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No association of neighbourhood volunteerism with mortality in New Zealand: a national multilevel cohort study

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Background The association of social capital with health and mortality is contentious, and empirical findings are inconsistent. This study tests the association of neighbourhood-level volunteerism with mortality.

Methods Cohort study of 1996 New Zealand census respondents aged 25–74 years (4.75 million person years) using multilevel Poisson regression analyses. Neighbourhood (average population 2034) measures included indices of social capital (volunteering activities for all census respondents) and deprivation.

Results Adjusting for just age and marital status, the mortality rate ratios for people living in the quintile of neighbourhoods with the lowest compared with highest volunteerism were 1.16 (95% confidence interval 1.08–1.24) and 1.09 (1.01–1.18), for males and females, respectively. Adjusting for potential individual-level and neighbourhood-level socioeconomic confounders reduced the rate ratios to 0.94 (0.88–1.01) and 0.92 (0.85–1.01), respectively. There was no significant association with any cause of death, including suicide [rate ratios 0.89 (0.64–1.22) and 0.57 (0.31–1.05), respectively]. Restricting the analyses to only those census respondents living at their census night address for five or more years, and therefore 'exposed' to that level of volunteerism for a longer period, did not substantially alter findings.

Conclusions This study, one of the largest multilevel studies yet, found no statistically significant independent association of a structural measure of neighbourhood social capital with mortality—including suicide. Assuming social features of neighbourhoods are important determinants of health, future research should examine other features (e.g. social fragmentation) and other outcomes (e.g. behaviour).

Keywords Mortality, suicide, neighbourhoods, multilevel study, social capital, volunteerism

Health varies between neighbourhoods, and characteristics of neighbourhoods (over and above characteristics of people) probably influence health.[1] Macintyre and others have long argued that 'unless we try to explore more systematically the ways in which different types of area differ, we are left without any suggestions for social or public health policies that might improve the health of those in the worst areas, other than those relating to individual improvements in lifestyle' [p. 219 in Ref. (2)]. Three generally agreed domains to explore neighbourhood determinants include physical features (e.g. air pollution), availability of services (e.g. health care facilities), and social features (e.g. social capital).

Social capital is one potential aspect of the social features of neighbourhoods that may affect health. Its possible role has been robustly debated.[3–5] Potential pathways from social capital to health include its influence on behaviour (e.g. by more rapid diffusion of health information), facilitation of access to services and amenities (e.g. more socially cohesive neighbourhoods may be more successful at securing services),

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or psychosocial processes (e.g. sense of place).[6] Social capital has been associated with mortality in ecological studies.[7–10] However, ecological studies are prone to error due to omission of individual-level confounders and other biases. Multilevel studies that control simultaneously for personal and neighbourhood-level characteristics are a more reliable study design,[11,12] but they are more challenging: a large number of both individuals and neighbourhoods are needed. Multilevel studies of social capital and mortality thus far have used different methodologies and have had mixed findings.[13–17] For example, no association was found between a range of social capital measures (political participation, trust in public and private institutions, social trust, neighbourhood integration, and isolation) and mortality in Tasmania, Australia, using routine mortality data to 'create' a multilevel study with age and sex at the individual-level.[16] On the other hand, a weak association was found in Helsinki of a rather basic measure of social cohesion (standardized score of proportion of men living with a partner, voter turnout, and residential mobility) with all-cause, injury, and alcohol-related causes of death among 25–64 year olds.[15] Subsequent work for all of Finland also found an ~10–20% elevated suicide rate for each quartile decrease in voter turnout for areas with mean size of ~60 000, after adjusting for a range of individual-level and area-level covariates.[17]

There are alternative theoretical perspectives on what social capital is and how to measure it. One perspective divides social capital into 'structural' and 'cognitive' aspects.[18] The former represents the 'store' of social capital that may be built up in communities and can be measured directly (e.g. number of community organizations) or by behaviours and activities (e.g. participation, volunteering). The latter 'cognitive' aspect represents peoples' beliefs and assumptions, such as trust and attachment. More recent conceptual work on social capital has proposed a division of the construct into bonding (trusting and co-operative relations between members of a network who see themselves as being similar), bridging (between people who know that they are not alike in some socio-demographic sense), and linking (between people who are interacting across explicit, formal, or institutional power or authority gradients) forms of social capital.[3] Specific measurement of these domains, however, is undeveloped.[5] One recent study in Tasmania, Australia, found no evidence of an association of linking social capital (using a composite measure of trust in public institutions) with self-rated health, and some evidence of bonding social capital (using a composite measure of social trust in friends and relatives) being associated with *poorer* self-rated health.[19] Finally, the level at which social capital is conceptualized to exist and operate varies. Some earlier theoretical perspectives emphasized social capital, or social cohesion more generally, being a property of the collective, with any putative association with health being over and above that due to, say, the individual-level manifestations of social networks and social support.[6,20] Alternatively, the individual-level and ecological-levels may both be incorporated. For example, a reconsideration of Bourdieu might highlight the importance of relationships in defining social space (and, by extension, perhaps geographical space)[21] or the accrual of resources to individuals as a result of their membership of social networks.[22] That is, the demonstrated importance (in observational studies at least) of social networks and support to health[23] are brought back into the social capital framework. Another recent study demonstrates that while an ecological measure of social trust is associated with individual self-rated health, it is largely mediated through individual perceptions of trust.[24]

In this study, we test the association of one measure of social capital, volunteerism measured at the neighbourhood-level, with mortality in New Zealand. A priori, an association with suicide seemed more likely than for other causes of death, because of the possibly shorter latency between exposure to a social context and suicide than for other causes of death, and sociological arguments dating back to Durkheim. Given the wide range of theoretical and empirical approaches to social capital, it is important at the outset to recognize what our conceptualization of social capital is, and what it is not. Using the 'cognitive-structural' distinction above, volunteerism is a structural measure of social capital; it is an indirect measure of community organizations occupying the space between personal networks and state or national organizations. Using the linking–bonding–bridging dimension, it arguably aligns more with linking social capital, although it also touches on bonding and bridging, i.e. we do not have good specificity on this dimension. Also, our volunteerism measure is an ecological measure; while it would be technically feasible to assess the role individual's volunteering behaviour has as an explanatory variable between the neighbourhood-level measure of volunteerism, it was beyond the scope of this study. Likewise, examination of other possible measures of neighbourhood social capital in New Zealand (e.g. political participation, trust) were beyond the scope and practicality of this study.

While cognizant of our above operationalization of social capital as volunteerism, several factors make this multilevel study internationally significant. First, analyses are conducted on linked census-mortality data for the entire adult population, making this one of the largest multilevel studies, internationally, of social capital and mortality. Second, neighbourhoods are identified with an average population size of ~2000, compared with the larger aggregations often used in other studies. The actual neighbourhood boundaries, 'area units', 'generally coincide with communities of interest or parts thereof' and in towns and cities 'generally coincide with suburbs or parts thereof' (www.stats.govt.nz). Third, covariate data are available at the individual-level (e.g. ethnicity, income, and education) and the neighbourhood-level (socioeconomic deprivation), allowing thorough multilevel analyses to adjust for cross-level confounding. Fourth, neighbourhood volunteerism was measured using census questions on volunteering of all New Zealanders, not just a survey sample, allowing the quantification of a precise and stable neighbourhood-level measure.

Methods

Neighbourhood measure of social capital

The 1996 census included six questions on unpaid voluntary activities outside the respondent's home in the 4 weeks up to census night:

(i) looking after a child
(ii) household work, cooking, repairs, gardening, or looking after a person who is aged, ill or has a disability

(iii) unpaid training, coaching, teaching, giving advice or counselling, helping at school, etc.
(iv) attending committee meeting, or organization, administration, policy work, etc., unpaid, for group, church, or marae (Maori tribal meeting place)
(v) unpaid fund-raising work, selling, etc., for group, church, or marae
(vi) other unpaid work for a group, church, or marae.

We used the 1683 census area units (average population 2034; constructed by Statistics New Zealand to fit the natural boundaries of communities of interest) as our neighbourhood units. This level of aggregation was purposely selected as it approximates the suburb level at which much voluntary effort is focused; the smaller 'meshblock' level aggregation (~100 people) is too small, capturing just streets or parts thereof; the larger 'urban area' or 'territorial authority' levels of aggregation captured whole cities (or large parts thereof) and in the latter case also mixed urban and rural zones. For each neighbourhood we calculated the proportion of census respondents aged 15 years or older responding positively to each of the above questions, and a summary proportion of people responding positively to any one of the six questions. Based on iterative principal components analyses, and a theoretical position that questions 1 and 2 above were not as relevant as the remaining four questions to our conceptualization of 'structural' or 'linking' social capital, we constructed an index using proportions for the last four questions above (loading on first component of 0.77, 0.92, 0.82, and 0.77, respectively) and the summary proportion variable (loading of 0.93; Eigen value 3.57). We then grouped the neighbourhoods into quintiles of social capital.

Linked census-mortality data

The linkage of census and mortality data in New Zealand has been described in detail elsewhere.[25] A total of 79% of eligible mortality records (age 25-77 years at death, aged up to 74 years on census night, New Zealand residents) for the 1996–99 period were linked back to a 1996 census record, with at least 98% of these links estimated to be correct.[26] The proportion of mortality records linked to a census record varied by sex, age, ethnicity, and neighbourhood deprivation. To adjust for any resultant linkage bias, we calculated inverse probability weights for use in all analyses in this paper. For example, if 20 out of 30 Māori male decedents were aged 45–64 years residing in moderately deprived small areas of New Zealand were linked to a census record, each of the 20 linked records received a weight of 1.5 (= 30/20). Similar weights were calculated and applied to numerous strata and have been shown elsewhere to be reliable.[27]

Covariates

Sex, age, marital status, and ethnicity (Maori, Pacific, and non-Maori non-Pacific) were included in all analyses as likely confounders. A range of potentially confounding individual-level socioeconomic variables were also available from the census data (Table 1). The household income variable was calculated by aggregating personal incomes in each household, then equivalizing (to adjust for economies of scale) for the number of adults and children. We used a logarithmic transformation of income as we have previously found it to be linearly associated with mortality risk (once negative and very low incomes are recoded to $1000).[28] At the small-area-level, we measured deprivation using the NZDep96 index.[29] This index was calculated from census data on socioeconomic characteristics (e.g. car access, tenure, and benefit receipt) at aggregations of ~100 people and assigned to individual census respondents.

Mortality outcome

Mortality was treated as all-causes, cardiovascular disease (CVD), cancer (malignant), unintentional injury, and suicide.

Analyses

All analyses were conducted with the GLIMMIX macro in SAS (version 8.2), using Poisson regression. In the first instance we specified a random error term at the neighbourhood-level at which social capital was measured. However, when the average number of outcome events (i.e. deaths) becomes less than about five in each level-2 unit (i.e. neighbourhood), the multilevel regression output may become unreliable.[30] Given the large number of neighbourhoods in our analyses, and the large amount of person-time, our models were probably robust to some violation of this general rule for all causes of death combined—but probably not for cause-specific mortality. For example, only 22.5 and 7.7% of neighbourhoods had at least one male or female suicide death, respectively. Moreover, analyses with a neighbourhood-level random error for injury and suicide deaths demonstrated an implausibly large variance at the neighbourhood-level (results not shown). Consequently, we only report cause-specific mortality analyses with the random term at a regional-level (n = 73 Territorial Authorities); all-cause analyses are presented with the random error term at both neighbourhood-level and regional-level. It is important to note, however, that the social capital variable was always measured at the neighbourhood-level or area unit-level.

Results

A total of 2.31 and 2.44 million person years of follow-up were available for 25–74 year olds during 1996–99 with complete data, with 16 446 and 10 398 male and female deaths (weighted up for linkage bias) occurring during the 3 year follow-up. The distribution of person time and deaths by volunteerism and covariates is shown in Table 1.

In the baseline regression model (model 1) that adjusts only for age, ethnicity, and marital status at the individual-level, and specifies a random effect at the neighbourhood-level, there was a modest association of low volunteerism with higher mortality rates (first column of results in Table 2 for males and Table 3 for females). Among males, the rate ratio comparing the people in the quintile of neighbourhoods with the lowest amounts of volunteerism to the quintile of neighbourhoods with the highest volunteerism was 1.16 [95% confidence interval (95% CI) 1.08–1.24] and among females it was 1.09 (1.01–1.18).

Adjusting for potential individual-level confounders in model 2 the association of volunteerism with mortality essentially halved for males and reduced almost to the null for females

Table 1 Distribution of person-years and deaths in 1996–99 cohort

	Person-years				Deaths (weighted)	
	Males		Females			
Level	*n*	%	*n*	%	Males	Females
Age						
25–44 years	1 176 423	51.0	1 274 004	52.2	1815	981
45–64 years	835 959	36.2	843 759	34.5	5448	3597
65–77 years	294 378	12.8	325 185	13.3	9183	5820
Ethnicity						
Mäori	221 616	9.6	244 464	10.0	2058	1440
Pacific people	65 007	2.8	71 523	2.9	465	297
Non-Maori Non-Pacific	2 020 137	87.6	2 126 958	87.1	13 917	8661
Income						
Low income	399 195	17.3	567 861	23.2	5757	4281
Medium-low income	382 044	16.6	418 425	17.1	3990	2400
Medium income	366 129	15.9	372 168	15.2	2355	1338
Medium-high income	433 794	18.8	417 309	17.1	2058	1209
High income	725 598	31.5	667 188	27.3	2283	1170
Education						
No qualifications	723 045	31.3	817 371	33.5	8049	5799
School qualifications	572 181	24.8	782 355	32.0	3285	2550
Post-school qualifications	1 011 534	43.9	843 222	34.5	5109	2046
Smoking						
Smoker	567 879	24.6	556 278	22.8	4758	2634
Ex-smoker	647 913	28.1	539 211	22.1	6930	3054
Never smoke	1 090 971	47.3	1 347 462	55.2	4755	4710
Car access						
Nil cars	117 747	5.1	174 498	7.1	1854	1827
1 car	832 503	36.1	966 060	39.5	8046	5229
2 or more cars	1 356 510	58.8	1 302 390	53.3	6543	3339
Labour force						
Employed	1 768 239	76.7	1 467 225	60.1	5367	2214
Unemployed	91 590	4.0	87 795	3.6	450	147
Non-labour	446 931	19.4	887 931	36.3	10 626	8037
Marital status						
Married	1 755 207	76.1	1 767 555	72.4	11 934	6177
Not married	551 556	23.9	675 393	27.6	4509	4221
Rurality						
Urban	1 743 456	75.6	1 884 618	77.1	12 234	7950
Minor urban	194 487	8.4	209 343	8.6	2022	1287
Rural and other	368 820	16.0	348 984	14.3	2187	1155
Neighbourhood deprivation						
Least deprived	476 568	20.7	495 729	20.3	2286	1428
Quintile 2	497 466	21.6	520 383	21.3	2961	1809
Quintile 3	496 983	21.5	524 919	21.5	3438	2235
Quintile 4	465 084	20.2	500 073	20.5	3876	2481
Most deprived	370 659	16.1	401 847	16.4	3876	2442
Neighourhood volunteerism						
Lowest	426 627	18.5	455 028	18.6	3018	1971
Medium-low	468 840	20.3	507 024	20.8	3321	2142
Medium	464 601	20.1	500 841	20.5	3438	2142
Medium-high	464 898	20.2	498 069	20.4	3540	2262
Highest	481 797	20.9	481 992	19.7	3123	1878

Table 2 Rate ratios of all-cause mortality (95% confidence intervals) and random variance estimates—males

	Neighbourhood-level random error			Regional-level random error	
Variable	Model 1: Baseline	Model 2: plus individual-level covariates	Model 3: plus neighbourhood-level covariates	Model 1: Baseline	Model 3: plus neighbourhood-level covariates
Ethnicity					
Mäori	2.19 (2.09–2.29)	1.93 (1.84–2.02)	1.84 (1.76–1.94)	2.23 (2.13–2.34)	1.85 (1.76–1.94)
Pacific people	1.74 (1.58–1.91)	1.45 (1.32–1.59)	1.37 (1.25–1.51)	1.87 (1.70–2.05)	1.38 (1.26–1.52)
Non-Mäori Non-Pacific	1	1	1	1	1
Marital status					
Married	1	1	1	1	1
Not married	1.44 (1.39–1.49)	1.22 (1.18–1.26)	1.21 (1.17–1.25)	1.45 (1.41–1.51)	1.21 (1.16–1.25)
Logarithm of household income (min $1000)		0.92 (0.89–0.94)	0.93 (0.90–0.95)		0.93 (0.90–0.95)
Education					
No qualifications		1.17 (1.13–1.21)	1.15 (1.11–1.20)		1.15 (1.11–1.19)
School qualifications		1.05 (1.01–1.10)	1.05 (1.01–1.10)		1.05 (1.01–1.10)
Post-school qualifications		1	1		1
Car access					
Nil cars		1.52 (1.44–1.61)	1.48 (1.39–1.56)		1.48 (1.40–1.57)
1 car		1.13 (1.09–1.17)	1.11 (1.07–1.15)		1.11 (1.07–1.15)
2 or more cars		1	1		1
Labour force					
Employed		1	1		1
Unemployed		1.39 (1.26–1.52)	1.37 (1.24–1.50)		1.37 (1.24–1.51)
Non-labour		1.98 (1.90–2.07)	1.96 (1.87–2.04)		1.96 (1.88–2.05)
Rurality					
Urban			1		1
Minor urban			0.97 (0.91–1.03)		0.98 (0.92–1.04)
Rural and other			0.90 (0.85–0.96)		0.89 (0.84–0.94)
Neighbourhood deprivation					
Least deprived			1		1
Quintile 2			1.11 (1.05–1.19)		1.13 (1.07–1.19)
Quintile 3			1.17 (1.10–1.24)		1.18 (1.12–1.25)
Quintile 4			1.29 (1.21–1.37)		1.29 (1.22–1.36)
Most deprived			1.45 (1.36–1.55)		1.44 (1.36–1.53)
Neighbourhood volunteerism					
Lowest	1.16 (1.08–1.24)	1.07 (1.00–1.13)	0.94 (0.88–1.01)	1.37 (1.28–1.46)	0.95 (0.89–1.02)
Medium-low	1.13 (1.06–1.21)	1.06 (1.00–1.13)	0.98 (0.91–1.04)	1.27 (1.20–1.34)	0.98 (0.92–1.04)
Medium	1.15 (1.08–1.22)	1.08 (1.02–1.15)	1.01 (0.95–1.07)	1.22 (1.16–1.28)	1.00 (0.95–1.06)
Medium-high	1.12 (1.05–1.19)	1.07 (1.01–1.13)	1.01 (0.96–1.08)	1.16 (1.10–1.22)	1.01 (0.96–1.07)
Highest	1	1	1	1	1
Random variance (standard error of variance)					
Individual-level	0.925 (0.0012)	0.923 (0.0012)	0.928 (0.0012)	0.963 (0.0012)	0.952 (0.0012)
Neighbourhood-level	0.065 (0.0060)	0.042 (0.0049)	0.030 (0.0044)		
Regional-level				0.020 (0.0048)	0.006 (0.0022)

All models additionally adjust for age in 5 year categories.

(Tables 2 and 3). Finally, the addition of rurality and neighbourhood deprivation caused any remaining association to disappear.

The final two columns of Tables 2 and 3 show the results for models 1 and 3 with the random error term specified at the regional-level. The model 1 association of volunteerism with mortality was stronger (e.g. a third higher than mortality in lower volunteerism neighbourhoods) than in the models with a random error at the neighbourhood-level. However, once covariates are adjusted for (i.e. model 3), there is essentially no difference in the volunteerism–mortality association between models with neighbourhood-level or regional-level random

Table 3 Rate ratios of all-cause mortality (95% CIs) and random variance estimates—females

	Neighbourhood-level random error			Regional-level random error	
Variable	Model 1: Baseline	Model 2: plus individual-level covariates	Model 3: plus neighbourhood-level covariates	Model 1: Baseline	Model 3: plus neighbourhood-level covariates
Ethnicity					
Mäori	2.50 (2.36–2.65)	2.26 (2.13–2.39)	2.14 (2.01–2.27)	2.50 (2.36–2.65)	2.14 (2.02–2.28)
Pacific people	1.76 (1.56–1.98)	1.55 (1.38–1.75)	1.47 (1.30–1.65)	1.82 (1.62–2.05)	1.46 (1.29–1.65)
Non-Mäori Non-Pacific	1	1	1	1	1
Marital status					
Married	1	1	1	1	1
Not married	1.26 (1.21–1.31)	1.11 (1.06–1.16)	1.11 (1.06–1.16)	1.26 (1.21–1.31)	1.11 (1.06–1.16)
Logarithm of household income (min $1000)		0.92 (0.89–0.95)	0.94 (0.90–0.97)		0.94 (0.90–0.97)
Education					
No qualifications		1.23 (1.17–1.29)	1.20 (1.14–1.27)		1.20 (1.14–1.27)
School qualifications		1.12 (1.06–1.19)	1.12 (1.05–1.18)		1.12 (1.05–1.18)
Post-school qualifications		1	1		1
Car access					
Nil cars		1.45 (1.36–1.55)	1.40 (1.31–1.50)		1.40 (1.30–1.50)
1 car		1.11 (1.05–1.16)	1.08 (1.03–1.14)		1.08 (1.03–1.14)
2 or more cars		1	1		1
Labour force					
Employed		1	1		1
Unemployed		1.09 (0.92–1.28)	1.08 (0.91–1.27)		1.08 (0.91–1.28)
Non-labour		1.88 (1.78–2.00)	1.87 (1.77–1.99)		1.88 (1.77–1.99)
Rurality					
Urban			1		1
Minor urban			1.00 (0.93–1.08)		1.00 (0.93–1.07)
Rural and other			0.91 (0.84–0.99)		0.91 (0.84–0.98)
Neighbourhood deprivation					
Least deprived			1		1
Quintile 2			1.07 (0.99–1.16)		1.09 (1.01–1.17)
Quintile 3			1.20 (1.11–1.29)		1.21 (1.12–1.30)
Quintile 4			1.27 (1.18–1.37)		1.27 (1.18–1.37)
Most deprived			1.45 (1.34–1.57)		1.42 (1.31–1.53)
Neighbourhood volunteerism					
Lowest	1.09 (1.01–1.18)	1.03 (0.95–1.10)	0.92 (0.85–1.01)	1.33 (1.23–1.44)	0.96 (0.88–1.04)
Med-low	1.07 (0.99–1.15)	1.01 (0.94–1.08)	0.94 (0.87–1.02)	1.23 (1.15–1.32)	0.97 (0.90–1.04)
Medium	1.05 (0.97–1.13)	1.00 (0.93–1.07)	0.94 (0.87–1.01)	1.14 (1.06–1.22)	0.95 (0.89–1.02)
Med-high	1.07 (0.99–1.15)	1.03 (0.96–1.11)	0.99 (0.92–1.06)	1.14 (1.07–1.21)	1.01 (0.94–1.08)
Highest	1	1	1	1	1
Random variance (standard error of variance)					
Individual-level	0.946 (0.0012)	0.967 (0.0012)	0.975 (0.0012)	0.979 (0.0012)	0.996 (0.0012)
Neighbourhood-level	0.063 (0.0075)	0.043 (0.0066)	0.031 (0.0060)		
Regional-level				0.027 (0.0070)	0.007 (0.0029)

All models additionally adjust for age in 5-year categories.

error terms. This latter equivalence gave us confidence that using a regional-level random error term for the cause-specific mortality analyses would be reliable—so long as covariates were adjusted for (i.e. model 3). Table 4 shows these results by cause of death. There was no association of volunteerism with any cause of death, with the possible exception of a protective association of low volunteerism with male unintentional injury. That said, there is little overall evidence that the association (null or otherwise) of volunteerism with all-cause and cause-specific mortality varies by sex given the similar patterns by sex and largely overlapping CIs between male and female rate ratios.

Table 4 Rate ratios (95% CIs) of cause-specific mortality by neighbourhood volunteerism adjusting for individual-level and neighbourhood-level covariates (i.e. model 3)

	All-cause	Cancer	Cardiovascular disease	Unintentional injury	Suicide
Males					
Neighbourhood volunteerism					
Low volunteerism	0.95 (0.89–1.02)	0.98 (0.88–1.10)	1.00 (0.90–1.12)	0.60 (0.44–0.82)	0.89 (0.64–1.22)
Medium-low	0.98 (0.92–1.04)	1.01 (0.92–1.12)	1.01 (0.92–1.11)	0.83 (0.64–1.09)	0.89 (0.67–1.18)
Medium	1.00 (0.95–1.06)	1.01 (0.92–1.11)	1.03 (0.95–1.13)	0.94 (0.74–1.20)	0.87 (0.66–1.14)
Medium-high	1.01 (0.96–1.07)	0.98 (0.90–1.07)	1.08 (0.99–1.17)	0.95 (0.76–1.18)	0.95 (0.74–1.23)
High volunteerism	1	1	1	1	1
Random variance (SE of variance)					
Individual-level	0.952 (0.0012)	0.964 (0.0012)	0.947 (0.0012)	0.967 (0.0012)	0.960 (0.0012)
Regional-level	0.006 (0.0022)	0.009 (0.0044)	0.014 (0.0058)	0.118 (0.0427)	0.097 (0.0501)
Females					
Neighbourhood volunteerism					
Low volunteerism	0.96 (0.88–1.04)	1.00 (0.89–1.12)	0.87 (0.75–1.02)	0.85 (0.51–1.44)	0.57 (0.31–1.05)
Medium-low	0.97 (0.90–1.04)	0.97 (0.87–1.08)	0.94 (0.81–1.08)	0.80 (0.50–1.28)	0.93 (0.56–1.53)
Medium	0.95 (0.89–1.02)	0.94 (0.85–1.03)	0.92 (0.80–1.06)	1.12 (0.73–1.72)	0.80 (0.50–1.29)
Medium-high	1.01 (0.94–1.08)	1.02 (0.93–1.12)	0.91 (0.80–1.04)	1.11 (0.74–1.67)	0.92 (0.59–1.43)
High volunteerism	1	1	1	1	1
Random variance (SE of variance)					
Individual-level	0.996 (0.0012)	0.977 (0.0012)	1.049 (0.0013)	0.926 (0.0011)	0.825 (0.0010)
Regional-level	0.007 (0.0029)	0.006 (0.0042)	0.008 (0.0058)	0.165 (0.0992)	0.397 (0.1590)

Sensitivity analyses excluding people who had not been usually resident in the same neighbourhood for at least 5 years prior to census night did not substantially alter findings. Also, dropping either labour force status or car access from model 3 (variables that one might argue are perhaps influenced by volunteerism, and not 'just' confounders) did not substantially change the results. Finally, we found no evidence of significant variation in the rate ratio association of volunteerism with mortality by third variables of age, ethnicity, or household income (i.e. no cross-level interaction; results available from authors).

Discussion

This study presents to our knowledge the largest multilevel study of social capital and mortality, albeit for one possible measure of social capital (i.e. neighbourhood volunteerism). Adjusting for a range of possible confounders, we found no significant association of volunteerism with mortality among 25–77 year olds in New Zealand. Some of the variables we modelled as confounders might be considered as mediating variables between social capital and mortality. Excluding the two variables we identified as most likely to potentially also be mediating variables (labour force status and car access) did not substantively change the association of volunteerism with mortality.

Our measure of social capital is derived from questions on voluntary activities answered by the full population at census night. In contrast, other studies have used only survey data to create neighbourhood-level measures of social capital that—because of small numbers of respondents in each area, or not all neighbourhoods being included in the survey—reduces the accuracy of the measurement of social capital and may reduce the number of neighbourhoods that can be included in analyses. A relative weakness of our structural measure of social capital is that it only measures volunteering rather than the actual presence of organizations. It also does not specifically measure voluntary activity in one's neighbourhood, meaning that we are implicitly assuming that an aggregated measure of peoples' overall voluntary behaviour is highly correlated with: within neighbourhood volunteerism (assuming *actual* neighbourhood volunteerism is the target variable to measure) or neighbourhood social capital more generally construed. Finally, the voluntary activity variables we used in the construction of our index only record yes/no responses, not intensity of activity.

As indicated in the Introduction section, our study cannot refute the possibility that other aspects of social capital (e.g. trust, direct measures of linking social capital), or social capital measured at different levels of aggregation (e.g. regions or national), or neighbourhood-level volunteerism in another context might actually be associated with mortality or health more generally. Regarding context, New Zealand during the late 1990s was emerging from a period of major structural reform including deregulation and privatization, and state sector reform. Associated with this reform income inequality increased markedly from the late 1980s to the early 1990s[31]—but did not reach the levels of the US. While there had been some retrenchment by the state and devolution to communities in the provision of social services in New Zealand, neighbourhood and regional-level variation in social capital may not have been as important for health outcomes as in other countries. Indeed, just as the association of income inequality with

mortality has only reliably been demonstrated in the US,[32,33] it might also be that social capital is also emerging as a health determinant in the US.[34] Put another way, context may be everything. Living in a country with a secure welfare system and universal provision of health and other social services may render neighbourhood social capital less important as a health determinant.

While mortality is a robust outcome to measure, it is likely to be removed in time from the relevant period of 'exposure' to social capital. Unless the volunteerism of the neighbourhood people lived in during 1996 was a good proxy for the social capital of neighourhoods over peoples' lifecourse, our null findings might be attributed to a misclassification bias of lifecourse social capital. We partially tested for this possibility by excluding people who had not lived at the same residence for at least 5 years, but no association of neighbourhood volunteerism with mortality was disclosed. Any association of social capital with health may only be detectable for morbidity and health-related behaviours. For example, studies have found an association of: social capital as an index of civic trust, reciprocity and voluntary group membership with self-reported health[35]; collective efficacy, and self-rated health[36] and self-reported respiratory disease.[37] A recent systematic review of social capital and mental health studies found seven studies conceptualizing and measuring social capital as an ecological-level variable that fitted their inclusion criteria.[18] However, the majority of study findings were null.

The issue of what it is about neighbourhoods that influences health, and the likelihood that social features of neighbourhoods are important, remains a challenge. It still seems highly plausible that neighbourhood (or more generally 'community') social environments matter for the myriad of pathways and mechanisms that lead to poor or good health. Future quantitative research on the social features of neighbourhoods should, in our view, be cognizant of the wider regional or national contexts, and undertake improved and alternative measurement of the social environment (e.g. careful measurement of linking–bonding–bridging social capital, measures of social fragmentation). Using continuously measured outcomes (e.g. mental health rather than suicide death) would improve statistical power. Finally, given problems with time lags and long causal chains between social capital, and cancer and cardiovascular death, we also suggest considering intermediate outcomes (e.g. physiological variables, behaviours).

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Ethical approval

Ethical approval for the NZCMS was obtained by the Wellington Regional Ethics Committee.

Summary statistics New Zealand security statement

(The full security statement is available at http://www.wnmeds.ac.nz/nzcms-info.html). The New Zealand Census Mortality Study (NZCMS) is a study of the relationship between socioeconomic factors and mortality in New Zealand, based on the integration of anonymized population census data from Statistics New Zealand and mortality data from the New Zealand Health Information Service. The project was approved by Statistics New Zealand as a Data Laboratory project under the Microdata Access Protocols in 1997. The datasets created by the integration process are covered by the Statistics Act and can be used for statistical purposes only. Only approved researchers who have signed Statistics New Zealand's declaration of secrecy can access the integrated data in the Data Laboratory. For further information about confidentiality matters with regard to this study please contact Statistics New Zealand.

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Commentary: Social capital and health: making the connections one step at a time

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The study by Tony Blakely *et al.*[1] in this issue of the journal adds to the growing international evidence suggesting that social capital matters less for the health of residents in comparatively egalitarian countries, in contrast to highly unequal societies with inadequate safety nets. Although New Zealand experienced dramatic surges in income inequality following the structural reforms of the 1980s and 1990s, the country, nonetheless, managed to preserve robust support for public infrastructure (e.g. primary health care services, public education) that arguably helps to mitigate the consequences of rising inequality.

The New Zealand study is broadly consistent with the survey of literature on social capital and health carried out recently by Islam *et al.*[2] The authors identified 42 studies on social capital and health published between 1995 and 2005, including 30 single-level studies (either individual-level or ecological data) as well as 12 multilevel studies from different countries. Regardless of study design, the review found a fairly consistent fixed effect association between social capital and a range of health outcomes. However, in the multilevel studies, the

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