

## *NZDEP96 – WHAT DOES IT MEASURE?*

Clare Salmond<sup>1</sup>  
Senior Lecturer  
Department of Public Health  
Wellington School of Medicine

Peter Crampton  
Senior Lecturer  
Department of Public Health  
Wellington School of Medicine

### **Abstract**

NZDep96 is an index of deprivation for small areas. Originally designed for use in health research, resource allocation and advocacy, it has now become a widely used social research tool. Concern has been expressed about possible errors arising as a result of its use as a measure of deprivation for individuals.

This paper explores the errors inherent in the use of the NZDep96 area index when the unit of analysis is the individual, by analysing 1996 Census data using both correlational and multilevel modelling approaches. The small area index of deprivation is shown to be weakly correlated with an individual deprivation index. It is concluded that, in the absence of individual information and with appropriate caveats, area deprivation may be used cautiously as a proxy for individual deprivation in some analyses. It is also noted that when NZDep96 is used as a legitimate residential attribute of individuals the precise causal mechanisms of an observed association are likely to be obscure.

---

### <sup>1</sup> **Acknowledgements**

This research was funded by a grant from the Health Research Council of New Zealand. Access was granted to unrounded census data under a special contract with Statistics New Zealand. The access was granted in a strictly protected environment on Statistics New Zealand premises under supervision of Statistics New Zealand staff. The researcher was bound to preserve the confidentiality of individual respondent data by the same provisions of the Statistics Act 1975 which bind staff of Statistics New Zealand.

We thank two anonymous reviewers for their helpful comments.

### **Correspondence**

Clare Salmond, Department of Public Health, Wellington School of Medicine, PO Box 7343, Wellington South, New Zealand, phone 64-4-385-5999 ext 6045, fax 64-4-389-5319, e-mail salmond@wnmeds.ac.nz

Peter Crampton, Department of Public Health, Wellington School of Medicine, PO Box 7343, Wellington South, New Zealand, phone 64-4-385-5999 ext 6045, fax 64-4-389-5319, e-mail cramptonp@wnmeds.ac.nz

In models of smoking behaviour incorporating both area and individual deprivation as explanatory variables, the association between area deprivation and individual smoking remains strong (albeit diminished) when individual deprivation characteristics are also taken into account. It is concluded that, in the case of smoking, and most likely for many other outcomes, the area index contains both compositional individual information and strictly contextual information. It is noted that including both areal and individual information in any model may help to identify associations at the level at which causality operates.

## INTRODUCTION

NZDep96 is an index of deprivation for small areas. The index was created as a result of requests from a wide group of individuals employed in the health and social services sectors in government, university, and various social agencies, who wanted a *small area* measure of “need”.

NZDep96 was created from 1996 Census data and based on the proportions of people in the small area with each of nine characteristics related to deprivation, as described under “Methods”. The small areas were based on meshblocks, the smallest administrative area used by Statistics New Zealand. Information from neighbouring meshblocks was pooled, if necessary, so that, as far as possible, the small areas contained at least 100 people.

NZDep96, like its predecessor NZDep91, was designed originally for use in resource allocation, health research and advocacy. It has become a widely used social research tool. Concern has been expressed about the degree of error arising as a result of its use as a proxy measure of deprivation for *individuals*. This paper examines to what extent the area measure is a measure of contextual circumstances, an average indicator of individual deprivation, and/or a proxy or a legitimate indicator of individual deprivation.

The paper begins by describing the theoretical underpinning of the NZDep96 index and how it is being used. The paper then attempts to evaluate the relative extent of macro-level contextual information and micro-level individual information in the NZDep96 index by using individual data from the 1996 Census and both a correlational and a multilevel approach to analysis.

## Deprivation

Socio-economic classifications have been developed from a number of theoretical and practical perspectives. Emphases include access to means of production (Marx 1981),

possession of knowledge and skills (Edgell 1993), employment relations (Rose and O'Reilly 1997), social standing related to occupation (Davis et al. 1997, Rose and O'Reilly 1997), and access to material and social resources (Townsend 1987, 1993).

Socio-economic deprivation describes access to material and social resources and has to some extent underpinned conceptions of social class and socio-economic status. It has been defined as a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs (Townsend 1987). It is possible for an individual to be deprived in one or more respects.

### Area-Based Measures of Deprivation

Area-based classifications of socio-economic deprivation have been developed over the past three decades in order to make summary measures available in circumstances when information is otherwise hard to collect or unavailable (Carstairs 1995, Morris and Carstairs 1991, Townsend 1990). They are usually based on aggregated personal information. The NZDep96 index of deprivation for small areas was developed from 1996 New Zealand Census data (Salmond et al. 1998b) and follows the earlier development of the NZDep91 index, based on 1991 Census data (Crampton et al. 1997, Salmond et al. 1998a). The NZDep96 index was derived from a weighted sum of nine adjusted proportions in a small area and has values from 1 to 10. High values of the index reflect relatively high levels of at least some of these proportions.

### What Do Area-Based Indexes Measure?

Diez-Roux (1998) notes that whenever composite derived variables like NZDep96 are used in analyses, "they are assumed to be capturing group properties that are more than summaries of individual properties". That is, they are capturing both aggregated compositional properties of the individuals in the neighbourhood and contextual properties of the area extrinsic to individuals, such as public amenities. The contextual factors may be shaped by the properties of the group. For example, lack of amenities may be the result of lack of money to support them. Alternatively, the contextual factors themselves may shape the properties of the group – such as a lack of youth activities encouraging young people to live elsewhere.

The NZDep96 area-based measure of deprivation, then, is a variable reflecting both aggregated compositional properties of the area and probably also contextual properties of the area. When the unit of analysis is an area, there is no cross-level problem with interpretation. However, when used where individuals are the unit of analysis, there are two possible interpretations, one of which is problematic.

The first interpretation considers the area of residence as an attribute of individuals. The deprivation of the area of residence is then also an attribute of individuals and thus a micro-level variable. In this case there is no cross-level interpretive difficulty, although reductionist causal pathways may be elusive.

The second interpretation, however, notes that the area measure is created from aggregated data and regards it as a rough approximation for an individual characteristic. In this view, the areal NZDep96 measure is interpreted as a micro-level variable measured with error. This invites an ecological fallacy, that is, an error arising as a result of making inferences about individuals on the basis of aggregated data (Gilman et al. 1994, Schwartz 1994). For example, as a result of likely heterogeneity of people in an area, it cannot be assumed that every resident of a deprived area is deprived. Researchers have found that the use of small spatial areas diminishes the extent of measurement error (Crayford et al. 1995, Hyndman et al. 1995). This paper explores what happens when the small area NZDep96 index of deprivation is used as a proxy for individual deprivation information.

In health research, associations with deprivation can be theorised as operating at different levels – individual, family, neighbourhood, local authority, etc. – each having a separate causal pathway. For example, at the small area level, living in deprived neighbourhoods may adversely affect health outcomes for individuals; and at the individual level, deprived individuals may be more likely to suffer various adverse health outcomes. An increasing number of studies are examining these multiple levels of association (Anderson et al. 1997, Duncan et al. 1999, Kleinschmidt et al. 1995, Reijneveld 1998, Shouls et al. 1996, Sloggett and Joshi 1994).

However, as pointed out by Macintyre and Ellaway (2000), there is frequently a lack of clarity in published research about whether the area-based measures are being used as neighbourhood indicators, or as if they characterise the individual – either as an attribute, or as a characteristic measured with error. Although associations between deprivation and health can be investigated irrespective of this lack of theoretical clarity, nevertheless theoretical considerations are important since public health interventions should be designed to operate at the level at which causality operates.

Two recent New Zealand reports have explicitly addressed this issue of theoretical clarity. In one, the Ministry of Health (1999) noted the likely effect of using the area deprivation measure, instead of an individual measure, on the level of observed associations when the unit of analysis was the individual:

The deprivation index applies to areas, not people, and so captures contextual as well as compositional variables affecting socio-economic status. However, it is used in this report also as a proxy for individual socio-economic

status when individual level data on income, education or occupation are not available. When used in this way, the heterogeneity that exists within meshblocks means that any socio-economic gradient in the outcome of interest will probably be under-estimated. (p. 65)

Another recent report alerted the reader to the possibility of multiple causal interpretations (Salmond and Crampton 2000:61):

NZDep96 is an area-based index of deprivation. Thus the associations observed [in this chapter] relate to area-level deprivation, that is, compositional and contextual effects of material and social circumstances. Given the small size of the areas on which the index is based, and the strength and consistency of the associations demonstrated in this chapter, it is likely that causality is operating at both the area level and the individual level.

Further elucidation was impossible for the mortality and hospitalisation data being analysed in the chapter referred to above, since deprivation information was not available at an individual level in those data sets. Although analysis of smoking data was included also in the chapter, it was restricted to an area-level deprivation analysis. In this paper, however, the smoking data are analysed further as a case study for multilevel analysis and interpretation.

### How is NZDep96 Being Used?

NZDep96 is being widely used as a graphic tool for advocacy. Here, areas are the unit of analysis. When the areas are mapped in colours graded according to NZDep96 value, complex information about the deprivation characteristics of the people in an area is presented in an easily comprehensible way – see, for example, Crampton et al. (2000b), Manukau City Council (1999) and Rotorua District Council (1998).

Used as a numerical measure, the index is being investigated for use in funding formulae for groups of people (Sutton 2000). This is an entirely appropriate use of the small area measure as aggregates are the unit of analysis – any funding adjustments made on the basis of a local NZDep96 distribution will result in funding flowing either to areas or to groups of people. However, NZDep96 cannot be used to target funding to individuals, since the inherent measurement error would result in discrimination for some people. For example, a student is entitled to a Community Services Card and hence to an increased subsidy for general practitioner consultations, yet a student living in a relatively non-deprived area would be required by such a funding application to pay full general practitioner costs.

NZDep96 has been considered explicitly as a proxy measure for individual deprivation characteristics in a recent multilevel ecological analysis (Barnett 2000) based on the small size of meshblocks. Clearly, if the index is to be theorised as a proxy measure for individuals rather than as an individual attribute, the extent of measurement error is critical. Assuming good-quality information, this error depends on the heterogeneity within an area, which is likely to be greater in large geographic areas. The NZDep indexes were deliberately created for small aggregations, with a target of 100 people, to reduce heterogeneity while maintaining a reasonable degree of statistical robustness. The question is: how reliable is NZDep96 as a proxy individual-level measure?

Small area measures of socio-economic deprivation are popular in health research, both overseas – see for example (Krieger et al. 1997, Kunst and Mackenbach 1995, Liberatos et al. 1988, Lynch and Kaplan 2000, Morris and Carstairs 1991) – and in New Zealand (Crampton et al. 1997, Kokaua 1993, Reinken et al. 1985), often when detailed information is not available at the individual level but area of residence is recorded. New Zealand examples of the use of NZDep91 and NZDep96 include research into mortality (Jackson et al. 1998, Salmond and Crampton 2000), hospitalisations (Jackson et al. 1998, Salmond and Crampton 2000), asthma (Salmond et al. 1999), smoking (Crampton et al. 2000c, Salmond and Crampton 2000), immunisation levels (Salmond et al. 1998a), cot death (Mitchell et al. 2000), primary care utilisation (Barnett and Coyle 1998, Crampton et al. 2000a), and nutritional status (Russell et al. 1999). In order to use the demonstrated associations with NZDep to inform public health interventions, researchers should be clear about the extent to which these associations refer to contextual information and/or to individual information measured with acceptable error and/or to average individual information in the area.

## METHODS

This paper compares the areal and individual deprivation data from the 1996 Census. Area deprivation is generally characterised by the NZDep96 index for small areas, but also by an average individual index for the area. Individual deprivation is characterised first by the nine individual deprivation variables, and second, because dealing with nine variables is cumbersome, by an index of deprivation for individuals. Individual smoking behaviour is used as the outcome variable in models that explore the relative performance of the various measures of deprivation.

### Socio-Economic Deprivation for Small Areas

The 1996 New Zealand Census contained many questions that measured potential aspects of deprivation. Nine deprivation indicators derived from this information were: having no access to a telephone; aged 18-59 receiving a means-tested benefit; aged 18-59 unemployed; living in households with equivalised income (that is adjusted

to control for household composition) below an income threshold; having no access to a car; aged <60 living in a single-parent family; aged 18-59 without any qualifications; not living in family-owned home; living in households below equivalised bedroom-occupancy threshold.

These nine source variables were used in the construction of the area-based measure of deprivation, NZDep96, where the derived variables were age/gender-standardised proportions of people in a small area with the deprivation characteristic (Salmond et al. 1998a, 1998b). The continuous distribution of NZDep96 scores was split into deciles, with each decile representing exactly one-tenth of the small areas in New Zealand. This meant that each decile included close to one-tenth of the population.

### Socio-Economic Deprivation for Individuals

The same primary information from the census is also used at the individual level in this paper, as nine binary indicators of personal deprivation characteristics. Although some of these variables are relevant only to certain age groups, all are available for those aged 18-59. Analyses presented here are therefore restricted to this age range.

In addition, an index of deprivation for individuals was created. The index was constructed in the same way as the NZDep96 index for small areas. That is, an underlying score was formed from the first principal component of the Pearson correlation matrix, but this time for the binary deprivation indicators, scored 1 if the deprivation characteristic was present, and 0 otherwise. Although the Pearson correlation coefficient is a measure intended for use with continuous data, it can also be used, as here, with binary variables. In this situation, it has several desirable properties. In particular, it is proportional to the phi coefficient, a measure of the strength of a relationship in a 2x2 table.

Unlike the small area scores, the scores on this first principal component formed a continuous distribution that could not be split into tenths, due to the relatively large number of people without any of the nine deprivation characteristics. A further complication was the similarly high number of people with just one such characteristic, because it is likely that some of these people are not deprived in any meaningful way. For example, someone who indicated that they were unemployed may have been a highly paid worker recently made redundant through organisational restructuring whose likelihood of future well-paid employment is high.

Therefore, given the special nature of the groups with zero or one deprivation characteristic, an eight-point ordinal scale was defined to have value 0 for the score indicating individuals with no deprivation characteristic; value 1 for the next set of scores up to, but not including, the minimum score of anyone with two or more

deprivation characteristics; and values 2 to 7 for the sixths of the remaining distribution. A separate eight-point index was created for each gender in two age groups of similar size (18-39 and 40-59 years).

Combined into an index for people 18-59 years, the eight-point index thus describes the socio-economic deprivation of individuals relative to others of the same gender at a broadly similar stage in their lifecycle. Overall, 32.8%, 28.9%, 7.0%, 6.2%, 6.2%, 6.2%, 6.4%, and 6.5% of individuals are in the categories 0 to 7 respectively. These proportions vary slightly across the four age/gender groups, with the biggest differences being in the first group where 29.0% of women aged 18-39 years have no deprivation characteristic, compared to 37.4% of men aged 40-59 years.

### Smoking

In the 1996 Census everyone aged 15 years and older was asked: "Do you smoke cigarettes regularly (that is, one or more per day)? Count only tobacco cigarettes. Don't count pipes, cigars, or cigarillos." Anyone answering "yes" to this question was classified as a regular smoker. Smoking status was established for 92.1% of the 2.8 million eligible respondents.

### Statistical Analysis

All analyses in this paper are based on the 1.52 million individuals aged 18-59 years who provided complete information for the deprivation and smoking variables (73% of the usually resident population of that age on census night).

The prevalence odds (and rates) of smoking were modelled by generalised linear models (McCullagh and Nelder 1983) using INSIGHT in SAS (SAS Institute Inc. 1993). These models were used to investigate both the effect of explanatory variables and the level(s) at which causality might be operating (the individual or the area). We modelled these levels by including a random (error) term to describe variation among individuals, and a set of dummy terms to compare the ten areal deprivation categories, which are thus fixed effects in the statistical model. This approach is not to be confused with statistical multilevel modelling which is concerned with sampling variation among units at *each* level and therefore would model the areal effects as a single random term (analogously to the individual error term) rather than as a set of fixed effects.

For technical reasons, only the prevalence odds of smoking could be modelled whenever the nine binary deprivation variables were included as explanatory variables. Prevalence odds were estimated by a model with a logit link and binomial error structure (logistic regression). The more easily interpreted prevalence rates of



smoking were modelled when the nine deprivation variables were not included and comparisons were not required with models in which they were. In this case, the generalised models had a log link instead of a logit link (log-binomial regression). Dummy variables were used for the categories of the indexes to avoid any assumption of linear effects. Three further dummy variables representing the four age/gender groups (males and females aged 18-39 and 40-59 years) were included in all models to control for confounding. No intercept term was fitted to avoid multi-collinearity caused by multiple reference groups, although such collinearity caused a maximum change of only 0.02 in the estimated odds ratios. Nested models are compared through their deviance statistics giving rise to change in deviance, a measure of the variation accounted for by a term (McCullagh and Nelder 1983).

## RESULTS

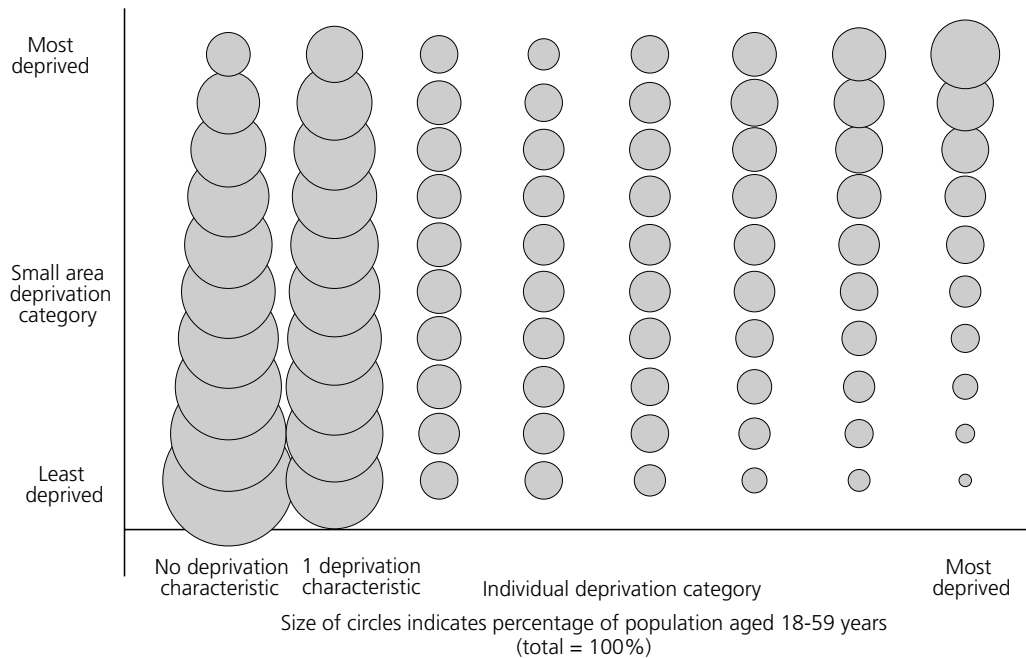
The two ordinal indexes of deprivation are used to easily compare area-level deprivation with individual-level deprivation. Given that three-fifths of the population have little or no deprivation as described by the nine deprivation variables, it is clear that they cannot all live in places characterised as being in the one or two least-deprived deciles of area deprivation. It is not surprising, therefore, that the Spearman rank correlation between the eight-point individual index of deprivation and the deciles of area deprivation (NZDep96) is only 0.34 ( $n=1.52H10^6$ ). The relationship is illustrated in Figure 1 where the considerable individual variation within the ten broad categories of NZDep96 is clear. The top row of circles illustrates that, even within the most-deprived 10% of small areas, one in ten individuals (10.8%) have none of the measured personal characteristics of deprivation. At the other extreme, the bottom row shows that one in 12 individuals (8.3%) in the least-deprived 10% of small areas are classified personally among those in the top four multiply-deprived groups.

It is clear, therefore, that NZDep96 is not a particularly good proxy at an individual level for a simple ordinal individual measure of deprivation, which of course it was not designed to be. Since there is, at least, some correlation, it is natural to assume that, if only area of residence is available from which to infer likely social circumstances, the small area index can be used provided results are interpreted very cautiously. The 1996 Census data afford an opportunity to illustrate the difficulties of interpretation by investigating the relative contributions of individual-level and/or area-level deprivation information to explaining the variations in smoking patterns at that time.

One-quarter of this study population of 1.52 million people were classified as regular smokers (25.6%), decreasing from 28.9% in those aged 18-39 years to 21.9% in those aged 40-59 years. All the deprivation characteristics considered here have a statistically significant association with smoking in this very large data set (model 1, Table 1). The single best predictor of increased odds of smoking is a lack of any formal school or

other qualification: after controlling for the other deprivation characteristics, individuals without qualifications had approximately twice the odds of smoking as those with qualifications. The atypical and apparently “protective” effect of low household income may be an indication of a deterrent effect of cigarette price.

**Figure 1 Individual and Small Area Deprivation (1996 Census Data)**



The small area index explains 48.6% of the variation in smoking explained by the individual characteristics after age and sex are taken into account (models 1 and 2: ratio of the change in deviance statistics is 44,639.2/91,809.3). The association between area deprivation and individual smoking remains strong (albeit diminished) when individual deprivation characteristics are taken into account (models 2 and 3). In the most-deprived NZDep96 decile, individuals have an odds of smoking more than four times greater than those in the least-deprived decile (model 2), and this is still more than two times greater after allowing for personal deprivation circumstances (model 3). Similar NZDep96 odds ratios were obtained when substituting the eight-point individual index for the nine individual variables (model 4). The diminished but still strong areal odds ratios in models 3 and 4, compared to model 2, suggest the existence of information in the NZDep96 index that is not contained in the individual deprivation circumstances. Thus both personal deprivation circumstances and contextual effects of the neighbourhood in which the individual lives contribute to explanations of variations in smoking prevalence.

**Table 1 Odds Ratios\* of Smoking by Individual and Small-Area Socio-Economic Deprivation, for All Individuals Aged 18-59 years, 1996 Census Data**

Deprivation Variable	model 1	model 2	model 3	model 4	model 5	model 6
On means-tested benefit	1.40		1.32			1.25
Low household income	0.91		0.86			0.82
In single-parent family	1.61		1.56			1.48
No access to car	1.22		1.13			1.11
No access to phone	1.77		1.61			1.62
Not in owned home	1.59		1.50			1.44
Unemployed	1.48		1.40			1.33
No qualifications	2.20		2.05			2.08
High household occupancy	1.05		(1.01)			(1.00)
Area index (NZDep96) =						
2		1.27	1.19	1.19		
3		1.47	1.31	1.33		
4		1.65	1.42	1.45		
5		1.85	1.54	1.57		
6		2.08	1.66	1.71		
7		2.40	1.83	1.90		
8		2.68	1.93	2.02		
9		3.15	2.08	2.21		
(most deprived) 10		4.09	2.23	2.49		
Individual index =						
1				1.42	1.51	1.05
2				1.82	2.06	1.18
3				2.01	2.23	1.30
4				1.83	2.11	1.25
5				2.08	2.52	1.27
6				2.58	3.25	1.42
(most deprived) 7				3.64	4.96	1.51

\* Estimated from logistic regression models (logit link and binomial errors) without an intercept, which also include three dummy terms for four age/gender groups. The reference group for the individual deprivation index is those with no deprivation characteristic (individual index = 0), and that for the small area index is the least-deprived decile (NZDep96 = 1). All coefficients are significant at  $p = 0.0001$  except the two in brackets for which  $p > 0.05$ .

A converse way to look at the effect of the combination of personal and areal measures of deprivation on smoking is to focus on the individual characteristics and see what happens when an areal component is added to the model. Model 5 includes the individual index but no areal component and shows a strong gradient of increased odds of smoking at the higher end of the individual index. When the area index is included in the model (model 4) this gradient diminishes but is still strong. The most-deprived individuals, for example, have an almost five-fold increased odds of smoking (over those with none of the measured deprivation characteristics) when their own

characteristics are taken into account, which reduces when the area index is also included but is still 3.6 times the odds. A reduction in each of the odds ratios associated with the nine individual characteristics is also seen by comparing models 1 and 3.

The individual index explains 69.7% of the variation in smoking explained by the individual characteristics after taking age and sex into account (models 1 and 5: ratio of the change in deviance statistics is 64,003.2/91,809.3). Multiple deprivation as measured by the individual index adds some explanatory power on top of that provided by the individual characteristics since both the index and the characteristics are significant in model 6. An individual in the most-deprived group had a 50% greater odds of smoking than individuals with no deprivation characteristics, even after allowing for the individual effects of the deprivation characteristics. This may indicate that multiply deprived individuals experience pressures that affect their risk of smoking on top of the risks associated with their individual deprivation characteristics.

To investigate whether average individual deprivation in an area characterises the area adequately, individual index values were averaged for each small area and a log-binomial model of smoking was fitted with the individual as the unit of analysis. This was compared to a log-binomial model with the NZDep96 area value as the explanatory variable and again with the individual as the unit of analysis. The change in deviance attributable to the average individual index, after taking age and sex into account, is 80% of the change in deviance attributable to the NZDep96 small area index (49,283.5/61,004.3; models not shown). At a small-area unit of analysis, therefore, the NZDep96 index explains more of the variation in smoking than the average of the individual index scores, suggesting that the NZDep96 small area index characterises an area rather better than an average of the individual index, at least when related to smoking.

## DISCUSSION

This paper has used the same primary source data from the 1996 Census to describe both small area socio-economic deprivation and the deprivation of individuals. This means that comparisons between the two are not affected by differential quantity, or quality, of information. Furthermore, errors arising from sampling are not an issue in this census-based study, although there is a possibility for bias arising from incomplete data.

The proportion of missing smoking data is not large. Nevertheless, it is possible that the lack of smoking data is correlated with socio-economic variables. If so, any associations between deprivation, however measured, and smoking may be underestimated.

The area index has been explored in the way in which it is most often used, as a ten-point scale. The models presented in this paper are all linear in the explanatory terms. It is possible that more complex models could improve the fit of the data – for example, by involving interaction terms among the nine deprivation characteristics – which would then become much harder to interpret. However, this paper is more concerned with exploring the relative merits of area and individual measures of deprivation than with deriving a “best” model of their association with smoking behaviour.

NZDep96 was designed to be a small area measure, with the small areas intended to be as homogeneous as possible, while still large enough for statistical calculations to be free from the large fluctuations in proportions to be expected from small denominators. The underlying assumption is that people with similar characteristics cluster in small neighbourhoods. This is not to assert, necessarily, that all unemployed people, say, live near each other. Rather, the assumption is that people who are multiply deprived will tend to live in geographical clusters, though the form of the deprivation will vary somewhat from person to person. The fact that there is some correlation (0.34) between the area and individual indexes of deprivation is consistent with this assumption.

#### NZDep96 as a Proxy for Individual Deprivation

One aim of this paper is to explore the consequences of using NZDep96 as a proxy indicator of individual deprivation, as may have been done in some of the examples cited in the introduction when individual outcomes, such as mortality, are analysed for their association with the small area measure of deprivation. Using two indexes of deprivation – small area and individual – based on the same source data, there is an observed correlation in the census data of 0.34, which is not very large. However, both the small area and the individual indexes are designed to be indicators of underlying constructs called deprivation. The real concern should be how correlated the latent deprivation variables are. Unfortunately this correlation cannot be measured.

However, the relationships found between the *small area* measure and *individual* outcomes, such as mortality, hospitalisations, immunisation, and so on, reported in the articles cited in the introduction, are consistent and strong. It is unlikely that such consistency would hold if the area index was measuring only contextual effects, for then similar contextual factors would apparently be affecting a wide cross-section of health outcomes in much the same way. The corollary, that the index is therefore also measuring individual effects, implies that both indexes are measuring the same latent individual deprivation variable, at least in part, and both with a misclassification error. If these errors are not systematic, this leads to the conclusion that there is likely to be a greater correlation between the latent deprivation variables than is exhibited by their observable indicators in the census data (0.34). This does not imply that the correlation is necessarily strong, but it does indicate that, if no other information is available, then

use of the index as a proxy individual measure may lead to plausible hypotheses for further exploration.

There is one circumstance, however, where NZDep96 can be used as a legitimate measure of individual circumstances. This occurs when we consider the area indicator to be a residential level, analogous to educational level or occupational status. In this usage NZDep96 is a legitimate attribute of an individual. Like education or occupation, though, the precise causal mechanisms through which NZDep96 affects an outcome is likely to require further work to elaborate.

### Contextual and Individual Information in NZDep96

Another aim of this paper is to explore the relative proportions of contextual and individual information incorporated into the NZDep96 index. Smoking has been used as a case study since it is well known to be strongly patterned on social circumstances and is available in the Census. For this analysis the nine individual measures of deprivation can be employed, for greater conceptual clarity, as well as the composite individual index, which estimates the latent deprivation variable.

In Table 1, models 2-4 show that the changes in the odds ratios of smoking among the ten areal deprivation classifications when individual deprivation (as nine variables or the index) is added to the model indicate that some of the information in the area index, but not all, is also contained in the individual variables (or index). Conversely, models 4 and 5 (or 1 and 3) show that the changes in the odds of smoking among the eight individual deprivation categories (or nine variables) when the area index is added to the model also indicate some common information among the areal and individual information, but not complete overlap.

Thus these analyses may indicate that the information contained in the NZDep96 index is greater than the sum of the information contained in its constituent variables; that is, that while the area index contains compositional individual information it also indicates some strictly contextual information. Another possibility, if contextual information is deemed unlikely, is that NZDep96 may be correlated with unmeasured individual-level deprivation, in which case its use as a proxy for individual-level deprivation is strengthened. A further possibility, of course, is that NZDep96 is correlated with some variable associated with smoking that is not related to deprivation, either individual or contextual.

The contextual and compositional information could well be inter-linked. Given a group of people with certain characteristics, whether deprivation or something else, it is reasonable to assume that outside influences also have an impact on the area in which they live and in such a way that the neighbourhood develops a character. This

is likely to have a feedback mechanism. For example, services are less likely to be provided if people cannot afford to use them, property values are thus likely to be relatively low, and so people are attracted to the area who have little money to spend on locally provided services like corner dairies, bank outlets, and so on. Although the provision of services is likely to be at a suburb level, some clustering of similar small neighbourhoods may occur within suburbs.

The use of an index in preference to the individual variables in any model will be issue driven. For example, here, although the individual index is probably easier to interpret than the collective influence of the nine individual variables, as an aid to deciding specific characteristics to target attempts to reduce smoking prevalence, the individual variables may be more important – though it is difficult to perceive a causal pathway between, for example, no access to a telephone and smoking that does not involve the concept of deprivation.

Relative deprivation is a concept that encompasses both social factors (such as lack of qualifications) and material factors (such as lack of car or telephone access) that arise from socio-economic circumstances. Socio-economically disadvantaged people may “choose” which material factor(s) to do without, for example, by choosing not to own a car in order to live in better housing conditions, or the converse. Thus the fact that lack of telephone access is strongly related to smoking variation (model 1) does not necessarily imply that increasing telephone access will decrease smoking. General deprivation as measured by an index – areal or individual – may therefore explain some health inequalities better than the component factors. This is particularly likely in studies where diminished sample size may suggest otherwise important factors to be chance effects.

The deprivation characteristics used in these analyses are limited to those available from census data. For the small area measure NZDep96 this has the clear advantage of providing a national measure. Using the same source characteristics to create the individual measure allows direct comparisons between contextual and individual information. However this individual measure of socio-economic deprivation can probably be improved by including other aspects of socio-economic deprivation not available in the census. For example, in the context of an analysis of smoking, a broader measure of individual socio-economic deprivation may show a stronger relationship with smoking. A community survey is being undertaken in 2001 which will gather information to explore more detailed indexes, and to explore the relevance of certain information to different ethnic groups. Mindful of the negative (but accurate) nature of the term “individual deprivation index”, we will use “non-occupational classification” as the descriptor in this survey work. This descriptor has the added advantage of indicating the all-inclusive nature of the index.

## CONCLUSIONS

In summary, relative deprivation has a strong relationship with smoking prevalence, however measured, which is of course not unexpected. The models presented here indicate that both area of residence and individual characteristics may help to determine smoking choices, a conclusion drawn also by Duncan et al. (1999) in Britain, using more extensive models. The causal mechanisms are no doubt complex, but it is not hard to imagine that an individual's predilection for smoking may be altered by the local neighbourhood attitudes to smoking, and that both may result from deprivation (Crampton et al. 2000c). Furthermore, when used on its own in this analysis of smoking, the area-based index NZDep96 appears to encapsulate both micro-level information about individual deprivation and macro-level information about contextual deprivation. While this might suggest that it is plausible to use NZDep96 as a proxy for individual deprivation in the absence of further information in analyses of smoking, two things should be remembered – first, that the individual and areal deprivation indexes are only weakly correlated and, second, that the level at which causality might operate is then indeterminate.

In a commentary on the measurement of socio-economic position, Ben-Shlomo and Davey Smith (1999) noted that “many studies show that both individual and area-based measures seem to have independent effects on health outcomes, possibly as a result of the contextual effects of residing in poor neighbourhoods”. There is no reason to believe, then, that use of the small area NZDep96 index as a proxy for an individual characteristic, but measured with error, would not be useful, though certainly not ideal, in analyses of outcomes other than the case study of smoking presented here. However, it is possible that more accurate and complete measurement of individual deprivation would diminish the relative effect of areal deprivation.

Indisputably, however, if deprivation of area of residence is considered an attribute of individuals, as a residential “level” analogous to educational level, then the NZDep96 value for the small area in which an individual lives can be attached to an individual without ecological error in any analysis or model in which the individual is the unit of analysis. Causal interpretations, however, may be difficult and there is no doubt that care should always be taken when interpreting associations with any areal measure like NZDep96. In addition, data collections should be expanded if possible to allow multilevel analyses that could help to elucidate levels of causality and so potentially improve the effectiveness of public health interventions.

## REFERENCES

Anderson, R., P. Sorlie, E. Backlund, N. Johnson and G. Kaplan (1997) “Mortality effects of community socioeconomic status” *Epidemiology*, 8:42-47.



- Barnett, J.R. (2000) "Does place of residence matter? Contextual effects and smoking in Christchurch" *New Zealand Medical Journal*, 113:433-435.
- Barnett, R. and P. Coyle (1998) "Social inequality and general practitioner utilisation: assessing the effects of financial barriers on the use of care by low income groups" *New Zealand Medical Journal*, 111:66-70.
- Ben-Schlomo, Y. and G. Davey Smith (1999) "Commentary: Socioeconomic position should be measured accurately" *British Medical Journal*, 318:844-845.
- Carstairs, V. (1995) "Deprivation indices: their interpretation and use in relation to health" *Journal of Epidemiology and Community Health*, 49 (supplement 2):S3-S8.
- Crampton, P., T. Dowell, A. Woodward and C. Salmond (2000a) "Utilisation rates in capitated primary care centres serving low income populations" *New Zealand Medical Journal*, 113:436-438.
- Crampton, P., C. Salmond, R. Kirkpatrick, R. Scarborough and C. Skelly (2000b) *Degrees of Deprivation in New Zealand: An Atlas of Socioeconomic Difference*, Bateman, Wellington.
- Crampton, P., C. Salmond and F. Sutton (1997) "NZDep91: a new index of deprivation" *Social Policy Journal of New Zealand*, 9:186-193.
- Crampton, P., C. Salmond, A. Woodward and P. Reid (2000c) "Socioeconomic deprivation and ethnicity are both important for anti-tobacco health promotion" *Journal of Health Education and Behaviour*, 27:317-327.
- Crayford, T., J. Shanks, M. Bajekal and S. Langford (1995) "Analysis from inner London of deprivation payments based on enumeration districts rather than wards" *British Medical Journal*, 311:787-788.
- Davis, P., K. McLeod, M. Ransom and P. Ongley (1997) *The New Zealand Socioeconomic Index of Occupational Status (NZSEI) Research Report #2*, Statistics New Zealand, Wellington.
- Diez-Roux, A. (1998) "Bringing context back into epidemiology: variables and fallacies in multi-level analysis" *American Journal of Public Health*, 88:216-222.
- Duncan, C., K. Jones and G. Moon (1999) "Smoking and deprivation: are there neighbourhood effects?" *Social Science and Medicine*, 48:497-505.
- Edgell, S. (1993) *Class*, Routledge, London.
- Gilman, E., L. Somerville and R. Griffiths (1994) "Deprivation and resource allocation in the West Midlands Regional Health Authority" in E. Gilman, E. Munday, L. Somerville and R. Strachan (eds.) *Resource Allocation and Health Needs: From Research to Policy*, University of Birmingham, Birmingham.
- Hyndman, J., C. Holman, R. Hockey, R. Donovan, B. Corti and J. Rivera (1995) "Misclassification of social disadvantage based on geographical areas: comparison of postcode and collector's district analyses" *International Journal of Epidemiology*, 24:165-176.
- Jackson, G., L. Kelsall, A. Parr and D. Papa (1998) *Socio-Economic Inequalities in Health Care*, North Health, a Division of the Health Funding Authority, Auckland.

- Kleinschmidt, I., M. Hills and P. Elliott (1995) "Smoking behaviour can be predicted by neighbourhood deprivation measures" *Journal of Epidemiology and Community Health*, 49 (Supplement 2):S72-S77.
- Kokaua, J. (1993) *Computation and Validation of Midland Health's Index of Relative Disadvantage*, unpublished paper, Midland Health, Hamilton.
- Krieger, N., D. Williams and N. Moss (1997) "Measuring social class in US public health research: concepts, methodologies, and guidelines" *Annual Review of Public Health*, 18:341-378.
- Kunst, A. and J. Mackenbach (1995) *Measuring Socioeconomic Inequalities in Health*, World Health Organisation Regional Office for Europe, Copenhagen.
- Liberatos, P., B. Link and J. Kelsey (1988) "The measurement of social class in epidemiology" *Epidemiologic Reviews*, 10:87-121.
- Lynch, J. and G. Kaplan (2000) "Socioeconomic position" in L. Berkman and I. Kawachi (eds.) *Social Epidemiology*, Oxford University Press, Oxford.
- Macintyre, S. and A. Ellaway (2000) "Ecological approaches: rediscovering the role of the physical and social environment" in L. Berkman and I. Kawachi (eds.) *Social Epidemiology*, Oxford University Press, Oxford.
- Manukau City Council (1999) *The Changing Face of Manukau, A Report on the Social, Economic and Environmental Conditions in Manukau City*, Manukau City Council, Manukau.
- Marx, K. (1981) *Capital*, Penguin, London.
- McCullagh, P. and J.A. Nelder (1983) *Generalized Linear Models* (second edition), Chapman and Hall, London.
- Ministry of Health (1999) *Our Health, Our Future: The Health of New Zealanders 1999*, Ministry of Health, Wellington.
- Mitchell, E.A., A.W. Stewart, P. Crampton and C. Salmond (2000) "Deprivation and sudden infant death syndrome" *Social Science and Medicine*, 51:147-150.
- Morris, R. and V. Carstairs (1991) "Which deprivation? A comparison of selected deprivation indices" *Journal of Public Health Medicine*, 13:318-326.
- Reijneveld, S. (1998) "The impact of individual and area characteristics on urban socioeconomic differences in health and smoking" *International Journal of Epidemiology*, 27:33-40.
- Reinken, J., J. McLeod, and T. Murphy (1985) *Health and Equity*, Department of Health, Wellington.
- Rose, D. and K. O'Reilly (1997) *Constructing Classes: Towards a New Social Classification for the UK*, ESRC/ONS, Swindon.
- Rotorua District Council Community Policy and Resources Division (1998) *Key Indicators of Low Socioeconomic Status in the Rotorua District 1986-1996*, Rotorua District Council, Rotorua.
- Russell, D.G., W.R. Parnell, N.C. Wilson, J. Faed, E. Ferguson and P. Herbison (1999) *NZ Food, NZ People: Key Results of the 1997 National Nutrition Survey*, Ministry of Health, Wellington.

- Salmond, C. and P. Crampton (2000) "Deprivation and health" in P. Howden-Chapman and M. Tobias (eds.) *Social Inequalities in Health: New Zealand 1999*, Ministry of Health, Wellington.
- Salmond, C., P. Crampton, S. Hales, S. Lewis and N. Pearce (1999) "Asthma prevalence and deprivation: a small area analysis" *Journal of Epidemiology and Community Health*, 53(8):476-480.
- Salmond, C., P. Crampton and F. Sutton (1998a) "NZDep91: a New Zealand index of deprivation" *Australian and New Zealand Journal of Public Health*, 22(7):95-97.
- Salmond, C., P. Crampton and F. Sutton (1998b) *Research Report No. 8: NZDep96 index of deprivation*, Health Services Research Centre, Wellington.
- SAS Institute Inc. (1993) "SAS/INSIGHT" (sixth edition), SAS Institute Inc., Cary, North Carolina.
- Schwartz, S. (1994) "The fallacy of the ecological fallacy: the potential misuse of a concept and the consequences" *American Journal of Public Health*, 84:819-824.
- Shouls, S., P. Congdon and S. Curtis (1996) "Modelling inequality in reported long term illness in the UK: combining individual and area characteristics" *Journal of Epidemiology and Community Health*, 50:366-376.
- Sloggett, A. and H. Joshi (1994) "Higher mortality in deprived areas: community or personal disadvantage" *British Medical Journal*, 309:1470-1474.
- Sutton, F. (2000) *Population-based funding for primary care: method and results; a report prepared for the Health Funding Authority*, Health Funding Authority, Wellington.
- Townsend, P. (1987) "Deprivation" *Journal of Social Policy*, 16:125-146.
- Townsend, P. (1990) *Deprivation and ill-health: new scientific evidence and the implications for policy*, Institute for Health Policy Studies, Southampton.
- Townsend, P. (1993) *The International Analysis of Poverty*, Harvester Wheatsheaf, New York.