The New Zealand Index of Neighbourhood Social Fragmentation: integrating theory and data

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Abstract. We report on the development and validation of a neighbourhood measure of social fragmentation. Firstly, we developed a theoretical model of neighbourhood-level social fragmentation, as the structural antecedent to collective social functioning, with three domains (attachment, resources, and means of sharing of norms and values). Secondly, utilising the New Zealand 1996 and 2001 Censuses, variables were constructed to create the New Zealand Index of Neighbourhood Social Fragmentation (NeighFrag) at the small-area level. Nine census variables contributed substantively to a principal components analysis: homeownership, mobility, marital status, nonfamily households, single-person households, children, immigrants, non-English/Māori speakers, and long-term residents. Thirdly, relationships between NeighFrag and other contextual measures were examined, as well as its relationship with individual perceptions of neighbourhood cohesion. The NeighFrag index had a moderate association with deprivation and social capital. It was inversely associated with individual perception of neighbourhood cohesion in multilevel analyses, after adjusting for individual factors and neighbourhood deprivation. Combined, this suggests that NeighFrag provides a meaningful national-level index of neighbourhood social environments for use in analyses.

Keywords: social fragmentation, neighbourhood, social capital, social cohesion, principal components analysis, deprivation

Introduction

'Neighbourhoods' have long been recognised as an important context for how we live our lives, and the influence neighbourhoods can have on residents' health and well-being is increasingly coming to light. Understanding such relationships requires robust measures of neighbourhood context. Broadly speaking relevant neighbourhood properties have been grouped into social, physical, and material domains. In this paper we address the measurement of one social property of neighbourhoods: social fragmentation—commonly interpreted as a lack of social cohesion and social capital within a social setting. We report on the development of a neighbourhood index of social fragmentation, and how the informative interplay between the methodological and theoretical parameters has contributed to our understanding of neighbourhood-level social fragmentation.

'Social fragmentation' is a term originating in Emile Durkheim's work that has loosely been grouped with other 'social' properties of groups and neighbourhoods such as cohesion, capital disorganisation, and collective social functioning (Stjarne et al, 2004). Briefly, in Durkheim's terms, 'societies', or social groups, vary in the extent to which they are cohesive or, conversely, fragmented, and therefore the extent to which they can provide balanced levels of integration and regulation for their members (Durkheim, 1951). Durkheim hypothesised that a society that is either excessively fragmented *or* cohesive would be less able to provide 'healthy' levels of support—a theory which he tested (with various degrees of success) by examining suicide rates in different 'societies' (Durkheim, 1951; Taylor and Ashworth, 1987). A U-shaped relationship between levels of integration and regulation and individual well-being has been suggested, in which a highly fragmented group or neighbourhood would leave individuals isolated, with reduced access to supportive levels of integration or regulation. On the other hand, a highly cohesive social setting could potentially 'subsume' individuals (Kushner and Sterk, 2005), overwhelming them and leaving them unable to act in their own interests.

Fragmentation of social environments has continued to be of interest to health researchers for its potential relationship with mental health. The role of social networks in the causal pathways between the social environment and health has been discussed widely by, for example, Berkman et al (2000). Kawachi et al (2008) describe social networks as the means by which forms of social capital, such as social support, are exchanged within social groups, such as neighbourhoods. The nature of social networks and, therefore, the social resources arising will vary across neighbourhoods, in part determined by factors both within the neighbourhood and wider societal processes (Berkman and Glass, 2000; Carpiano, 2006). Our aim therefore, was to develop a measure capturing neighbourhood-level conditions affecting levels of social resources such as social cohesion and social capital.

In recent epidemiological research the primary measure of neighbourhood-level social fragmentation has been a four-variable, small-area measure known as the 'Congdon index', developed in the United Kingdom (Congdon, 1996). In the original study, Congdon sought to create a measure which could account for the particular distribution of suicide and parasuicide in London better than did the standard deprivation measures (Congdon, 1996). Census data were used to capture the small-area proportions of private rental accommodation, single-person households, married adults, and residential mobility. Both the Congdon index and the Index of Neighbourhood Social Fragmentation (NeighFrag) presented here have been used in health analyses: for example, suicide (Collings et al, 2009; Congdon, 1996; Evans et al, 2004; Middleton et al, 2004; O'Reilly et al, 2008; Whitley et al, 1999); psychiatric hospitalisation (Allardyce et al, 2005; Curtis et al, 2006; Evans et al, 2004); mental health (Fagg et al, 2006; 2008; Ivory et al, 2011; Stafford et al, 2008a); and non-mental-health outcomes, such as heart disease (Stjarne et al, 2004) and injury (Laflamme and Reimers, 2006).

Having established that neighbourhood social fragmentation is a risk factor for mental health, in this paper we describe the conceptual and methodological background to the NeighFrag, and its relationship with other contextual factors and cohesion. This will allow research to consider more robustly first what NeighFrag may be a proxy for, and second, potential pathways to health. The Congdon Index and similar variables are commonly used in neighbourhoods and health research as *antecedents* to the collective nature of a neighbourhood (Carpiano, 2006; Sampson et al, 1999). Yen and Syme (1999) recognised the importance of capturing such processes, summarising that "there are features of areas that strengthen or weaken social support

and cohesion, and these have important implications for the health of residents in those areas." (Yen and Syme, 1999, page 293). For example, high levels of residential mobility can act as a structural barrier to the development and sustaining of the kinds of local social ties needed to control neighbourhood-level problems such as delinquency (Sampson and Groves, 1989), or affect the development of the close networks required for cohesion (Fagg et al, 2008). Such processes imply that there might be certain neighbourhood-level inhibitors for the production of 'collective social functioning' because of the characteristics of the neighbourhood population (Macintyre et al, 2002).

To conduct neighbourhood-level research in New Zealand (NZ), but being uncertain how 'off-the-shelf' measures such as the Congdon index might translate to our local context, we embarked upon constructing an index of social fragmentation from available New Zealand data. We sought a balance between using relatively rich, but still restrictive, census data and having a theoretically informed index (Congdon, 2004; Stjarne et al, 2004)

The Congdon index was originally created to measure the 'nondeprivation' aspects of small areas, and was later described as the level of "social integration and social support resting on non-institutional ties (with partners, families) and on institutional and community ties" (Congdon, 2004, page 741). More recently, 'social fragmentation' has been conceptualised as the opposite of either cohesion or integration (Allardyce et al, 2005; Evans et al, 2004; Fagg et al, 2006; 2008). Yet a compositional index built from census data cannot measure the actual presence of social ties within a neighbourhood or its level of cohesion. This raises the question of what is being measured by compositional indices such as the Congdon index, and why that might be important for health. Such issues have implications for the selection of variables for an extended index and the usefulness of a given measure for examining the neighbourhood–health relationship.

Bringing theory and data together: creating the Index of Neighbourhood Social Fragmentation

In response to the points raised above, we sought to create a 'useful' index of neighbourhood-level social fragmentation, that is, one that was relevant to the NZ setting, made the most of the available data, and which operationalised a clearly specified construct. National-level datasets with direct measures of social ties and so on within a neighbourhood are not currently available in New Zealand. In their absence, NZ Census and the Health Behaviours Surveys[1] provide the most relevant data. Accordingly, we built a neighbourhood-level index of social fragmentation in three stages. First, we developed a conceptual model based on current indicators and related literature. Second, we selected variables which operationalised the model as fully as possible and which were statistically related to the hypothesised underlying concept. Third, we sought to understand what was captured by our index and assess its validity by examining its relationship with other contextual measures: specifically, deprivation, social capital, and rurality. Fourth, we explored the relationship with social cohesion by assessing the extent to which individual perception of neighbourhood social cohesion was predicted by our index.

[1] Data on perceptions of neighbourhood social cohesion were available from a representative sample of 15 930 New Zealanders by combining two national surveys (Health Behaviours Survey: Drugs; and the Health Behaviours Survey: Alcohol) conducted in 2003 and 2004 by the Ministry of Health, New Zealand.

Translating Durkheim's concept of fragmented societies into a neighbourhood measure required definition of the societal unit: that is, what is being fragmented? Two possibilities are suggested in the literature: wider social institutions (eg, marriage and family) and neighbourhoods themselves. It is possible that indices capturing neighbourhood aggregations of individuals who were (for example) less integrated into key national-level institutions such as marriage would be related to spatial variation in health outcomes. However, the range, quality, and validity of census-based indicators of social institutions relevant to the diverse New Zealand population were limited. For example, although religious affiliation was asked about, there were no equivalents for other important social groups such as sport or activity groups. Moreover, institutions such as marriage may be less relevant to some segments in society (Congdon, 2004), decreasing its potential value as an indicator of integration into the broad NZ society. We argue, therefore, that basing the index on integration into national-level social institutions, relying on census variables, would be too limiting.

A second possible unit of fragmentation in the literature was the 'neighbourhood' as the 'society' of interest. This was in keeping both with Durkheim's use of the term and with the framing of the fragmentation construct in the recent literature as a neighbourhood-level construct. It was also feasible to construct neighbourhood-level variables from the NZ Census as data were available for all individuals and households, with small-area identifiers. However, no data about people's relationship to their area of residence (or other key social settings aside from the household) were collected in the census. Because of this we argue that it was not possible to use census data alone to directly measure actual levels of cohesion in the neighbourhood 'society', nor an individual resident's integration into his or her neighbourhood. However, it should be possible to measure compositional factors hypothesised to be antecedent to neighbourhood collectivity, as discussed above.

To drive the selection of potential variables and increase content validity, we identified three interlinking dimensions which conceivably 'fragment' neighbourhood collective social functioning: the 'how' (limited means of communicating norms and values across neighbourhoods); the 'who' (neighbourhood social resources); and the 'why' (levels of attachment to people and place).

Dimension 1: limited means of sharing norms and values
The ability to communicate readily within a neighbourhood has been established as important for neighbourhood functioning (Sampson and Groves, 1989). Forrest and Kearns (2001) emphasised the importance of shared values and interaction for a sense of social cohesion, and opined that without them "a society lacking cohesion would be one which displayed social disorder and conflict, disparate moral values, extreme social inequality, low levels of social interaction between and within communities and low levels of place attachment" (page 2128). Individual-level census data cannot directly measure the extent of sharing of norms and values within a neighbourhood. However, three factors were noted in the literature as being potential indicators of the *means* of communicating norms and values. First, a lack of shared languages may result in communication difficulties within a group (Sampson et al, 1999). Second, a high proportion of recent immigrants may inhibit the local sharing of norms and values (Sampson et al, 1999). It is important to note here that we do not see diversity as a fragmenting factor per se: it is only when cultural factors impede communication between subgroups that diversity becomes important. There are other means of facilitating communication or common interests which can override cultural and language barriers.

Third, there being few common interests amongst residents may hinder cross-neighbourhood communication. The presence of children in a neighbourhood has been suggested as a potential factor in creating common interests—and one which would be available in our census data. Sampson et al (1999) suggested that children can act as a focus for local collective action. Others have noted that the presence of children (notably those of school age) impacts on the social networks within a neighbourhood (Nomaguchi and Milkie, 2003; Witten et al, 2007), and volunteering activities of parents (Wilson and Musick, 1998). Conversely, income inequality may potentially be a polarising factor by reducing shared values (Forrest and Kearns, 2001).

Dimension 2: attachment

Attachment by residents to place and people can provide motivation for the development and maintenance of social networks and ties, or collectivity, in an area. Conversely, high levels of population turnover are judged to weaken the ability of a neighbourhood to develop and sustain social networks and controls because of the time needed to develop such ties (Forrest and Kearns, 2001; Lindstrom et al, 2002; Martikainen et al, 2003 ; Winstanley et al, 2002). Home ownership is seen as a measure of commitment to an area, be it via participation in activities or 'social investment' (Franzini and Spears, 2003; Lindstrom et al, 2003; Winstanley et al, 2002). Relationships such as marital status capture personal attachments. On the other hand, living alone has generally been associated with less participation in social networks (Lindstrom et al, 2002).

Dimension 3: social resources

There is little direct discussion in the literature of who or what is required to cultivate neighbourhood-level collectivity which, we argue, is a critical omission. Baum and Palmer (2002) argued that physical resources such as parks and amenities could act as 'opportunity structures' for social interaction, thereby potentially contributing to neighbourhood collectivity, but these were not represented in our census data. So, given our reliance on NZ census data, we were restricted to capturing *who* might have the time, energy, and motivation to contribute to local social life (Fullilove et al, 1998): that is, the social resources in a neighbourhood. The literature on volunteering suggested some potential groups. Caregivers not in the paid workforce have been recognised as important contributors to neighbourhood social networks through volunteering (Gerstel and Gallagher, 1994; Hook, 2004; McPherson, 2004). Although this is not specifically discussed in the literature, we also propose that retired residents may be an important social resource. Long-term residence has also been associated with increased local ties and institutional knowledge (Forrest and Kearns, 2001; Parkes and Kearns, 2006).

Having considered a wide range of potential factors and their role in the social environment, we concluded that a fragmented neighbourhood could be one with limited related means of communication, low levels of attachment, and few social resources. The composition of individuals in a neighbourhood could act as the local social topography which underlies the construction of social ties and institutions within a neighbourhood: the topography does not directly construct the social ties, but provides the context within which they are more or less easily made. We argue that variables such as those discussed above represent the fragmenting *conditions*, rather than the actual level of integration or social ties themselves.

In constructing a social fragmentation index we were mindful that the question remained: what fragmentation processes were being captured by aggregating individual-level census data to create neighbourhood measures? How closely could the measures derived relate to the construct of social fragmentation discussed in the literature?

The Health Behaviour Surveys provided the opportunity to address these questions. These surveys contain data on respondents' perceptions of the cohesiveness of their neighbourhood, and the survey participants were a geographically stratified representative sample of New Zealanders. These survey data could therefore be used to assess respondent's social ties to their neighbourhood, and the relationship between neighbourhood fragmentation and levels of cohesion.

Methods
Creating the Index of Neighbourhood Social Fragmentation
Separate indices were created from each of the 1996 and 2001 Census datasets by the methods described below. Where the year is interchangeable, the general name NeighFrag is used.

Scale of 'neighbourhood'
We sought to measure fragmentation at a scale of neighbourhood that would be recognised as a socially relevant community. In order to create a consistent national index we were restricted to the available administratively defined boundaries. Therefore, we used the official census area unit (CAU) classifications which are considered natural communities, or parts thereof, with varying population sizes having a median of close to 2000 persons in 1996. Although the CAUs attempt to reflect geographically based communities, it is acknowledged that their boundaries may be less appropriate in nonurban areas (Statistics New Zealand, no date).

Data
Anonymised 1996 and 2001 national census datasets were restricted to usual residents: $n = 3618\,300$ and $3737\,280$ people, respectively, living in 1775 CAUs (all counts have been randomly rounded to base 3 in accordance with the rules of controlled access to the census datasets). Exploratory counts revealed considerable variation across areas in the proportions of people usually resident in nonprivate dwellings: for example, individuals residing in motor camps or university hostels. A failure to include those usually resident in these types of dwellings would therefore contribute to the misclassification of areas with higher proportions of people resident in nonprivate dwellings. Therefore, we only excluded dwellings where residents could reasonably be considered as not part of the local community: prisons, police lockups, and hospitals.

Variables
The census questionnaire and data dictionary were examined for items which could plausibly be proxies for each dimension. The thirteen variables described below (characterised as proportions of the neighbourhood population) were created to operationalise the three dimensions: 'more population mobility < 1 year'; 'less home ownership/more private renting' [for the Congdon(NZ) index]; 'fewer married adults'; 'fewer nonfamily households'; 'more single-person households' (aged < 70 years); 'fewer school-aged children' (aged $5-15$ years); 'more recent immigrants < 1 year'; 'more non-NZ language speakers'; 'greater income inequality within the neighbourhood' [for exploratory purposes an approximation was created using Jensen-equivalised household income to investigate variation in the range of household incomes within CAUs (Jensen, 1978, 1988)]; 'fewer at-home parents'; 'fewer unpaid caregivers'; 'fewer pensioners without limiting health conditions/pensioners'; 'fewer long-term residents > 15 years' (further details available from authors).

Figure 1 shows these dimensions and the candidate census variables within each dimension. Note that, in order to create a measure distinct from material deprivation, we excluded variables used in the New Zealand Index of Deprivation (NZDep) (Salmond and Crampton, 2002). NZDep was developed with the same methods as
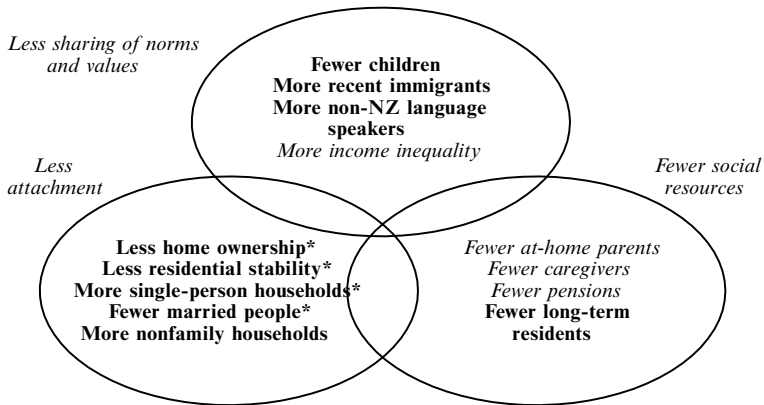
Notes: Variables shown in bold were retained in factor analysis and principal components analysis to be included in the final NeighFrag index. *indicates variables also included in the Congdon(NZ) index. Variables in italics were discarded from the NeighFrag index due to non-significant contributions.

Figure 1. Diagrammatic representation of three domains and subsumed variables selected for creation of the Index of Neighbourhood Social Fragmentation.

NeighFrag, using census data on socioeconomic characteristics (means-tested benefits, employment, equivalised household income, access to a telephone, access to a car, single-parent family, qualifications, homeownership, household overcrowding). The exception was homeownership, because of its strong theoretical justification for inclusion in both indices. Interestingly, the four Congdon variables all fell into the attachment dimension.

Constructing the index
Preliminary factor analysis (FA) and principal components analysis (PCA) were used to explore relationships and to select the most parsimonious set of variables. Both orthogonal and oblique rotation methods were used in the factor analyses to understand the factor structure of the variables (DeVellis, 2003). PCA was used to create a score based on the first principal component, reflecting the maximum variation of the variables selected by FA (Armitage and Colton, 1998). The score was used to create a weighted index. The procedure was repeated for both years. A weighted New Zealand version of the Congdon index [the Congdon(NZ) index] was also created using PCA.

As expected when measuring a 'lack', the actual values both of the NeighFrag index and of the Congdon(NZ) index were strongly positively skewed. For practical use, the CAU scores were classified into deciles, with decile 10 including the most fragmented 10% of area units in NZ.

Exploring the index
Reliability, or consistency, of the measure was assessed with checks on stability in weights and rankings of areas between the 1996 (NeighFrag96) and 2001 (NeighFrag01) versions (Tuckman, 1988). Some change in the ranking of neighbourhoods might be expected over the two consecutive five-yearly censuses: for example, reflecting changing housing developments or area boundary changes. A comparison between the versions was used to assess alternate-form reliability (Tuckman, 1988). Once again, the versions were expected to be different, but not too divergent.

Assessing the validity of the index—that is, the extent to which it measures the construct of interest (Tuckman, 1988)—was problematic. The concurrent validity of the index would normally be assessed by comparing NeighFrag against an accepted gold standard (Tuckman, 1988). It was not known whether the Congdon(NZ) index

could be considered the 'gold' standard in the NZ setting (indeed, whether it would be was of substantive interest). Nevertheless, the Congdon(NZ) index provided a useful internationally recognised alternative standard.

The construct validity (Tuckman, 1988) of our index was assessed using our knowledge of particular neighbourhoods in NZ, and from predicted relationships with urbanicity and two other area measures. As with the Congdon index, we expected deprivation to be related to, but different from, fragmentation. A positive, but not strong correlation was expected with NZDep. On the other hand, we hypothesised an inverse relationship between NeighFrag96 and a measure of social capital. Accordingly, a moderately negative relationship was expected with SoCInd, an ecological measure of social capital, created from the 1996 Census data on the neighbourhood proportions of formal volunteering (Blakely et al, 2006).

In addition, criterion validity was addressed using survey data to assess the extent to which NeighFrag01 is associated with individual perception of neighbourhood social cohesion—again, we hypothesised an inverse relationship. These data were collected in two national surveys (Health Behaviours Survey: Drugs, and the Health Behaviours Survey: Alcohol) conducted in 2003 and 2004 by the Ministry of Health, New Zealand. The combined survey population consists of a general population sample (people aged 13 to 65 years, living in permanent private residential dwellings in New Zealand) and a Maori oversample, a total of 17942 respondents. The response rate was 68% for the 2003 Health Behaviours Survey: Drugs and 59% for the 2004 Health Behaviours Survey: Alcohol. The majority of interviews were conducted by computer-assisted telephone interviewing (CATI). However, people in households without access to landline telephones were included through two computer-assisted cellphone interviewing (CACI) samples. CACI respondents were recruited via an initial face-to-face contact, and interviewed by cellphone. Information on neighbourhood cohesion was sought only for people over 18 years of age. After restricting by age, and those with complete data on age and cohesion measure, the final combined analysis sample from the two surveys consisted of 6936 males and 8994 females ($n = 15\,930$) from 1572 CAUs.

Measures

Neighbourhood cohesion was measured by asking respondents to what extent they agree with the following seven statements about the neighbourhood they live in: "People are willing to help"; "Neighbours watch out for kids"; "It's a close-knit neighbourhood"; "I can borrow $10 from a neighbour"; "If there is a problem with neighbours we can deal with it if needed: eg, dogs, noise, rubbish"; "The neighbours cannot be trusted (reverse coded)", and "People will take advantage of you [reverse coded]" (Sampson and Raudenbush, 1999; Sampson et al, 1997). A five-point Likert scale was used, with scores ranging from 1 (strongly agree with the statement) to 5 (strongly disagree with the statement). An average score for each respondent over the seven items was calculated, with higher scores denoting stronger neighbourhood cohesion (mean = 3.76, SD = 0.60). The Cronbach's alpha for this scale was 0.73, indicating good internal consistency.

Individual-level covariates were: age (continuous); gender (female reference category); ethnicity [dummy variables for NZ European(reference category), Maori, Pacific People, Asian, other]; marital status [with partner (reference category), separated, single]; employment status [full-time (reference category), part-time (< 30 hours per week), student, unemployed, sick/invalid, retired, parenting/unpaid/unknown)]; income (continuous); educational qualifications (continuous).

Neighbourhood-level variables: NZDep01 and NeighFrag01were treated as continuous variables ranging from 1 to 10. The estimate shows the change in social cohesion score with every unit change of NZDep01 and NeighFrag01.

Analysis
Linear regression models using Proc Mixed (SAS v9.1) with a random intercept were fitted in the hierarchical modeling, with neighbourhood cohesion score as the outcome variable (cohesion score was transformed from the original scale of 1 – 5 to a percentage score: ie, 0 – 100). Exposure variables were added in four stages. First, the null model was built, which included only the intercept and the neighbourhood-level NeighFrag01. The second and third model included individual-level socioeconomic variables and one of the two neighbourhood-level variables (NeighFrag01 and NZDep01). In the fourth model both neighbourhood-level variables were introduced simultaneously.

Analyses using individual level census data conducted in the Data Laboratory at Statistics New Zealand were conducted in SAS (8.2); other analyses were conducted in SAS (9.1)

Results
Index description
Following exploratory and iterative factor analysis and PCA, nine variables were found to be related to a single factor, with each domain represented to some degree (figure 1). FA and PCA did not support the inclusion of four variables: income inequality; fewer at-home parents; fewer caregivers; fewer pensioners. Consequently, the index was less able to operationalise the theorised social resources dimension. The final PCA model is shown in table 1, with both years shown for comparison. There is little change in most weightings across the two censuses for any of the versions. This suggests that the indicators were stable proxies for the underlying constructs they were measuring. Two components had an eigenvalue greater than 1.0, but the first component had a substantially higher value

Table 1. Weights and eigenvalues from final principal components analysis.

Domain	Proportion in the area unit	Weight (coefficient in the first principal component)	
		1996	2001
Less sharing of norms and values	fewer school-aged children	0.58	0.58
	more recent immigrants (< 1 year)	0.63	0.62
	more non-NZ language speakers	0.42	0.41
Less attachment	less home ownership	0.83	0.79
	more residential mobility	0.91	0.87
	fewer married adults	0.72	0.74
	more nonfamily households	0.78	0.76
	more single-person households	0.42	0.41
Fewer resources	fewer long-term residents (> 15 years)	0.63	0.63
Statistics			
Proportion of total variance		0.44	0.46
Eigenvalue of first principalo component		3.97	4.12
Eigenvalue of second principal component		1.61	1.65
Congdon(NZ) index			
	private rentals	0.87	0.89
	single-person households	0.63	0.61
	married adults	0.77	0.83
	residential mobility	0.82	0.83

(3.97 versus 1.61), supporting a single strong underlying primary factor. Further, FA trials using either orthogonal or oblique rotations failed to settle on a simple loading pattern across multiple factors. In particular, the proportion of school-aged children tended to have significant loadings across more than one factor. Specifying a single factor resulted in nine variables demonstrating substantial positive loadings. Accordingly, we selected the first component from the PCA of these nine variables as our NeighFrag index.

Figure 2 shows a map of New Zealand and, in greater magnification, the Wellington (capital city) region, by NeighFrag96. Inner-city areas of Wellington (and other cities—data not shown) were more likely to be ranked as the most fragmented. The Congdon(NZ) index demonstrated a very similar distribution, but with the centre and east of the North Island and the northwest of the South Island ranked as slightly more fragmented. Reliability checks demonstrated a small amount of change between the 1996 and 2001 versions, and between the Congdon(NZ) index and NeighFrag versions. We used several strategies to investigate these differences, including our combined personal knowledge of historical changes, as well as Statistics New Zealand information concerning boundary changes and compositional differences [for example, factors unaccounted for in the Congdon(NZ) index, such as the proportion of children]. Our investigations verified that the differences were unlikely to be due to statistical artefact.
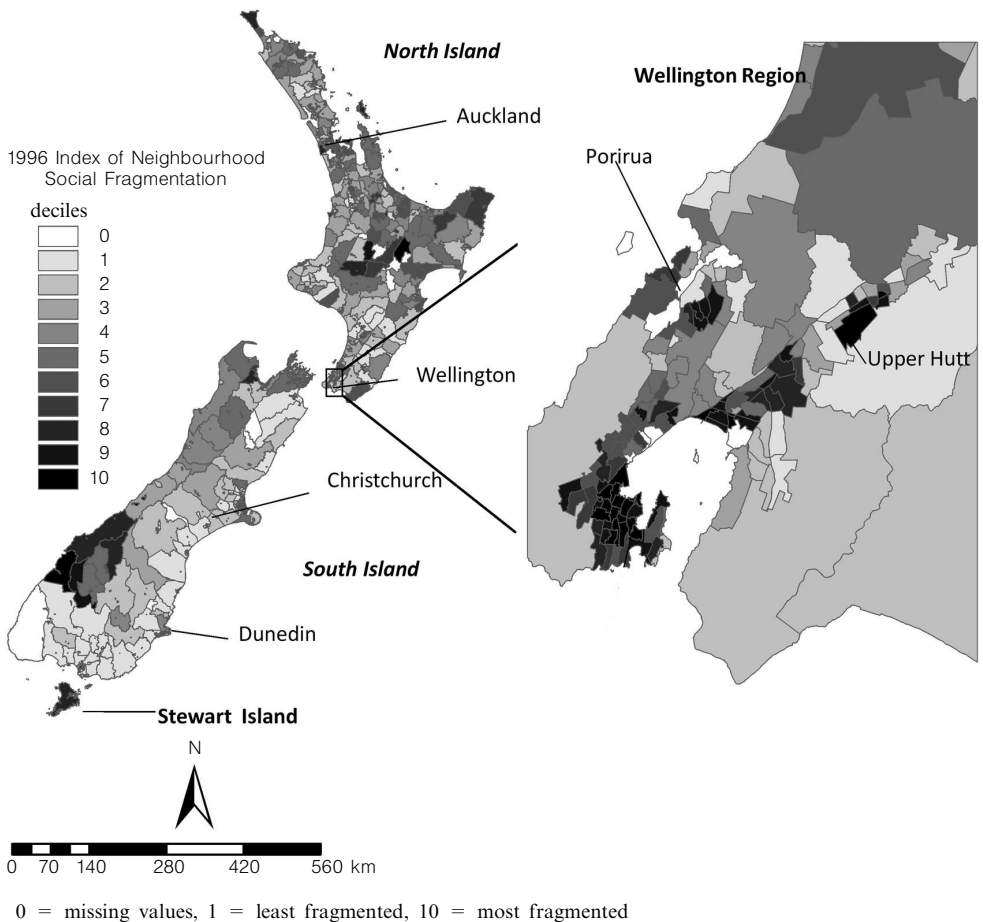

Figure 2. The 1996 geographical distribution of the Index of Neighbourhood Social Fragmentation (NeighFrag) across New Zealand and the Wellington region (actual values of NeighFrag by area unit available from authors).

Relationship between area characteristics

As expected, the 1996 Congdon(NZ) index and the NeighFrag96 index were strongly correlated, with a Spearman rank correlations coefficients of 0.86. The relationship between NeighFrag96 and other area measures was as expected: that is, NZDep96 was moderately positively correlated (0.41) and SoCInd more strongly, but negatively, so (−0.59) ($p < 0.001$ in all instances).

The census population was not evenly distributed across urban and rural areas. With regard to Neighfrag96, the percentage of the population living in rural areas in decile 10 is very small (1.2%) whereas in decile 1, the urban – rural split was almost even: 47.8% of the population living in rural areas were in neighbourhoods ranked as the least fragmented. Those living in minor urban areas such as small towns were more likely to be in neighbourhoods ranked as moderately fragmented (22.5% in decile 5, whereas there were less than 1% in either of deciles 1 or 10). Although inner urban areas were all ranked as highly fragmented (as seen in central Wellington, figure 2) there was a full range of NeighFrag values across rural areas. Generally speaking, there was a pattern of relatively lower fragmentation in areas surrounding towns and cities. Resident dwelling type was related to NeighFrag: almost one sixth of residents in decile 10 were living in nonprivate dwellings such as hostels and boarding houses (14.3%), whereas residents in the least fragmented areas were classified as living in dwellings that were their usual residence (93.9%).

Relationship between area and individual measures

Both NeighFrag01 and NZDep01 were statistically significantly associated with individual perception of neighbourhood cohesion scores, even after accounting for individual factors (table 2). Increasing fragmentation was associated with individuals reporting lower levels of neighbourhood cohesion. When both neighbourhood variables were included in the model the magnitude of the NeighFrag01 estimate increased, whereas NZDep01 decreased substantially and became nonsignificant.

Discussion

Creating useful neighbourhood measures from secondary data to capture social properties of place has long proved to be problematic, yet it is critical to moving the field forward. We used a theoretically and methodologically grounded process to develop a measure of neighbourhood social fragmentation from New Zealand census data. The resulting Index of Neighbourhood Social Fragmentation captures the compositional factors thought to fragment social connections within a neighbourhood, using a weighted index of nine variables which were selected to operationalise the construct and found to be statistically related. The index has the expected relationships with other contextual factors, indicating that it is not equivalent to deprivation and that it is inversely related to social capital measures. Further, a strong inverse relationship was found with individual perception of neighbourhood cohesion—as hypothesised.

The large census dataset enabled us to use statistical tools (PCA and FA) to rigorously refine the variables and develop a parsimonious index. Nine out of the thirteen indicators were found to be statistically related, with covariation in the area proportions of the nine variables. It does not necessarily follow that the nine variables are actually related to the social fragmentation construct—only that they have something in common (DeVellis, 2003). However, the use of the conceptual model and subsequent analyses provide some reassurance that the latent statistical and theoretical constructs are related.

Table 2. Relationship between individual perception of neighbourhood cohesion, individual-level socioeconomic variables, and area-level NeighFrag01 and NZDep01: estimates, with 95% confidence intervals shown in parentheses.

	Model 1	Model 2	Model 3	Model 4
Intercept	73.56 (72.91, 74.20)	69.53 (68.24, 70.81)	67.32 (66.02, 68.62)	69.45 (68.13, 70.78)
Age		0.07 (0.05, 0.09)	0.08 (0.06, 0.10)	0.07 (0.05, 0.09)
Male		−1.04 (−1.50, −0.57)	−0.96 (−1.43, −0.50)	−1.04 (−1.50, −0.58)
Maori		0.39 (−0.05, 0.84)	0.47 (0.01, 0.92)	0.36 (−0.10, 0.81)
Pacific people		−1.57 (−2.61, −0.52)	−1.91 (−2.97, −0.86)	−1.57 (−2.62, −0.53)
Asian		−0.92 (−1.99, 0.15)	−1.52 (−2.59, −0.45)	−0.90 (−1.97, 0.17)
Separated		−1.44 (−2.26, −0.62)	−1.52 (−2.35, −0.70)	−1.44 (−2.27, −0.62)
Single		−1.51 (−2.08, −0.94)	−1.69 (−2.26, −1.12)	−1.50 (−2.07, −0.93)
Income[a]		0.32 (0.17, 0.47)	0.27 (0.11, 0.42)	0.32 (0.17, 0.47)
Education[a]		0.11 (0.00, 0.22)	0.05 (−0.06, 0.16)	0.11 (0.01, 0.22)
Part-time		1.29 (0.53, 2.05)	1.31 (0.55, 2.07)	1.29 (0.53, 2.05)
Student		0.66 (−0.12, 1.43)	0.47 (−0.31, 1.25)	0.65 (−0.13, 142)
Unemployed		−1.26 (−2.37, −0.16)	−1.27 (−2.38, −0.16)	−1.27 (−2.38, −0.17)
Sick		−3.74 (−5.13, −2.35)	−3.80 (−5.19, −2.40)	−3.75 (−5.14, −2.36)
Retired		0.84 (−0.50, 2.17)	0.64 (−0.71, 1.98)	0.84 (−0.50, 2.18)
Parenting		0.53 (−0.28, 1.34)	0.54 (−0.27, 1.35)	0.52 (−0.29, 1.33)
NeighFrag[a]	−0.078 (−0.88, −0.68)	−0.69 (−0.79, −0.59)		−0.71 (−0.81, −0.60)
NZDep[a]			−0.27 (−0.37, −0.17)	0.03 (−0.07, 0.13)

[a] Continuous scale (lowest to highest)

To make the most of the available data we employed a deductive approach, working from Durkheim's theory of social groups to a specific conceptual model, and then to variable selection (Frohlich et al, 2007). We first established which aspects of the neighbourhood social environment were able to be measured from the available data. Neither direct measures of the social ties within a neighbourhood nor measures of integration into national-level social institutions, with the exception of marriage, were available. Consequently, we were restricted to compositional factors (which *could* be measured with census data) which may be antecedent to the collectivity of a neighbourhood. Such distinctions allow for more considered pathways between neighbourhood social properties and health-related outcomes, as well as better understanding of the limits of proxy measures.

The observed relationships between NeighFrag and other area measures suggest that a characteristic distinct from either deprivation or social capital has been captured. Importantly, from a validity aspect, the moderate relationship between the social capital indicator and NeighFrag supported our hypothesis that the index may well be capturing the antecedents to the production of social capital—in this instance, the factors which may predict the likelihood of volunteering in a neighbourhood. The association between NeighFrag and individual perception of cohesion remained robust after adjusting for individual factors and (importantly) neighbourhood deprivation. The results indicate that neighbourhood composition as measured by NeighFrag is directly associated with how residents perceive the local social environment, providing further validation that NeighFrag is capturing something about the 'collectivity' of a neighbourhood.

It is possible that the index is simply acting as a proxy for the degree of urbanicity or rurality of a neighbourhood. While this may be the case to some extent, there is variability in rural and suburban values, which suggests that rurality does not completely explain the variation captured by the index. The observed pattern of relatively lower fragmentation in areas surrounding urban centres may be due to national and regional processes which may drive mobility (for example, variations in the provision of rental housing across urban/rural areas). In both instances, we would argue that a census-based fragmentation index adds more information to understanding how populations are distributed—beyond rurality.

We have demonstrated that NeighFrag is distinct from NZDep, but they are clearly related. Future analyses will be able to examine interactions between neighbourhood properties, which are of substantive interest: for example, deprivation could modify the effect on well-being of being in a closely knit neighbourhood (Caughy et al, 2003; Fone et al, 2007). Having more 'specific' measures will allow us to describe neighbourhoods more comprehensively, as well as to observe how different neighbourhood factors are related to a given outcome (Diez Roux, 2008; Drukker and van Os, 2003).

Specific pathways between fragmentation, a lack of local social support, and mental health and well-being have been suggested (Fagg et al, 2008; Fone et al, 2007; Stafford et al, 2008b). The relationship between neighbourhood fragmentation and health is not simple, however. NeighFrag has been used in multilevel analyses with suicide and self-reported mental health: no clear association was observed with the former (Collings et al, 2009), while a strong relationship was found for women in the latter, even after adjusting for individual factors and NZDep (Ivory et al, 2011). In contrast, mixed findings have been observed for a relationship between neighbourhood fragmentation indices and mental illness measures, such as hospitalisation (Allardyce et al, 2005; Evans et al, 2004) and deliberate self-harm (Congdon, 1996; 2004; Corcoran et al, 2007; Gunnell et al, 2000).

Conceivably, neighbourhood fragmentation could be related to mental illness because of there being reduced informal social control of those who are vulnerable in highly fragmented neighbourhoods (Drukker et al, 2004). Such an association is perhaps even more likely if those with mental illness were more likely to live in highly fragmented neighbourhoods because of factors such as accessible housing and health-care services (Gleeson et al, 1998)

Our theoretical and statistical approaches have both strengths and weaknesses. The deductive process prompted us to optimise the opportunities available in the census dataset. For example, our search to find indicators for limited means of sharing norms and values led to a search for a lack of interests common across the neighbourhood, resulting in the proportion of school-age children being included as a potential variable. Yet the limits of using secondary data were clear when we attempted to operationalise all domains. It is not surprising, therefore, that there was no distinct three-factor structure which plausibly represented the conceptual model as one might have expected with a specifically designed survey. Given the considerable costs involved with primary data collection at a national level, however, a more practical balance has been reached in which theory is used to drive variable selection.

Our study has two important strengths. First, the objective neighbourhood exposures were measured separately from the subjective measures collected in the Health Behaviour Surveys. This ensured that participants' reports of their neighbourhood were separate from the way in which neighbourhoods were categorised by exposure, reducing the opportunity for correlated measurement error giving rise to spurious associations. Second, we were able to account simultaneously for individual factors *and* neighbourhood deprivation when examining the independent association of Neigh-Frag with individual perception of cohesion, as well as to observe interactions between neighbourhood factors.

What cannot be assessed with the cross-sectional data available here is the potential for selection effects. It may be, for example, that people who are less likely to perceive their neighbourhood as cohesive are more likely to seek highly fragmented neighbourhoods because they prefer the anonymity in these neighbourhoods. It is likely, however, that the observed association is a combination of the particular aggregation of NeighFrag factors and the characteristics of residents themselves which foster social distance (Hipp, 2010).

The most difficult, and subsequently least developed, domain to operationalise was 'social resources'. It may be that the a priori variables selected as proxies (income inequality, fewer at-home parents, fewer caregivers, fewer pensioners) were less successful in operationalising the underlying construct and were therefore not statistically related to the variation in the other variables when constructing NeighFrag. It could also be that there was insufficient variation in the area proportions of the variables to make a statistically significant contribution to the latent factor.

Using the New Zealand Census classifications of CAUs to define the 'neighbourhood' is both a strength and weakness. CAUs are less arbitrary than smaller units such as meshblocks, and less heterogeneous than the much larger territorial authorities. Nevertheless, they may not accurately reflect actual communities. Because rural areas are more likely to be heterogenous than aggregations in urban areas, they are also more likely to be misclassified as functioning 'communities' CAUs (Flowerdew et al, 2008). Finding more accurate ways of classifying rural areas in New Zealand deserves further examination to facilitate robust health analyses beyond the urban population. Nevertheless, CAUs are recognised as the most meaningful and valid unit available in New Zealand (Statistics New Zealand, no date), and were therefore judged the most appropriate scale.

Conclusion

The identification of ways of utilising secondary data sources to develop good neighbourhood measures remains an important research task. The index presented here provides researchers with a means of examining social aspects of the neighbourhood setting, alongside the material and physical. Clear specification of what is being measured (and what is not) provides researchers with a clearer framework with which to understand why and how neighbourhood-level social fragmentation (as captured by NeighFrag) might be an important factor in understanding health.

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