience index (RINZ).

| Neighbourhood characteristics – social environment | | Low | | | | High | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RINZ 1 | RINZ 2 | RINZ 3 | RINZ 4 | RINZ 5 | R5: R1 | $r^2$ | *p* value |
| *Culture* | *Marae* travel time, mean | 3.1 | 3.0 | 3.1 | 3.0 | 2.9 | 0.98 | 0.04 | <0.001 |
| *Participation* | % Volunteer, mean | 12.3 | 11.8 | 11.6 | 10.5 | 10.0 | 0.81 | 0.29 | <0.001 |
| | % Childcare, mean | 32.1 | 33.8 | 33.6 | 33.7 | 31.7 | 1.00 | 0.03 | <0.001 |
| | % Any service, mean | 30.7 | 30.4 | 29.6 | 28.2 | 26.4 | 0.86 | 0.29 | <0.001 |
| *Rurality* | Urban-rural status, mean | 2.7 | 2.5 | 2.5 | 2.0 | 1.7 | 0.75 | 0.20 | <0.001 |
| | Main urban area, % | 16.7 | 18.4 | 17.6 | 22.2 | 25.0 | 1.50 | | |
| | Independent urban area, % | 23.8 | 23.8 | 23.8 | 15.5 | 13.0 | 0.54 | | |
| | Satellite urban area, % | 23.3 | 11.6 | 25.6 | 20.9 | 18.6 | 0.80 | | |
| | Rural area w/high urban influence, % | 18.9 | 20.8 | 26.4 | 20.8 | 13.2 | 0.70 | | |
| | Rural area w/moderate urban influence, % | 26.3 | 27.6 | 15.8 | 22.4 | 7.9 | 0.30 | | |
| | Rural area w/low urban influence, % | 30.2 | 18.8 | 28.2 | 10.7 | 12.1 | 0.40 | | |
| | Highly rural/remote area, % | 25.0 | 34.1 | 20.5 | 18.2 | 2.3 | 0.09 | | |
| | Population density (in thousands) | 0.8 | 1.0 | 1.1 | 1.5 | 2.0 | 2.50 | −0.31 | <0.001 |
| *Cohesion* | Social fragmentation index, mean | 5.2 | 5.3 | 5.0 | 6.0 | 6.7 | 1.30 | −0.19 | <0.001 |
| | % Lived in area for 0 yrs, mean | 21.9 | 21.7 | 21.7 | 22.3 | 24.5 | 1.12 | −0.13 | <0.001 |
| | % Lived in area for 1–4 yrs, mean | 29.7 | 29.6 | 29.8 | 30.1 | 31.0 | 1.05 | −0.12 | <0.001 |
| | % Lived in area for 5–9 yrs, mean | 16.0 | 16.2 | 16.4 | 16.5 | 15.9 | 1.00 | −0.04 | <0.001 |
| | % Lived in area for 10–14 yrs, mean | 9.7 | 9.8 | 9.6 | 9.1 | 8.5 | 0.88 | 0.16 | <0.001 |
| | % Lived in area for 15–29 yrs, mean | 11.7 | 11.6 | 11.4 | 10.7 | 9.7 | 0.83 | 0.21 | <0.001 |
| | % Lived in area 30 + yrs | 4.9 | 4.9 | 4.9 | 4.4 | 4.0 | 0.83 | 0.12 | <0.001 |
| | % TLA pop lost or gained in 10 yr, mean | 6.8 | 7.6 | 9.3 | 11.5 | 14.1 | 2.07 | −0.25 | <0.001 |

NOTE: TLA = Territorial Land Authority; Travel time (5 = low access, 1 = high access); Urban-rural status (1 = most urban, 7 = most remote); Social fragmentation index (10 = high, 1 = low).

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of Mitchell and colleagues indicated that areas that attract populations did so due to local housing policies, employment opportunities, the heritage of places, and high levels of particular ethnic or religious groups, which through a variety of pathways might improve living conditions and health. Yet, other research indicates that the association between population change and mortality is an artefact of social deprivation, as areas of deprivation have disproportionately high rates of population change (Exeter, Feng, Flowerdew, & Boyle, 2005). We observed a much higher population density in the most resilient neighbourhoods, which likely relates to the general upward gradient in urban areas across resilience quintiles. Living in densely populated places is associated with positive and negative health influences such as access to active transportation infrastructure, walking destinations, chronic stress from noise and respiratory problems associated with increased traffic. In our research, resilient places also had high levels of short-term residents. While this is consistent with other resilience research (van Hooijonk et al., 2007), there is the potential for artificially low mortality rates in these neighbourhoods, as residents reside in the area for shorter lengths of time and are thus less likely to die while living there.

The surprising results of this study highlight important areas for further investigation. First, some findings related to the built environment were unexpected. For example, we observed a downward gradient in access to healthcare and healthy living infrastructure from low to high RINZ score. This may indicate that similarly poor areas within cities may be either closer to, or farther from, the city centre. Areas closer to the centre may have better access to aspects of the built environment, but may also be less conducive to healthy living due to crime, traffic, increased access to fast food outlets or other infrastructure that hinders health. Some evidence underscores the need to develop a better proxy or measurement of social cohesion or social capital and to understand the potential protective effects of ethnic density. For example, the social environment of resilient places had high levels of fragmentation. When considering that the index is composed of variables such as recent immigrants, non-New Zealand language speakers, residential mobility, fewer school aged children, homeowners, and long-term residents, this finding seems less surprising and likely pertains to the high numbers of short-term residents and the high influx of new residents to resilient neighbourhoods. We also found an unanticipated downward gradient in volunteerism and unpaid community service in resilient areas. However, these findings were consistent with research in New Zealand which did not find an association between volunteerism and mortality (Blakely et al., 2006). Access to *marae* decreased across the gradients, which is surprising as *marae* are places of social connection, belonging and identity, may strengthen mental health and reduce stress thus, potentially boosting resilience. The regression analyses suggest a potentially protective effect of Māori density, warranting further exploration in the future. Access to *marae* may be more relevant specifically in resilient Māori communities.

Last, we argue for the importance of examining 'place-specific' resilience factors, given the *U*-shaped relationships observed between resilience and many of the neighbourhood characteristics. This suggests that some factors may be associated with positive health outcomes in some neighbourhoods, but not in other areas. These findings highlight the importance of the interactions between people and their neighbourhoods, rather than simply the presence of certain factors. Understanding people's perceptions of their own neighbourhoods, the history of those places, and the role of social networks and social norms in places may inform the success of infrastructural and policy changes. Simply altering environments may not actually change behaviours or outcomes, as other research suggests (Simoes et al., 2009). Making practical use of these findings would benefit from 'place-specific' and perhaps qualitative inquiry to understand the interplay between these neighbourhood factors, perceptions of places, behaviours and health.

One of the strengths of the current study over previous work was our ability to explore resilience and associated factors within relatively small population area units. Other studies have either not explored factors associated with resilience (Tunstall et al., 2007) or have used area units with large populations (Doran et al., 2006; Mitchell et al., 2009; Tunstall et al., 2007). Researchers argue that the modifiable area unit effect is best ameliorated by using a small unit of analysis (Shuurman, Bell, Dunn, & Oliver, 2007). Conversely, the sparsely populated rural areas and relatively small population of New Zealand can be a concern when using rates due to small denominators leading to spurious high proportions and the potential lack of representativeness (Crampton et al., 2004). Our use of negative binomial regression models limited the sensitivity of the results to small populations.

There are limitations to our study. This study was an observational ecological study and as such, we aggregated individual deaths by geographic areas. This can be problematic if the areas are composed of heterogeneous groups (Duncan, Jones, & Moon, 1993). In addition, NZDep is an area-level indicator of deprivation and is not a perfect indicator of individual-level deprivation (Salmond & Crampton, 2002). We emphasise that this is a study of *community health* rather than individual health outcomes, and that an advantage of our approach is that it includes the entire New Zealand population, using relatively small units of aggregation likely to be sociologically relevant. These small units (census area units) typically correspond with a 'suburb' or a neighbourhood which also has meaning for the residents. Since NZDep is an indicator of deprivation, there may be cases of misclassification of deprivation, but we do not anticipate that this would significantly alter the results of this study. This ecological study was a useful starting point for investigation into neighbourhoods and resilience and future research could usefully address some of the concerns related to ecological studies using nationally-collected individual data (i.e. the New Zealand Health Survey) and multilevel modelling (Merlo, 2003).

In addition, due to our reliance on addresses at the time of death, the neighbourhood in which one lived the majority of their life and was 'exposed' to levels of deprivation may be different from the neighbourhood of their residence at death. The movement of individuals between neighbourhoods may lead to misclassification of exposure to levels of deprivation. This cross-sectional study does not incorporate any lag time between exposure to deprivation levels and death. Neighbourhood deprivation levels may change over time for both technical and substantive reasons (Crampton et al., 2004). Incorporating temporal changes in exposure to deprivation and individual-level health outcomes over the life course is likely to be a productive area of investigation for resilience researchers. In addition, the use of census-based boundaries does not account for characteristics which may define neighbourhoods such as social networks, concentrated use of area facilities or special emotional and symbolic connotation for inhabitants. Yet, the advantages include the fact that CAUs typically encompass walkable areas around homes, the ability to spatially link diverse data sources and the ability to compare findings with other research. Last, our conception of resilience is admittedly narrow, where 'success' was measured by fewer people dying than expected and adversity was solely defined as neighbourhood-level socioeconomic hardship. This approach does not take into account aspects of flourishing or thriving, self-defined accomplishments, or varying conceptions of resilience among subpopulations, which is an important area of contemporary research (Wiles, Wild, Kerse, & Allen, 2012).

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In conclusion, this research has contributed to an emerging area of investigation in healthy, resilient places or anomalous neighbourhoods that experience good health despite poor conditions. We argue that quantifying resilience and understanding neighbourhood characteristics associated with resilience provides significant opportunities for furthering our understanding of the pathways by which even poor places may be rich in important amenities, social capital and environmental goods and thus have unexpectedly positive health outcomes. We produced a resilience index (RINZ) and demonstrated its utility in understanding spatial patterns in aspects of the built, physical and social environment of neighbourhoods and its potential limitation in understanding 'place-specific' resilience factors. In identifying areas of resilience, this work also highlighted areas with poorer outcomes than expected, or vulnerable areas. Such findings may be useful for targeting interventions and identifying under-performing affluent areas where there may be fragmentation and differences in health service performance or amenity infrastructure. These findings indicate the potential to improve health through policy and urban planning and zoning, thus complementing efforts to reduce structural inequalities in society that lead to health inequalities. Policies that empower communities, and protect or improve the physical or built environments may be important first steps in providing equitable opportunities for health in New Zealand, followed by 'place-specific' research to understand how people interact with those environments.

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