

NZDep2018 Index of Deprivation

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Acknowledgements

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While the contents of this report have benefited considerably from the assistance of colleagues, the responsibility for this report remains solely with the authors.

Ethics and confidentiality

Ethical approval for the original NZDep91 project was obtained in May 1995 from the Central Regional Health Authority Wellington Ethics Committee.

Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics New Zealand.

Executive Summary

NZDep2018 is an updated version of the NZDep91, NZDep96, NZDep2001, NZDep2006 and NZDep2013 indexes of socioeconomic deprivation.

NZDep2018 combines nine variables from the 2018 census which reflect eight dimensions of deprivation. NZDep2018 provides a deprivation score for each Statistical Area 1, and its constituent meshblocks, in New Zealand.

Meshblocks are the smallest geographical units defined by Statistics New Zealand. They are the building blocks for their new small geographical areas, called Statistical Area 1 [SA1], which generally contain between 100 and 200 people. These new areas, and sometimes combinations of them, were used as the basis from which NZDep2018 was calculated.

The NZDep2018 index of deprivation has two forms—an ordinal scale and a continuous score.

- The NZDep2018 index of deprivation ordinal scale ranges from 1 to 10, where 1 represents the areas with the least deprived scores and 10 the areas with the most deprived scores.
- The NZDep2018 index of deprivation interval variable is the first principal component score, which has been scaled to have mean 1000 index points and standard deviation 100 index points. The NZDep2018 10-point scale is derived from this interval variable.

The NZDep2018 scale of deprivation from 1 to 10 divides New Zealand into tenths of the distribution of the first principal component scores. For example, a value of 10 indicates that the meshblock or SA1 is in the most deprived 10 percent of our small areas in New Zealand, according to the NZDep2018 scores.

It should be noted that NZDep2018 deprivation scores apply to areas rather than individual people.

NZDep2018 combines the following census data (calculated as proportions for each small area):

Dimension of deprivation	Description of variable (in order of decreasing weight in the index)
Communication	People with no access to the Internet at home
Income	People aged 18-64 receiving a means tested benefit
Income	People living in equivalised* households with income below an income threshold
Employment	People aged 18-64 unemployed
Qualifications	People aged 18-64 without any qualifications
Owned home	People not living in own home
Support	People aged <65 living in a single parent family
Living space	People living in equivalised* households below a bedroom occupancy threshold
Living condition	People living in dwellings that are always damp and/or always have mould greater than A4 size

*Equivalisation: methods used to control for household composition.

Why is this an interim report?

In order to preserve the confidentiality of individuals' information, Statistics New Zealand have always random rounded all their published numbers to base 3 [RR3]. This was done independently for every number in every table produced. This independence meant that numbers didn't always round to the same values when produced by different users.

Statistics New Zealand's new confidentiality rules remove this anomaly. The new random rounding scheme is still to base 3 but is also fixed in such a way that values in all tables are rounded consistently across different tables, no matter who produces them [FRR3]. The implementation of FRR3 is complex and not yet available to researchers using the confidential data lab environment, such as the authors of NZDep2018.

This report explains the development of NZDep2018, and notes the small changes in the construction of NZDep2018 from previous versions—the new need to investigate various forms of mitigation for missing information in the form of alternative sources of data; a change in the way we define small areas; and the introduction of a new variable and the deletion of an old one. It also shows that NZDep2018 performs as expected (based on the previous indexes of deprivation) as a good measure of small area relative deprivation.

In order to provide evidence of the effects of the development changes, we need to provide the occasional percentages for national distributions of people, and some graphics involving large groups of people. To achieve this, we have currently used the old RR3 rounding, and then added a second level of rounding to preserve the confidentiality of the eventual FRR3 results. We did this by rounding each already rounded RR3 number to the nearest 10 before either calculating percentages (which are reported to 1 decimal place only) or drawing graphics (from which no accurate numbers can be identified). Finally, in order to give an indication of the number of people living in sparsely-populated small areas for which there is no published NZDep2018 value, the relatively small total number of people has been reported as 'fewer than 1,000'.

This report will be updated with FRR3 numbers, percentages and graphics when the FRR3 process becomes available to researchers. They will make no substantial difference to the report.

Introduction

This report describes the development of NZDep2018. The methods used in the creation of NZDep2018 are based on very similar methods used in the creation of NZDep91, NZDep96, NZDep2001, NZDep2006 and NZDep2013. These are described in detail in *Research Report No.5 NZDep91 Index of Deprivation* (Crampton et al., 1997), *Research Report No.8: NZDep96 Index of Deprivation* (Salmond et al., 1998), *NZDep2001 Index of Deprivation* (Salmond & Crampton, 2002), *NZDep2006 Index of Deprivation* (Salmond et al., 2007) and *NZDep2013 Index of deprivation* (Atkinson et al., 2014).

Small changes have been made to some details in the creation of NZDep2018. First, the way of defining our small areas as been adjusted to benefit from Statistics New Zealand's newest small geographical areas. Second, two variables in the index have had minor adjustments, one removing a previous age restriction (Internet access), and the other resulting from changed income categories in the Census form (low income). In addition, a new deprivation variable (damp/mould) has replaced a previously relatively low-performing one (no access to a car). Descriptions and explanations of these changes are given in the methods section. NZDep2018 was created in the Statistics New Zealand external data laboratory at University of Otago, Wellington.

An overview of the theory and conceptualisation of socioeconomic deprivation can be found in the following two sources:

Salmond C, King P, Crampton P and Waldegrave C (2006). NZiDep: A New Zealand index of socioeconomic deprivation for individuals. *Social Science & Medicine*, 62, 1474-1485.

White P, Gunston J, Salmond C, Atkinson J, Crampton P (2008). *Atlas of Socioeconomic Deprivation in New Zealand: NZDep2006*. Wellington, Ministry of Health.

Further information regarding NZDep and its various uses may be obtained in the following methodological papers, research reports, application papers and atlases.

NZDep methodological papers

Crampton P, Salmond C and Sutton F (1997). NZDep91: a new index of deprivation. *Social Policy Journal of New Zealand*, 9, 186-193.

Crampton P, Salmond C and Sutton F (1997). *The NZDep91 index of deprivation*. In Crampton P and Howden-Chapman, P. (eds.), *Socioeconomic Inequalities and Health - Proceedings of the Socioeconomic Inequalities and Health Conference, Wellington, December 9-10, 1996*, Wellington, Institute of Policy Studies, Victoria University of Wellington.

Salmond C, Crampton P and Sutton F (1998). NZDep91: a new index of deprivation. *Australian and New Zealand Journal of Public Health*, 22, 95-97.

Crampton P and Davis P (1998). Measuring deprivation and socioeconomic status: why and how. *The New Zealand Public Health Report*, 5, 81-84.

Salmond C and Crampton P (2001). NZDep96 - What does it measure? *Social Policy Journal of New Zealand*, 17, 82-100.

Salmond C and Crampton P (2002). Heterogeneity of deprivation within very small areas. *Journal of Epidemiology and Community Health*, 56, 669-670.

Salmond C E, Crampton P (2012). Development of New Zealand's Deprivation Index (NZDep) and Its Uptake as a National Policy Tool. *Can J Public Health*, 103(Suppl. 2), S7-S11.

Salmond C, Crampton P (2012). Measuring socioeconomic position in New Zealand. *J Prim Health Care*, 4(4), 271-280.

Crampton P, Salmond C and Atkinson J (2019). A comparison of the NZDep and New Zealand IMD indexes of socioeconomic deprivation. *Kōtuitui: New Zealand Journal of Social Sciences Online*.

<https://www.tandfonline.com/doi/full/10.1080/1177083X.2019.1676798>

NZDep research reports

Crampton P, Salmond C and Sutton, F (1997). *Research Report No. 5: NZDep91 Index of Deprivation*. Wellington, Health Services Research Centre.

Salmond C, Crampton P and Sutton, F (1998). *Research Report No. 8, NZDep96 Index of Deprivation*. Wellington, Health Services Research Centre.

Salmond C and Crampton P (2002). *NZDep2001 Index of Deprivation*. Wellington, Department of Public Health, Wellington School of Medicine and Health Sciences, www.moh.govt.nz and www.otago.ac.nz.

Salmond C, Crampton P (2007). *NZDep2006 Index of Deprivation*. Wellington, Department of Public Health, University of Otago, Wellington, www.moh.govt.nz and www.otago.ac.nz.

Atkinson J, Salmond C and Crampton P (2014). *NZDep2013 Index of Deprivation*. Wellington, Department of Public Health, University of Otago, Wellington, www.moh.govt.nz and www.otago.ac.nz.

Research papers illustrating applications of NZDep

Over the past twenty-five years NZDep has been used in many academic papers, book chapters, social reports and advocacy documents -- far too numerous to be itemised here. Following are a few recent examples which illustrate some of the varied research uses of NZDep.

McKenzie F, Ellison-Loschmann L and Jeffreys M (2010). Investigating reasons for socioeconomic inequalities in breast cancer survival in New Zealand. *Cancer Epidemiology*, 34(6), 702-8.

Wall R, Bell A, and Theobald J (2011). Pertussis (whooping cough) epidemiology in Waikato, New Zealand: 2000-2009. *New Zealand Medical Journal*, 124(1332), 52-61.

- Mehta, S., Wells, S., Riddell, T., Kerr, A., Pylypchuk, R., Marshall, R., Ameratunga S, Chan W C, Thornley S, Crengle S, Harrison J, Drury P, Elley CR, Bell F and Jackson R** (2011). Under-utilisation of preventive medication in patients with cardiovascular disease is greatest in younger age groups (PREDICT-CVD 15). *Journal of Primary Health Care*, 3(2), 93-101.
- Moodie P, Jaine R, Arnold J, Bignall M, Metcalfe S and Arroll B** (2011). Usage and equity of access to isotretinoin in New Zealand by deprivation and ethnicity. *New Zealand Medical Journal*, 124(1346), 34-43.
- Ellis C, Pryce A, Macleod, G and Gamble, G** (2012). The most deprived Auckland City Hospital patients (2005-2009) are 10 years younger and have a 50% increased mortality following discharge from a cardiac or vascular admission when compared to the least deprived patients. *New Zealand Medical Journal*, 125(1357), 15-35.
- Wilson D, Harding SA, Melton I, Lever, NA, Stiles M K, Boddington D, Heald S and Larsen PD** (2012). Geographic, ethnic and socioeconomic factors influencing access to implantable cardioverter defibrillators (ICDs) in New Zealand. *Heart, Lung & Circulation*, 21(9), 576-81.
- Khieu TQT, Pierse N, Telfar-Barnard LF, Zhang J, Huang QS, Baker MG** (2017). Modelled seasonal influenza mortality shows marked differences in risk by age, sex, ethnicity and socioeconomic position in New Zealand. *Journal of Infection*, 75(3):225-233.
- de Boer S, Lewis C, Fergusson W, Ellyett K, Wilsher M** (2018). Ethnicity, socioeconomic status and the severity and course of non-cystic fibrosis bronchiectasis. *Internal Medicine Journal*. 48(7):845-850.
- Murray C, Roke C** (2018). Who can afford a Mirena® for contraception? *Journal of Primary Health Care*, 10(3):201-206.

Atlases

- Crampton P, Salmond C, Kirkpatrick R, Scarborough R and Skelly C** (2000). *Degrees of Deprivation in New Zealand: An atlas of socioeconomic difference*. Auckland, David Bateman Ltd.

Crampton P, Salmond C and Kirkpatrick R (2004). *Degrees of Deprivation in New Zealand: An atlas of socioeconomic difference. 2nd Edition.*

Auckland, David Bateman Ltd.

White P, Gunston J, Salmond C, Atkinson J, Crampton P (2008). *Atlas of Socioeconomic Deprivation in New Zealand NZDep2006.* Wellington,

Ministry of Health.

INTERIM

Aim

The aim of the NZDep research programme is to develop small area indexes of socioeconomic deprivation for New Zealand.

Purpose of indexes

NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013 and NZDep2018 have been developed with three principal purposes in mind: resource allocation, research, and advocacy.

1. Indexes of deprivation have application in funding formulas. For example, indexes of deprivation have a long history of being used in capitation funding formulas for primary health care services, the population-based funding formula for District Health Boards, and in funding formulas for social services in other sectors.
2. Indexes of deprivation have application in research in a variety of settings such as health and other social services. For example, in the health sector, many researchers use small area indexes to describe the relationship between socioeconomic deprivation and health outcomes; increasing levels of deprivation are associated with higher mortality rates, and higher rates of many diseases.
3. Indexes of deprivation are used by community groups and community-based service providers to describe the populations they serve, and to advocate for extra resources for community-based services.

Cautions

A number of potential problems arise in using measures of socioeconomic position. The following are of particular importance for NZDep.

The indicator becomes the reality

The problem of confusing the indicator with the underlying phenomenon is discussed by Carr-Hill and Chalmers-Dixon (2002):

A common problem is to confuse the index with the phenomenon it purports to measure and, as a result, forget that *an index is only a proxy or partial measure*. (Emphasis added)

This common problem is referred to as reification. It is crucial that users of any measure of socioeconomic position recognise this problem and scrutinise both the theoretical basis for, and the construction of, the specific index. Carr-Hill and Chalmers-Dixon (2002) give the following UK-based example:

The tendency is not unknown with measures of deprivation where it is more common to use phrases such as the ten most deprived local authorities, rather than "the authorities with the top ten scores on the DETR2000 index".

Users of NZDep indexes should refer to 'areas that have the most deprived NZDep scores' rather than 'the most deprived areas'.

Area versus individual measures

Please note that NZDep is a small-area measure of deprivation. Caution must be used if the index is applied to individuals. This issue is discussed in greater detail in *NZDep - What does it measure?* (Salmond & Crampton, 2001), in

Heterogeneity of deprivation within very small areas (Salmond & Crampton, 2002a), and in *NZiDep: A New Zealand index of socioeconomic deprivation for individuals* (Salmond et al., 2006).

Relative versus absolute deprivation

A view is sometimes expressed in reference to NZDep that 'it is disgraceful that still 10% of areas are most deprived'. Please note that 10% of areas will *always* fall into the most deprived decile of NZDep scores—NZDep is designed to measure *relative* socioeconomic deprivation, not *absolute* socioeconomic deprivation.

Apparent simplicity

The NZDep scales (from 1 to 10) have been constructed so that they can be readily used in a variety of contexts. They are easily presented graphically. This simplicity should not be allowed to obscure the underlying complexity of construction, the limitation to components available from the Census, and the underlying theoretical assumptions. This is discussed in the *Atlas of Socioeconomic Deprivation in New Zealand: NZDep2006* (White et al., 2008), in *Development of New Zealand's Deprivation Index (NZDep) and Its Uptake as a National Policy Tool* (Salmond & Crampton, 2012), and in *A comparison of the NZDep and New Zealand IMD indexes of socioeconomic deprivation* (Crampton et al., 2019).

Longitudinal comparisons

Difficulties arise in making comparisons between different NZDep indexes (NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013 and NZDep2018). These difficulties are discussed in detail in Appendix five.

Constructing the index

Overview

Creation of a small area index of deprivation requires:

1. A source of data.
2. A definition for the small area.
3. Choice of, and definitions for, the variables included in the index.
4. A method for using the variables to create the index.
5. Internal and external validation of the index.

Data sources

NZDep2018 was created from data from the 2018 Census of Population and Dwellings. The variables included in NZDep2018 are all age and sex standardised proportions of people in a small area with an attribute.

Information was maximised by obtaining files from two sources:

- 1) All individual census forms of persons usually resident in New Zealand, whose Statistics New Zealand geographic variable 'Statistical Area 1' for their usual residence can be ascribed, whether present in their usual residence on census night or not (4.70 million).
- 2) Dwelling forms from private dwellings, which yielded 4.16 million records, one for each person usually resident in a private dwelling.

More details concerning the source populations are given in Appendix one.

Defining small areas

The NZDep small areas used to create the base index of deprivation are unique to this deprivation project (NZDep2018 small areas).

In previous versions of NZDep we used Statistics New Zealand's meshblocks as the building blocks for our small areas, with the aim of creating small areas having at least 100 persons usually resident, where possible. The meshblocks were combined within Statistics New Zealand's internal primary sampling unit boundaries.

In the 2018 data we have used a new Statistics New Zealand geography, Statistical Area 1 [SA1], as our starting point for creating our small areas, since these SA1s are already clusters of one or more meshblocks that together generally contain 100 – 200 usual residents, generally with a maximum of 500. There are 29,889 defined SA1 geographies, which in turn build into 2,253 Statistical Area 2 [SA2] geographies, the latter replacing the old Area Units. Of the 29,889 SA1s, 228 had zero usual residents so they were not included in the development of NZDep2018, leaving 29,661 SA1s as the building blocks for our small areas.

The 2018 census data contains more mitigation than in previous censuses due to the unexpectedly high levels of missing data. We based our agglomeration process on the unmitigated number of residents usually living in each SA1 so that we would maximise the chance of having enough people in our small areas no matter what level of mitigation we explored. For maximum robustness, we used the residents living in private dwellings for the agglomeration since a number of NZDep variables are restricted to people in private dwellings.

In order to combine smaller SA1s within SA2s we used SA1 boundary information (supplied by John McCarthy, Ministry of Health) to locate coterminous SA1s within an SA2. Agglomeration was done by combining a too-small SA1 with the smallest of its coterminous SA1s, repeating if necessary until a population of 100 or more was obtained. We allowed for agglomerating into

whole SA2s if necessary. Agglomeration beyond SA2 boundaries was not desirable.

Choice of variables for inclusion in NZDep2018

The effect of mitigation

There were more missing respondents in the 2018 census than in previous censuses. Statistics New Zealand embarked on an extensive programme to improve the census data through various types of mitigation and imputation. At the variable level, some variables have always had imputation (age, sex) in order to provide Government with adequate population estimates, but many other variables also had mitigation in 2018 from alternative sources – 2013 census data (Historic); administrative data from the Integrated Data Infrastructure (Administration); probabilistic determination; or using the Canadian Census Editing and Imputing System (CANCEIS), which was configured by Statistics New Zealand for use with the 2018 New Zealand census data.

Most NZDep variables could have various levels of mitigation, which we grouped into three levels: No alternative sources; Historic or Administrative alternative sources; Probabilistic or CANCEIS imputation. We created and compared three versions of NZDep using:

1. No alternative sources for all variables ('None')
2. No alternative sources plus Administrative and Historic data for all variables where there were alternative sources ('Administrative/Historic')
3. No alternative sources plus all alternative or imputed sources for all variables where there were alternative or imputed sources ('Full')

More people are included in the NZDep calculations as more forms of alternative sources are accepted. Versions of NZDep2018 were explored and compared for each of the three levels of alternative sources above. The final version used the administrative/ historical level of alternative sources.

Variables in NZDep2018

The NZDep2018 index of deprivation reflects eight dimensions of material and social deprivation. These dimensions reflect lacks of income, employment, communication, support, qualifications, owned home, living space and dry living conditions. A list of the variables used in NZDep2018 is given in Table 1.

Table 1: Variables included in NZDep2018

Variable (proportions in small areas) in order of decreasing weight in the index
People with no access to the Internet at home
People aged 18 - 64 receiving a means tested benefit
People living in equivalised* households with income below an income threshold
People aged 18 - 64 unemployed
People aged 18 - 64 without any qualifications
People not living in own home
People aged < 65 living in a single parent family
People living in equivalised* households below a bedroom occupancy threshold
People living in dwellings that are always damp and/or always have mould greater than A4 size

*Equivalisation: methods used to control for household composition.

Possible new candidate variables available in the 2018 census

The 2018 Census was examined in detail for possible new candidate variables for NZDep2018. To be considered for inclusion in the index, variables needed to be consistent with the theoretical approach adopted for NZDep (see *Research Report No. 5* (Crampton et al., 1997b)). Potential variables explored were severe damp or mould in the home (questions 14 and 15 in the Dwelling Form) and lack of basic amenities (question 16 in the Dwelling Form). Only a variable describing severe damp and/or severe mould proved useful. It is theoretically a deprivation issue, as defined by Townsend (1987), since it involves the physical environment which was part of his description of material deprivation; and it is closely related, statistically, to the known deprivation characteristics used in the previous NZDep indexes.

Damp/mould

The presence of ‘severe’ damp and/or mould (that is, the dwelling is always damp and/or it always has mould greater than an A4 sheet of paper) is strongly correlated with the other variables in the index, with correlations varying from 0.40 (no qualifications) to 0.56 (crowding). (The smallest correlation among all the variables is 0.37 and the largest is 0.72.) The unit of analysis is a small area, that is $N = 25,928$ because eleven (very small) small areas had at least one variable where the information for everyone was missing. A factor analysis of the variables in the index does not isolate the damp/mould variable in any way; and the weight for this variable on the first principal component, 0.301, while the lowest, is only marginally less than that for unemployment (0.304). The weights vary from 0.301 to 0.384.

Thus the presence of severe damp or mould in the dwelling has theoretical validity, face validity and statistical validity as a deprivation characteristic in 2018. This new variable (last row in Table 1) replaces the previously used ‘access to a car’ variable, which no longer performs as a strong deprivation characteristic.

Unchanged variables

A short description of each of the five unchanged variables in NZDep2018 – unemployment, single parent family, no qualifications, bedroom occupancy, and dwellings not owner occupied – have been extracted from *NZDep2013 Index of Deprivation* (Atkinson et al., 2014) and placed in Appendix two.

Slightly modified variables

Three variables included in previous versions of NZDep – Internet access, household income and means tested benefits – have been very slightly modified as described below.

Internet access

In 2013, the Internet access variable was restricted to those under 65. In 2018, the age restriction has been removed (after testing) since the Internet has become increasingly necessary for everyday activities like trading, banking, interacting with government departments, and so on.

Household income

Income equivalence scales are “measures of the relative incomes needed by different types of families to attain the same material standard of living” (Whiteford, 1983). Equivalised household income was used for calculating the income variable so that, for example, the standard of living of a household consisting of a single person with an income of \$40,000 could be compared to that, say, of a household consisting of two adults and two children aged 9 and 11, also on an income of \$40,000.

The setting of the household equivalised income *threshold* was based on two principles:

1. The proportion of the population identified as being socioeconomically deprived by the threshold should be broadly consistent with the other variables in the index (i.e., the threshold should be neither too inclusive nor too restrictive).
2. The threshold should be broadly consistent with other measures of income poverty.

The poverty-line work of Stephens and Waldegrave (2001) was used as a guide for setting the NZDep2001, NZDep2006 and NZDep2013 household equivalised income thresholds as close as possible to 15% of people [*NZDep2001 Index of Deprivation* (Salmond & Crampton, 2002b), *NZDep2006 Index of Deprivation* (Salmond et al., 2007), *NZDep2013 Index of Deprivation* (Atkinson et al., 2014)]. This threshold is maintained for NZDep2018, although we updated our Jensen equivalisation formula to that used by Statistics New Zealand (2017). This latest

version of Jensen equivalisation uses the actual ages of any children as well as how many there are in the household. The cut-off equivalised income – which reweights a household income to a two-adult household – is \$34,023, so that people living in a household with an equivalised household income below this threshold are considered to be income-deprived (amounting to 15.00% of people whose household income could be established).

Means tested benefit status

This variable is obtained for those people aged 18 to 64. The means-tested benefits we included in 2013 were the sickness benefit, the domestic purposes benefit (DPB), and the invalid's benefit. Means-tested benefits are different in 2018. There are now just three relevant benefits (among the sources of income listed in Question 30 on the Individual Form): supported living payment, sole parent support, and job-seeker support (Ministry of Social Development, 2019a and 2019 b). These were part of

- *Supported living payments* consists of the old invalid's benefit and the old DPB for care of the sick and infirm. We needed to include both of these.
- *Sole parent support* consists of the old DPB for sole parents with children aged up to 13 years; and the old widow's benefit for clients with no children, or children aged up to 13 years. We needed to include both of these.
- *Job seeker support* consists of the old 'unemployment benefit related'; 'unemployment benefit training'; 'sickness benefit related'; and 'DPB – sole parent / woman alone / widow's benefit – for clients with children 14 years and over'. The first two are unsuitable for NZDep because they would correlate highly with the unemployment variable and, if included, would double count people in the index development. Exploration showed that the *vast majority* of those on the job seeker support are also labelled unemployed in the NZDep unemployment variable. Therefore, for NZDep means-tested benefits purposes, we created an adjusted job seeker support

payment variable by removing those who were labelled unemployed from the recipients.

The means-tested variable was positive if anyone received one or more of the adjusted job-seeker support payment, sole parent support payment, and supported living payment.

Creating the index

Principal components analysis was used, as previously, to create the index. Principal components analysis is a multivariate method that identifies linear combinations of variables that progressively account for the overall variation in the data. The first principal component accounts for the most variation, the second accounts for as much of the remaining variation as possible, and so on. Further information is contained in *Research Report No. 5* (Crampton et al., 1997b).

NZDep2018 is the first principal component of nine variables. Each variable is a proportion of persons in a small area. The index was created, as before, using standardised proportions, where each small area proportion was standardised in eight age/sex groups (0-17, 18-39, 40-64, 65 and over, for each sex) to the New Zealand population structure. Proportions were calculated both standardised and unstandardised as a way of checking the effect of standardisation. A description of the standardisation process used in creating NZDep2018 is given in Appendix three.

Technical difficulties, encountered occasionally when an NZDep2018 small area had no one in certain age/sex groups, were overcome, as before, by *defining* such proportions to be zero. The explanation given in *Research Report No. 5* is repeated in Appendix four (*Structural zeros*). Other technical difficulties involving 'not specified' codes were treated as before and are also described in Appendix four (*Not specified*).

We compared versions of the index using each of the three levels of alternative sources (see: *The effect of mitigation*, page 21) to choose the version to be produced as NZDep2018 (see: *NZDep2018 scores*, page 30).

Validation

Validation for the earlier indexes is discussed in *Research Reports No. 5* and *No. 8* (Crampton et al., 1997b; Salmond et al., 1998c) as well as in the web-based research reports for the 2001, 2006 and 2013 indexes (Salmond & Crampton, 2002b; Salmond et al., 2007; Atkinson et al., 2014).

As in 1996, 2006 and 2013 we were able to validate the NZDep2018 index against individual smoking data contained in the 2018 census.

Results

Defining small areas

The final small areas were either SA1s or, if necessary, agglomerated SA1s that were coterminous within SA2 boundaries. In preparation for constructing the index, we also agglomerated those building-block small areas that had insufficient denominators to calculate reasonably robust proportions. That is, for those small areas where there was more than one proportion based on fewer than 20 persons, the small area was agglomerated further, where possible. Where this was not possible, the NZDep2018 value is considered unreliable and has been withheld.

The distribution of the number of SA1s incorporated in each NZDep2018 small area is shown in Table 2.

Table 2: Number of Statistical Area 1s per NZDep2018 small area

Number of Statistical Area 1s in NZDep2018 small area	Percentage of NZDep2018 small areas	Total number of Statistical Area 1s accounted for
1	87.0	22,557
2	12.2	6,342
3	0.5	378
4	0.2	240
5 to 8	0.1	144
Total	100.0 (N = 25,939)	29,661

The population distribution in the NZDep2018 small areas is shown in Table 3.

Table 3: Distribution of the population in NZDep2018 small areas

Usually resident population	Overall		In private dwellings	
	Number of NZDep2018 small areas*	Percent	Number of NZDep2018 small areas*	Percent
0 - 29	30	0.1	42	0.2
30 - 59	18	0.1	16	0.1
60 - 69	0	0.0	5	0.0
70 - 79	2	0.0	2	0.0
80 - 89	1	0.0	3	0.0
90 - 99	4	0.0	3	0.0
100 - 149	7,595	29.3	11,690	45.1
150 - 199	10,495	40.5	10,193	39.3
200 - 299	7,198	27.7	3,775	14.6
300 - 399	443	1.7	147	0.6
> 399	153	0.6	63	0.2
total	25,939	100.0	25,939	100.0

* The target size for NZDep2018 small areas was a minimum of 100 persons usually resident in private dwellings, where possible. Percentages above are based on populations randomly rounded to base 3, and then to the nearest 10. A small number of people usually resident are not accounted for in NZDep2018 because they live in small off-shore islands, inlets, etc.

In total, 41 small areas do not have a published NZDep2018 value. For 30 of these small areas, the value was withheld (involving 50 component SA1s consisting of 224 meshblocks). In the remaining 11 small areas, at least one of the component variables in the index had no information (involving 12 SA1s consisting of 59 meshblocks). The 62 SA1s without an NZDep2018 value are:

7000413 7000915 7001121 7001123 7001125 7001153 7001172 7001760 7002089 7002128
 7004264 7004841 7008338 7008445 7008338 7008387 7009019 7009896 7010595 7010596
 7010599 7013476 7013537 7015376 7015399 7015401 7016792 7017949 7018882 7019132
 7019190 7022480 7022484 7022485 7022489 7022490 7022495 7022626 7022709 7023111
 7023112 7023235 7023237 7023238 7025531 7025539 7025540 7025541 7025693 7026622
 7026657 7026765 7028087 7029117 7029118 7029119 7029120 7029121 7029122 7029123
 7029871 7999901

Almost half of these 62 SA1s (29) were inlets, islands or oceanic areas. In total, there were fewer than 1,000 people usually resident in the 62 SA1s.

Note that there are a further 228 SA1s that had zero usual residents so they could not have an NZDep2018 value (see page 20). Therefore, of the 29,889 SA1s, there are 29,599 with an NZDep2018 value and 290 SA1s without a value.

NZDep2018 scores

We used principal components analysis to create the index from the nine variables listed in Table 1.

We compared versions of the index using each of the three levels of mitigation (see: *The effect of mitigation*, page 21). The chosen version included information for an individual obtained from administrative and historical sources when that information for the individual was lacking from the 2018 census records (pink column, Table 4).

Table 4: Weights for the first principal components of the NZDep2018 variables for three levels of mitigation

Variable (Full descriptions are given in Table 1)	Mitigation level		
	None	Administrative / Historical	Full
No Internet	0.357	0.356	0.356
Means tested benefit	0.373	0.384	0.384
Low equivalised income	0.361	0.360	0.360
Not own home	0.312	0.315	0.314
Sole parent family	0.328	0.328	0.329
Unemployed	0.308	0.304	0.304
No qualifications	0.338	0.329	0.330
Crowded (bedroom occupancy)	0.312	0.314	0.312
Damp/mould	0.303	0.301	0.300

The blue cells highlight appreciable differences (≥ 0.005) between the weights for *No mitigation* and those for *Administrative/Historical mitigation*. There is little difference between the *Administrative/Historical* and *Full* versions, which is to be expected since there were a much smaller number of extra mitigations in the *Full* version than there were in the *Administrative/Historical* version. Our reason for not using the remaining mitigations (probabilistic and CANCEIS) is that they add information through probability matching, or by ‘borrowing’ information that

is available for neighbours. These two processes do not provide an individual's actual data to add to the information for the small area; they provide a best guess.

Additionally, the variance explained by the first principal component is greatest for the *Administrative/Historical* version (Table 5). In each case, the eigenvalue for the second principal component, being less than 1, indicates that it explains less variation than an average single variable would, illustrating the utility of the first principal component scores for our index of deprivation for small areas.

Table 5: Principal component summaries for three levels of mitigation using the variables included in the eventual NZDep2018

	Mitigation level					
	None		Administrative / Historical (source for NZDep2018)		Full	
Principal component	1	2	1	2	1	2
Eigenvalues	5.140	0.866	5.207	0.873	5.203	0.874
Variance explained (%)	57.1		57.9		57.8	

The first principal component for the Administrative/Historical level of mitigation used for NZDep2018 explained 57.9% of the overall variance, which is better than the NZDep2006 figure of 55.4%, but less than the NZDep2013 figure of 60.7%. The first principal component yields the NZDep2018 score.

The weights for each of the nine variables in the first principal component, which is the basis of NZDep2018, are shown in the last column of Table 6. The equivalent weights for 2006 and 2013 are also shown in the table, which is ordered by decreasing weights for 2018.

Table 6: Weights on the first principal components for 2006, 2013 and 2018

Proportion of people (with a lack of something)	2006	2013	2018
People aged 18-64 receiving a means tested benefit	0.371	0.364	0.384
People living in households with equivalised income below an income threshold (same threshold definitions)	0.356	0.332	0.360
People with no access to the Internet at home (aged < 65 in 2013; all ages in 2018)	-	0.372	0.356
People aged 18-64 without any qualifications	0.326	0.332	0.329
People aged < 65 living in a single parent family	0.333	0.317	0.328
People not living in own home	0.334	0.322	0.315
People living in households below an equivalised bedroom occupancy threshold (same threshold)	0.318	0.303	0.314
People aged 18-64 unemployed	0.332	0.338	0.304
People living in homes with severe damp and/or mould	-	-	0.301
People with no access to any phone at home	0.314	-	-
People with no access to a car	0.311	0.286	-
Proportion of variance explained	55.4%	60.7%	57.9%

* Equivalisation: methods used to control for household composition.

Comparison of NZDep2018 scores with those for NZDep2006 and NZDep2013

Table 6 shows that the changes in weights between 2006 and 2018 are relatively small, showing how consistent the selected variables are in describing the underlying concept of deprivation.

The observed small changes in weights in Table 6 are similar to those seen between comparable indexes in 2001 and 2006, where the maximum change was 0.022 (Salmond et al., 2007). The largest change in weights, between 2013 and 2018, is for people aged 18 to 64 who were unemployed (a decrease of 0.034 in 2018).

One likely partial cause of the small changes in weights is the exclusion of one of the previous variables (access to cars) and the inclusion of a new one (damp/mould) in 2018. Another partial cause, of course, is likely to be changing social circumstances. For example, the reduced loading for 'lack of access to the Internet at home' in 2018 may be, at least partly, a consequence the ever-increasing availability of such access.

Part of the small differences observed may also be a result of differing levels of missing information, affecting the 2018 data in particular (see page 21).

The NZDep2018 Index of deprivation

An NZDep2018 scale of deprivation has been produced from the distribution of the NZDep2018 scores. This scale from 1 to 10 divides New Zealand into tenths of the distribution of the first principal component scores, where, for example, a value of 10 indicates that the area is in the most deprived 10 percent of NZDep2018 small areas in New Zealand.

Figure 1 shows the relationship between the NZDep2018 scores and the NZDep2018 scale from 1 to 10. The skewed distribution illustrates clearly that NZDep2018 reflects a continuum from 'least deprivation' to 'most deprivation', rather than from 'affluence' to 'deprivation'. This was intended, as all the variables in NZDep2018 reflect a lack of something.

Note that the decile cut-points of the NZDep2018 scale are not equally spaced, so that, for example, the difference between deciles 2 and 5 is not huge, unlike the difference between deciles 7 and 10. Other scales can be created from the NZDep2018 scores. For example, fortieths have been used to explore national five-year mortality rates, and quintiles have been used to explore National Health Survey data. The choice of division for the scale should be made bearing in mind the skewed nature of the distribution of the underlying NZDep2018 scores. Divisions based on unequal sub-sample sizes should be used with caution, as the precision of any resulting statistics will vary by division category.

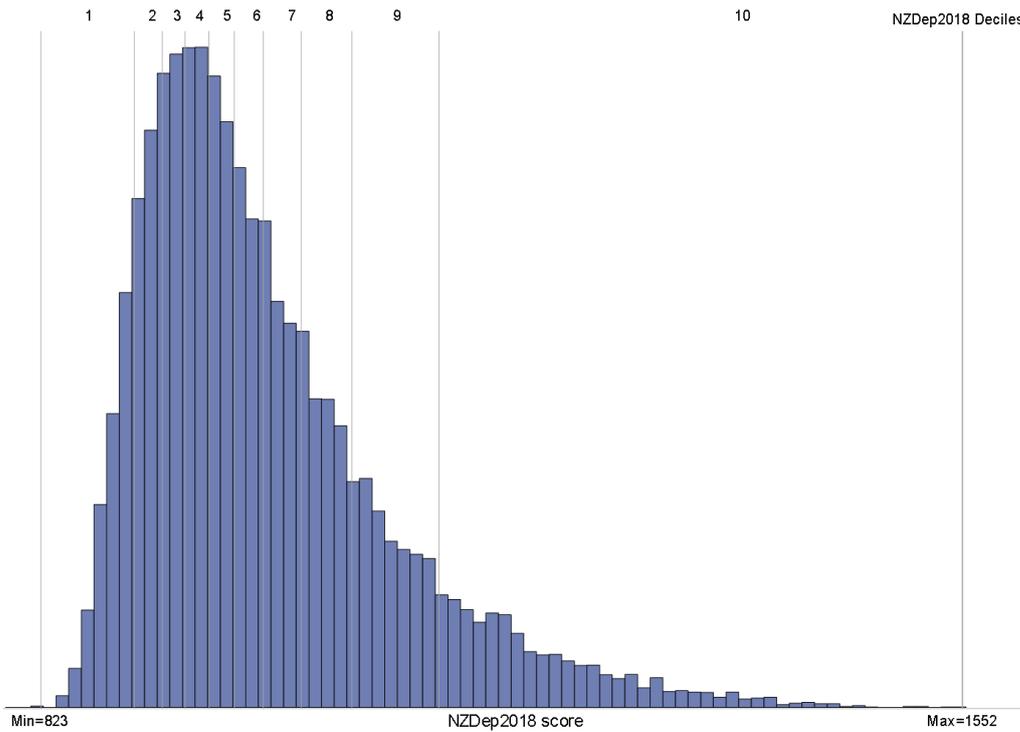


Figure 1: Distribution of NZDep2018 scores, with the NZDep2018 decile scale superimposed

Variation within communities

There is frequently a considerable amount of variation between neighbourhoods or small areas within any given larger geographical area. For example, if a Territorial Authority boundary is used for creating an NZDep profile there may be pockets of relatively deprived areas and relatively non-deprived areas within the territorial authority. This point is illustrated in Figure 2 (next page), which starts with the total New Zealand usually resident population and then focuses on successively smaller areas.

Figure 2 shows the New Zealand profile at the top of the figure. The numbers are not exactly equal across the categories because the index is created from a distribution based on small areas, not people.

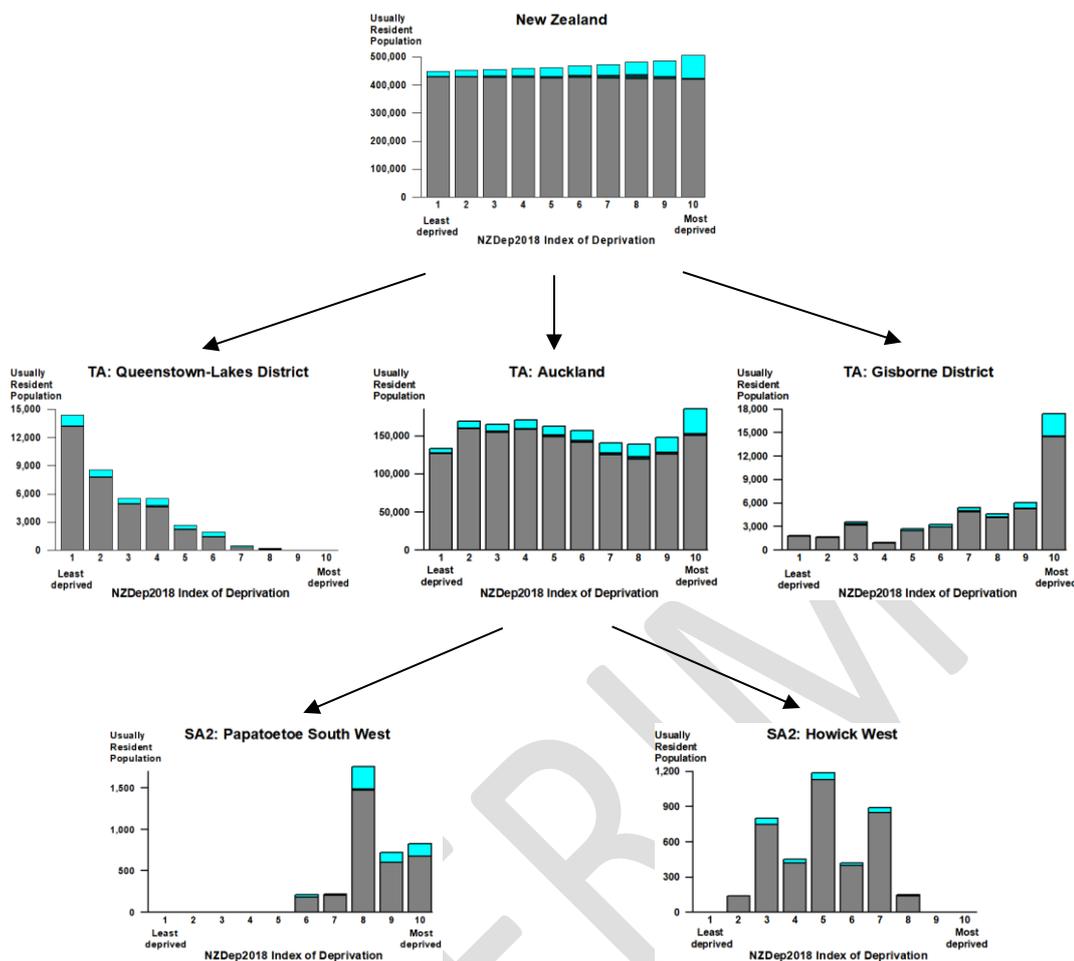


Figure 2: Variation in NZDep2018 profiles

There are three stacked bars in each of these histograms. The grey stack represents people in private dwellings. Those in non-private dwellings are in the middle black stack, which is not easily seen at the size of these histograms. Those in the blue stack are either people providing an Individual Form but with an inadequate address, or people who did not provide an Individual Form.

Statistics New Zealand have identified those people who either did not provide an individual census form or, having provided one, gave insufficient address information for the dwelling of their usual residence to be ascertained, either from a household form or from Administrative and Historical data, though they may have been able to ascertain the SA1 of usual residence. Thus, since the NZDep2018 index has a value for almost every SA1 in the country, almost everyone usually resident in New Zealand is included in the top histogram in Figure 2.

When three Territorial Authorities (TA) are compared in Figure 2, marked differences in their NZDep2018 profiles are observed. Again, when two smaller geographical areas – Statistical Area 2s (SA2) – in Auckland are compared, there are clear differences in their NZDep2018 profiles.

The bottom two stacks in each of the above histograms show those people who completed census forms, whose address was identifiable, and who were living in either private dwellings (grey) or in non-private dwellings (black). The top stacks (blue) in each histogram indicate a census non-response of some form.

Statistics New Zealand have documented an unexpectedly high number of the usually-resident population from whom they did not obtain either a complete, or a partial, census form (Statistics New Zealand, 2018). Approximately 4 percent of all people in the census dataset were counted from partial census form responses, where information was received via the dwelling form or household summary form but an individual form for the person was not received. Their dwelling type (private/non-private) was therefore identifiable. Post-census, the mitigation processes used by Statistics New Zealand have filled in some of the other information on these forms and we have been able to use some of their Administratively-mitigated or Historically-mitigated information in the calculation of NZDep2018. That is, some mitigated information from people in the blue stacks is included in the NZDep2018 index (income sources, qualifications).

Some of the non-responders will have chosen not to respond. Other non-responders would not have been followed up adequately after census night. It is clear from the top histogram in Figure 2 that non-responders are represented unequally across the deprivation deciles. Clearly, they were likely to live in the more deprived small areas in New Zealand, as measured by NZDep2018.

Standardisation

Standardisation of the input variables made a small but appreciable difference to the overall performance of the index. An illustration of the difference was

provided for NZDep96 in *Research Report No. 8* (Salmond et al., 1998c). Further details about the standardisation procedure are contained in Appendix three.

Validation

The objective of validation is to confirm the usefulness of the indices. Validation asks the question: do the indices accurately measure what they purport to measure, levels of socioeconomic deprivation in small areas? Validation of the index, in the absence of a gold standard, has consisted of checking for construct validity and criterion validity.

Construct validity seeks agreement between a theoretical concept, socioeconomic deprivation in this instance, and the measuring device. We explored construct validity at the time of the development of NZDep91 with investigations of technical aspects of the index and exploration of scores in sentinel areas (Crampton et al., 1997b).

Criterion validity checks how well the measure predicts other variables known to be associated with the underlying construct, socioeconomic deprivation. The first two NZDep indexes (NZDep91 and NZDep96) were validated against a number of health outcome and health behaviour variables (Crampton et al., 1997b; Salmond et al., 1998c). In the 2006 and 2013 censuses there was a further opportunity to validate the NZDep index of deprivation by using the smoking information provided by adults aged 15 years and over. This is again possible from the smoking data contained in the 2018 Census.

There is good evidence in the literature that smoking patterns are strongly correlated with socioeconomic position (Wilson et al., 2006). Therefore, if NZDep2018 is a good indicator of area socioeconomic deprivation, we would expect the proportions of regular smokers to increase across the deprivation deciles from least-deprived to most-deprived.

The percentage of regular smokers was calculated using only those individuals who provided information on their census forms. The strong relationship between smoking and the NZDep2018 index of deprivation is shown in Figure 3. The

same strong relationship for 2013 is also shown. Clearly the rates of smoking have declined in each NZDep decile.

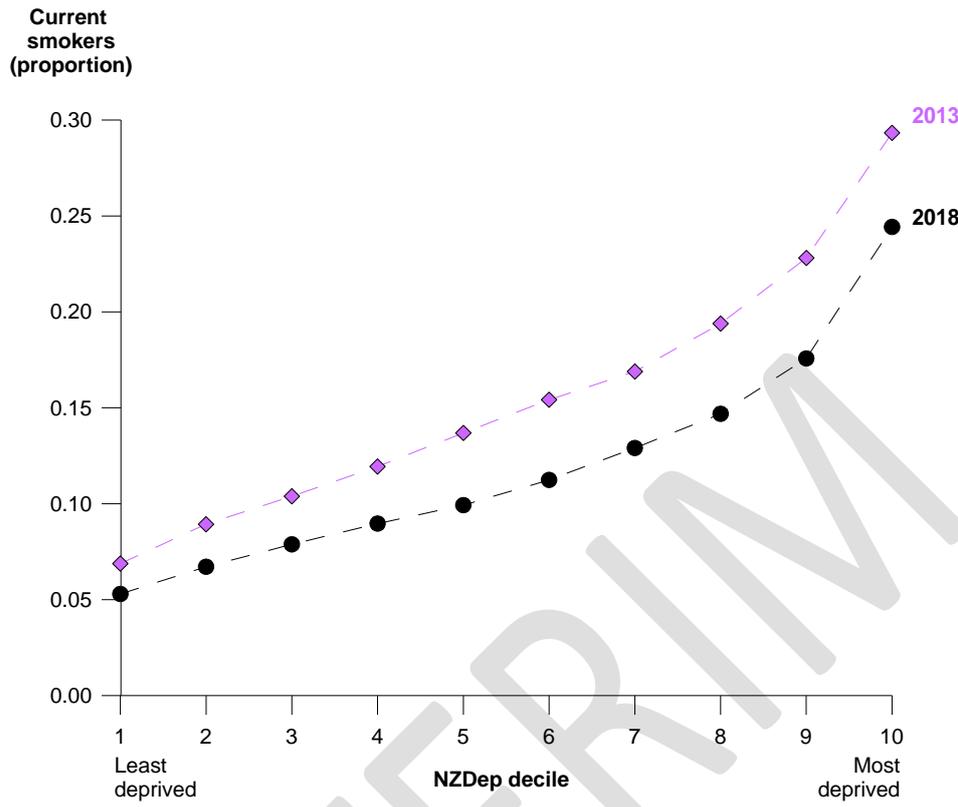


Figure 3: Regular smoking by deciles of NZDep2018 and NZDep2013

The strong validation of NZDep2018 as a measure of socioeconomic deprivation is clearly in line with that observed in 2013 (Atkinson et al., 2014) and is also consistent with the 1996 validation of the smoking information contained in the 1996 Census (*Research report No. 8*; Salmond & Crampton, 1998) and with the similar validation in 2006 (Salmond et al., 2007). The relationship between area deprivation and smoking behaviour among various age groups, both sexes, and across ethnic groups has been explored in detail in *Deprivation and Health* (Salmond & Crampton, 2000); in *Socioeconomic deprivation and ethnicity are both important for anti-tobacco health promotion* (Crampton et al., 2000b); and, more recently, in *A decade of tobacco control efforts in New Zealand (1996-2006): impacts on inequalities in census-derived smoking prevalence* (Salmond et al., 2012).

Mapping

The authors are not GIS experts. Nevertheless tools are available within SAS to enable us to map the NZDep index as a simplified illustration of the visualisation possibilities. Details of the mapping procedures used for the *Atlas of Socioeconomic Deprivation in New Zealand: NZdep2006* (White et al., 2008) are given therein. For coloured mapping purposes, quintiles of NZDep2018 are shown instead of deciles.

Two maps are shown on the following pages. They show the quintiles for the North and South Islands in five shades of orange.

The total population of the 62 inhabited SA1s for which there are no NZDep2018 data, or for which the data are withheld, is less than 1000.

NZDep2018

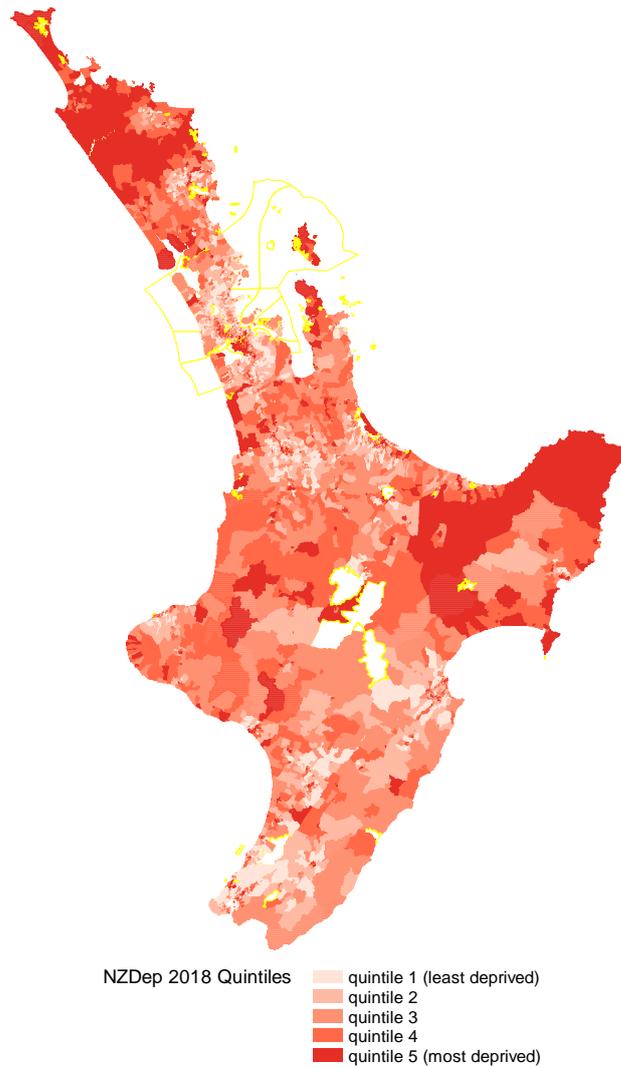


Figure 4: NZDep2018 distribution in the North Island of New Zealand

Yellow areas either had no one usually resident or a withheld NZDep2018 value due to very small numbers of residents providing information.

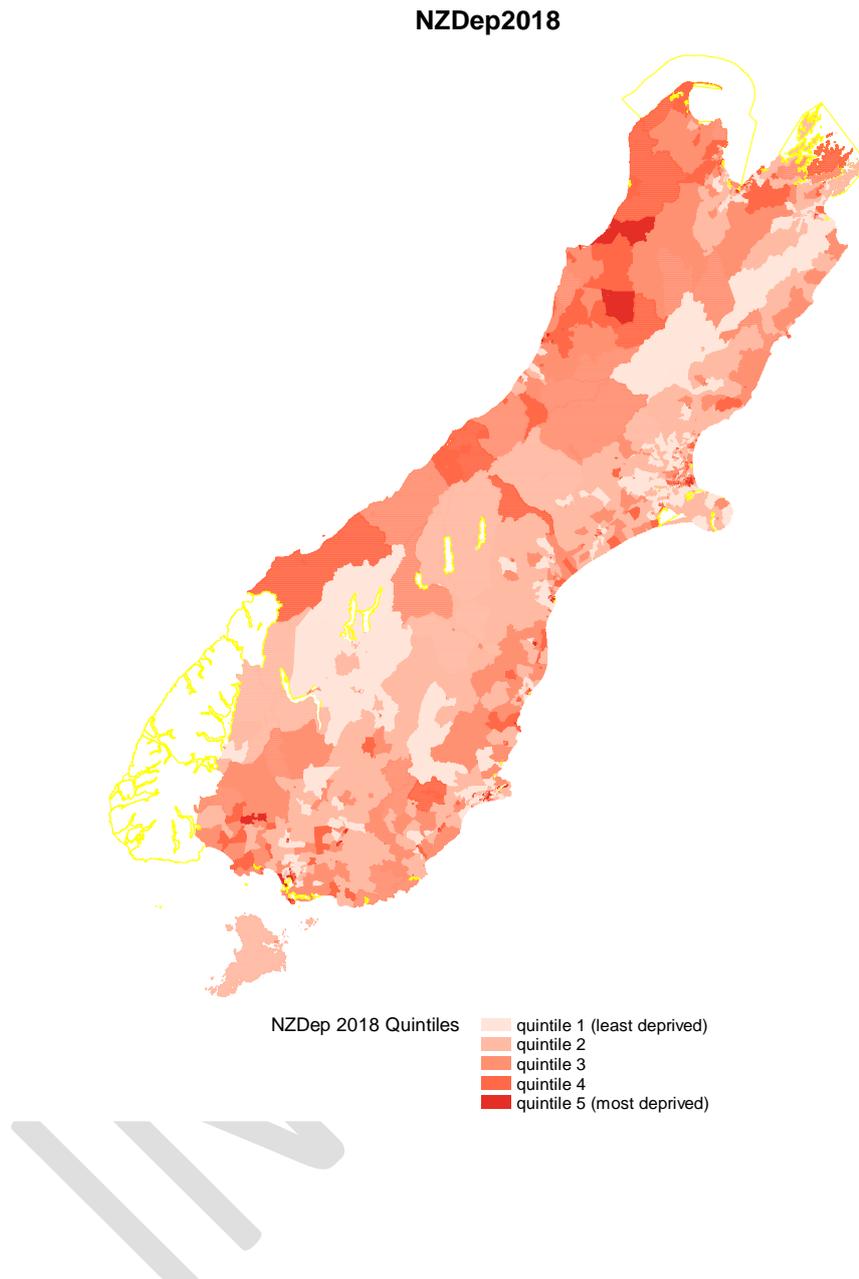


Figure 5: NZDep2018 distribution in the South Island of New Zealand

Yellow areas either had no one usually resident or a withheld NZDep2018 value due to very small numbers of residents providing information.

Glossary of terms and abbreviations

Agglomeration	Combining areas that are geographically connected.
Deprivation	Deprivation is 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). Townsend distinguishes between material and social deprivation. Material refers to material apparatus, goods, services, resources, amenities and physical environment and location of life. Social refers to the roles, relationships, functions, customs, rights and responsibilities of membership of society and its subgroups.
Meshblock	Meshblocks are the smallest administrative areas used by Statistics New Zealand.
NZDep2018 scale	A ten category ordinal scale from 1 (assigned to the 10% of NZDep2013 small areas with the least deprived NZDep2018 scores) to 10 (assigned to the 10% of NZDep2018 small areas with the most deprived NZDep2018 scores). (Note the wording to avoid 'reification'—see <i>Cautions, The indicator becomes the reality</i> , page 17).
NZDep2018 score	The value for a small area is the score for the area on the first principal component. The distribution has mean 1000 and standard deviation 100. The distribution is skewed.
Ordinal scale	A measurement scale having a natural ordering, such as 'most' to 'least' deprived.
Principal components analysis	Principal components analysis is a method of multivariate analysis that is used to find a few combinations of variables, called components, that adequately explain the overall observed variation, and thus reduce the complexity of the data (Kirkwood, 1988).

SAS	SAS refers here to a statistical software suite used in the production of NZDep2018. The suite is a product of SAS Institute.
Socioeconomic position	Socioeconomic position is a descriptive term for a person's position in society, which may be expressed on an ordinal scale using criteria such as income, educational level obtained, occupation, value of dwelling place, deprivation of area of residence, etc.
Statistical Area 1 (SA1)	Census SA1s are administrative areas defined by Statistics New Zealand that generally contain between 100 and 200 residents. They are built from meshblocks.
Statistical Area 2 (SA2)	SA2s are administrative areas defined by Statistics New Zealand and built from SA1 areas.
Territorial Authority (TA)	TAs are larger administrative areas defined by Statistics New Zealand.

Appendix one: Source populations

Data for NZDep are extracted from either individual forms or dwelling forms of the Census.

Individual form data

Eligible people are those usually resident in New Zealand, even if they are temporarily absent from their usual residence, but are elsewhere in New Zealand. Such 'visitors' will have on their individual forms two meshblock identifiers: (1) meshblock of residence on census night, and (2) meshblock of usual residence. Using the meshblock (or SA1) of usual residence as the identifier ensures that the entire usually resident population of New Zealand is included in the calculation of the following three variables: qualifications, unemployment, and income support.

Dwelling form data

Eligible people are all those living in private dwellings. This excludes people permanently or temporarily living in hospitals, nursing homes, prisons, retirement homes, welfare education or relief institutions, defence establishments, hotels, motels, guest houses, boarding houses, motor camps, construction camps, youth camps, staff quarters (e.g. nursing home, seasonal fruit pickers), vessels (except the navy), communes, marae, and others. Data for people living in non-private dwellings are not necessarily relevant; for example, housing tenure and occupancy are not salient characteristics for people in retirement homes. Also excluded are visitors to private dwellings.

In 2018, 0.6 percent of all occupied dwellings were non-private. Their residents account for the difference between denominators based on information in the individual and dwelling forms.

The six dwelling form variables are: household income, crowding, communication, tenure, family type, and living conditions. The denominators for the proportions using these variables are people living in private dwellings.

Why do we use two different source populations?

The rationale for choosing the source populations was to maximise the amount of information incorporated into NZDep. Another option would have been to develop the index restricting both individual form data and dwelling form data to the usually resident population in private dwellings. This approach would have omitted information (related to the three non-dwelling variables) from individual forms from people living in non-private dwellings.

The denominator for rate calculations using NZDep could appropriately be the usually resident population, or the usually resident population in private dwellings. We recommend the former; in practice there will be very little difference.

Appendix two: Description of unchanged NZDep variables

Nine deprivation-related variables have been used to create NZDep2013. Four have already been described because they included changes since 2013 (Access to the Internet, Household income threshold, Severe damp and/or mould, Means tested benefit; see page 22 onwards). The remaining five are described below.

Unemployed

In the 2018 Census, taken on 5 March, unemployment is defined for all people aged 15 years and over who, during the week ended Sunday 3 March 2018, were without a paid job, were available for work, and had actively sought work in the past four weeks. For NZDep2018, the unemployed variable refers only to the 18 to 64 year age group.

Single parent families

Our definition of the *proportion of single parent families* variable is: *people less than 65 in a single parent family with dependent children less than 18 as a proportion of all people under 65*. In the 2018 census, some of the family relationships were unclear and we may have been conservative in defining single parent families with dependent children.

The denominator includes everyone aged less than 65 years (i.e. those considered eligible of being in a single parent family). This variable is restricted to those aged less than 65 years in order to avoid inflation of the denominator by large numbers of elderly people who are less likely to be in a single parent family with dependent children.

No qualifications

The no qualifications variable refers only to the 18 to 64 year age group. No qualification indicates that no qualification has been obtained from a completed course of at least three months of full time study.

Dwellings not owner occupied

The housing tenure variable is: proportion of people in dwellings not owner occupied. Two categories of 'dwelling not owned by usual resident(s)' were used to capture not owner occupied. The third category, 'dwelling not owned by usual resident, who do not make rent payments', was treated as not specified since it was not possible to determine whether this represents an advantage or a disadvantage (for example, both a farm labourer and a multinational company executive could have accommodation provided rent free). In 2006, three further categories involving housing provided by Trusts were introduced as answer options on the census form. For the purposes of NZDep it was considered that people living in such Trust accommodation are not deprived.

Occupancy

Occupancy describes the relationship between housing space available and persons usually resident in the house. For deprivation purposes, the extreme of an occupancy scale is used. It is usually called overcrowding.

For NZDep2001, NZDep2006 and NZDep2013 the Canadian National Occupancy Standard formula for calculating occupancy was used. This formula was considered to be a more precise way of capturing occupancy than the OECD formula used earlier. The Canadian National Occupancy Standard sets the bedroom requirements of a household according to the following composition criteria (Statistics New Zealand, 1998, p.79):

- There should be no more than two people per bedroom.
- Parents or couples share a bedroom.
- Children under five years, either of the same or the opposite sex, may reasonably share a bedroom.
- Children under 18 years of the same sex may reasonably share a bedroom.
- A child aged five to 17 years should not share a bedroom with one under five of the opposite sex.
- Single adults 18 years and over and any unpaired children require a separate bedroom.

We have continued to use this definition in 2018. In a handful of cases the formula produced an extreme level of crowding suggesting a likely non-private dwelling. We omitted those records. Approximately 10.8 percent of people in private dwellings do not have sufficient bedrooms by this definition and are considered deprived (Table 7).

Table 7: Crowding index

'Spare' bedrooms ^a	Percent of people in private dwellings	Cumulative percent
< - 2	1.4	1.4
- 2	2.3	3.7
- 1	7.1	10.8
0	24.1	34.9
+ 1	32.1	67.0
+ 2	23.8	90.8
> + 2	9.2	100.0

} *Deprived*
} *Not deprived*

^a Number of bedrooms under or over those required by the Canadian National Occupancy Standard.

Appendix three: Standardisation

Age and sex

All variables are related to age and sex to some extent. Therefore it was important to standardise for both age and sex, and compare the standardised indexes with non-age/sex standardised indexes. The resulting comparisons allowed investigation of the effect of age/sex standardisation on the ranking of small areas.

The options available for controlling for age and sex confounding were: age/sex standardisation; stratification; and, restriction. Age/sex standardisation was used with each variable.

Age/sex standardisation in five year age bands was not possible because of the problem of small numbers (small areas of about 100-200 people will not allow full age/sex standardisation). Therefore indirect standardisation was carried out using four age bands: 0-17; 18-39; 40-64; 65+. The youngest age group, 0-17, reflects non-voting status and, in general, dependency. The oldest age group, 65 and over, reflects the 2018 entitlement to state retirement income, and vulnerability to changing living arrangements, income levels, employment status, and health status. The remaining adults have been split into two groups of roughly equal size: 18-39 and 40-64.

Indirect standardisation

The purpose of standardisation is to remove the effects of age and sex, as far as possible, from our deprivation variables within each small area. Indirect standardisation of proportions was used, with the New Zealand population as the standard population. Indirect standardisation for age and sex was chosen due to the small denominators in each small area observation (see Borman (1992) for further discussion of indirect standardisation).

The following formula was used as the basis for indirect standardisation of the variables.

$$\text{Standardised ratio} = \frac{\sum_{i=1}^8 n_i}{\sum_{i=1}^8 p_i R_i}$$

where

- i is the age/sex member of the array
- n is the number of people in the small area with the specific characteristic
- p is the population 'at risk' in the small area
- R is the rate of the characteristic in the standard (New Zealand) population

The result of the above calculation was multiplied by the overall New Zealand rate to create an age/sex adjusted proportion.

Non-responses were those records in which the value was recorded as 'not-specified'. The number of 'not-specifieds' was removed from the p and R denominators (and was automatically not included in the numerators). Thus the population at risk in any age/sex category (p_i) was the sum of those with and those without the characteristic.

The effect of standardisation is illustrated by the analysis of data in 2001, which showed that, overall, 11.1% of small areas at that time changed their decile rank by ± 1 when comparing indirectly standardised and raw deciles, with a further two small areas changing by 2, and one small area changing by 3.

Ethnicity

Ideally proportions should have been standardised by ethnicity (European, Maori, Pacific Island, other) as well as by age and sex. However, small numbers per ethnic group in NZDep small areas preclude standardising for this variable on top of age and sex. This is of no concern in funding formula applications since they treat ethnicity explicitly along with age and sex. Similarly, ethnicity can be included explicitly in any research application.

Appendix four: Methodological issues

Structural zeros

The research considered the implications of small areas with no one in certain age/sex groups.

Taking a small area with no one aged 65 or over in it as an example then proportions of those aged 65 or over with certain characteristics are mathematically not defined. In a SAS programme the proportion would be given a missing value. This, in turn, means that no principal component score could be calculated for this meshblock.

Conceptually, if there is no one in a small area aged 65 or over then the *small area* is not deprived from the point of view of, say, elderly people not living in their own home. Thus the proportion in the meshblock deprived in this way was *defined* to be zero. This allowed the small area to be allocated a meaningful principal component score.

Not specified

'Not specified' refers to census questions for which there was no response. Values for 'not specified' were not included in denominators for the input variables for the principal components analysis.

A simple modelling exercise carried out for the 1991 Census dataset indicated that there would be little to choose between including the 'not-specified' and excluding them. The bias when 'not-specified' are included is always negative, whereas the sign of the bias can vary when the 'not-specified' are left out.

Appendix five: Longitudinal analyses

Introduction

The NZDep2018 index of deprivation is the sixth census-based NZDep index to be produced (the earlier ones were NZDep91, NZDep96, NZDep2001, NZDep2006 and NZDep2013). The first two were created one year apart in calendar time, and the second, NZDep96, was improved in two ways. First, we dropped two variables for theoretical reasons. Second we were able to include another deprivation variable into NZDep96 from a new question in the 1996 census relating to whether people had access to a telephone or not. These changes—from ten variables in the 1991 version to nine variables in the 1996 version, eight of which were common to both indexes—mean that these indexes should be compared with caution. There are, in addition, technical reasons to be cautious (see below).

There are fewer obvious differences between the 1996 and 2001 versions of NZDep, or between the 2001 and 2006 versions. In 2013 we changed the communication variable from access to a phone of any kind at home to access to the Internet at home. In 2018 we have dropped access to a car, introduced a new variable (severe damp and/or mould), and dropped the upper age restriction for access to the Internet.

We are aware that many researchers would like to use the index to inform longitudinal studies. We can distinguish two types of longitudinal study—those comparing areas over time, and those looking for changes in the relationship between deprivation and some other variable (e.g. mortality) over time.

Our conclusions are that:

- COMPARISONS OF AREAS as small as single meshblocks (and SA1s in the future) across time may not be meaningful. Comparisons of areas at a higher aggregation, such as Territorial Authorities, or Area Units (and SA2s in the future), should be reasonable, although we advise caution in interpreting small changes over time as being practically meaningful. See *Comparing areas over time* below.
- COMPARING RELATIONSHIPS between deprivation and another variable, over time, is reasonable. See *Comparing relationships with deprivation over time*, page 59.

Note that each NZDep index of relative deprivation (NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013 and NZDep2018) divides the country into 10, where the highest value indicates the 10% of NZDep[year] small areas with the most deprived NZDep[year] scores. It is important to remember that *by definition 10% of small areas will always fall into the most deprived group*—irrespective of the absolute deprivation in those areas at that time, or the overall wealth of the country.

Comparing areas over time

Meshblocks (and larger geographic areas such as the new Statistical Areas 1 and 2) can change deprivation values between any two censuses for both substantive and technical reasons.

1. Substantive reasons

- a) The local neighbourhood has changed in population size and/or characteristics through housing development—such as new subdivisions, or inner-city apartments created in disused office or warehouse space, or housing demolition.
- b) The local neighbourhood has changed in characteristics through changes in house ownership.

These changes may give rise to either or both of two consequences:

- a) The usually resident population size in the meshblock (and SA1 in the future) changes somewhat and the meshblock/SA1 boundary remains unchanged; and/or
- b) The usually resident population size increases substantially and Statistics New Zealand splits the original meshblock (or future SA1) into two (or more) new meshblocks/SA1s. This situation was exacerbated in 2018 because there were a lot of changes to meshblock boundaries when the new SA1s were being prepared.

These substantive changes can thus give rise to new meshblocks (and future SA1s) that are not readily comparable to old ones as well as to meshblocks/SA1s that have ‘legitimately’ changed NZDep values through changes in population composition.

2. Technical reasons

- a) *Small area definitions are not identical across the Censuses.*

In the indexes for censuses from 1991 to 2013, small areas were defined on the basis of the current usually resident population count in meshblocks, where meshblocks with usually resident populations under 100 were agglomerated (pooled) within Statistics New Zealand’s then-current internal Primary Sampling Unit (PSU) boundaries, if that was possible. PSUs usually contained one or two meshblocks, but may have contained more (often with very small population counts). The resulting census-time-specific small-areas thus had the least number of constituent meshblocks consistent with the dual requirements of at least 100 people usually resident and boundaries within a single PSU. In 2013, this resulted in roughly 23,000 small areas constructed from over 40,000 meshblocks.

The agglomeration procedures applied to different censuses prior to 2018 inevitably changed the composition of some of the small-areas as a result of changes in the size of the New Zealand population and changes in the occupiers of individual homes.

In 2018, there is the additional change to SA1s at the starting blocks for any necessary agglomeration. The Statistics New Zealand SA1 boundaries form a new standard geography for which they will be able to produce more confidentialised counts than were possible using meshblocks. It made sense to use these SA1s as our new starting blocks, particularly as PSU boundaries are no longer being updated (the last to be produced was in 2014). SA1s consist of meshblocks and meshblock boundaries were changed in 2017 when SA1s were established. Thus, inevitably, the new small area boundaries will be different from those used before. There were 29,661 SA1s with non-zero usually-resident populations in 2018, resulting in 25,939 NZDep-specific small areas. The increase in small areas is mostly due to population increase.

The NZDep index is created from proportions created for each small-area. Changed small-area boundaries may give rise to somewhat different constituent populations from which proportions are derived. This may result in changes in the final NZDep value for the constituent SA1s for the small-area (which are each given the small-area NZDep value). Such a change, therefore, may have more to do with the boundary changes for the small-area than any changed circumstances among the residents.

b) *NZDep distributions are not identical across the censuses.*

The base NZDep values are the scores on the first principal component of the correlation matrix of the nine component adjusted proportions. Table 8 shows a fairly close agreement on the form of the 1996, 2001, 2006, 2013 and 2018 distributions, where each has been derived with a *mean* of 1000 and a *standard deviation* of 100. This is particularly reassuring in

2018 given the larger than expected level of missing census returns (see the description following Figure 2 on page 35).

Table 8: Comparison of the NZDep score distributions from 1996 to 2018

Quantile *	NZDep96 score	NZDep2001 score	NZDep2006 score	NZDep2013 score	NZDep2018 score
100% (most deprived)	1528	1521	1619	1549	1552
99%	1315	1307	1320	1314	1327
95%	1202	1199	1203	1203	1201
90%	1140	1141	1138	1141	1138
80%	1073	1075	1072	1074	1069
70%	1032	1034	1030	1030	1029
60%	1000	1002	999	1000	999
50% (median)	975	976	974	974	976
40%	954	953	953	954	956
30%	936	934	935	934	937
20%	917	916	918	917	919
10%	897	895	899	898	897
0% (least deprived)	830	834	838	833	823

* The unit of analysis is the year-specific NZDep small area.

- c) *At least one of the nine component variables—the proportion below a household income threshold—is inevitably not identical from one Census to another.*

Changes to the income categories in Census forms, due to changes in dollar values, give rise to changes in the household income variable, as this assumes the estimated median of the category as the income for the purpose of adding up incomes over household members. Data from the Household Economic Survey for Income 2017/18 has been used to estimate the medians in 2018. This gives rise to a finite number of possible household incomes, depending on the number of earners in the household and what each of them is estimated to earn. In turn, this yields a finite number of equivalised household incomes (that is, incomes adjusted to take account of the size and composition of the household).

From the distribution of people within these categories we have to decide

which of these finite values will be the threshold below which we will define a household, or people, to have a ‘low’ equivalised household income. The threshold of equivalised household income used in 1996 was 17,100 ‘equivalised dollars’, which cut off 13.9% of *households*; in 2001 it was 17,700 ‘equivalised dollars’, which cut off 15.0% of *people*. (The change from household to people is due to the fact that, in 2001, Statistics New Zealand staff provided the information in the raw data set of individuals, whereas, in 1996, the information was calculated in the data laboratory and the decision was made from a household file.) The change between 2001 and 2006 was slight as the threshold in 2006 cut off 14.96% of people. For 2018 the threshold cuts off 15.00% of people, as it had been in 2013.

As a result of the inevitable changed proportions of individuals living in households below the equivalised income threshold, there has been a slight difference in information being added to the composite NZDep index, though this is very small in the last three indexes – and will have been swamped by changes in the underlying monetary value.

- d) *One further variable—occupancy—was deliberately changed between the 1996 and 2001 censuses, but has remained consistent from 2001 to 2018.*

The occupancy (also referred to as ‘crowding’) definition used in the 1996 NZDep calculations was the OECD definition. This counted the number of people in a household and the number of bedrooms available to it (see Ulrich Cloher & Murphy, 1994). A ratio of more than one ‘equivalent’ person per bedroom was defined to be ‘crowded’ for the purposes of establishing the proportion of people in a small area living in ‘crowded’ accommodation. A person-equivalent was defined following Morrison (1994): children aged 10 years and over are equivalent to one adult; children aged under 10 years are equivalent to half an adult.

In the 2001 and subsequent indexes we have improved our indicator of crowding by using the Canadian definition (Statistics New Zealand, 1998,

p.79) which allows couples and certain small children (on the basis of their ages and sexes) to share a bedroom (see *Occupancy*, page 47). This has resulted in a better performance for the indicator in the principal component analysis. Whereas the OECD-defined variable in 1996 had a weight of 0.228, which was the lowest of all the weights (range 0.228 – 0.363), the Canadian-defined variable in 2001 had a weight of 0.309, again the lowest, but in closer alignment with the other eight coefficients (range 0.312 – 0.361). In 2006, the weight was similar to 2001 (0.318), in close alignment with the other weights (range 0.311 – 0.371). In 2013, the weight was 0.303, again in close alignment with the other weights (range 0.286 – 0.372). In 2018, the weight was 0.314 and also in close alignment with the other weights (range 0.301 – 0.384).

As a result of the change in crowding definition, there was a slight difference in information being added to the composite NZDep96 and NZDep2001 indexes, but no difference in information between the last four indexes, NZDep2001, NZDep2006, NZDep2013 and NZDep2018.

Despite the above technical changes, it must be remembered that the purpose of pooling information from nine deprivation-related characteristics is to describe an underlying, but not directly measurable, axis identified as ‘area deprivation’. We use the best information available from each census to define this axis. By using a reasonable number (nine or ten) of inter-related and measurable theoretical deprivation variables in a standard analytic procedure, we have attempted to define the *same* not-directly-measurable axis at each census-time. In that sense, the several NZDep indexes are comparable.

The index created along the small-area deprivation axis at a particular time is a relative one, separating one small-area from another relative to the overall distribution of deprivation at that time. In that sense, the several NZDep indexes are again comparable. However, not much weight should be given to a small change in the relative deprivation of a

meshblock over time. In practice the small change might easily be one decile point simply because the change in underlying score, although very small, crosses a decile boundary. Even changes of two decile points may not indicate a large change in underlying deprivation score if they are not at the extremes of the decile distribution (say, if they are within deciles 2, 3, 4, 5, 6, 7 and 8).

e) *Non-response can affect the indexes.*

There was a relatively substantial increase in non-response to the 2018 census relative to that in earlier censuses. As shown earlier, non-response was unevenly distributed across the deprivation deciles, being more prevalent at the more deprived end of the NZDep2018 scale (see Figure 2 on page 35). That is, some information is missing from those deciles that, if included, may have changed the decile cut-off values on the underlying first principal component in 2018. Thus some changes in decile value for a small area may have changed between 2013 and 2018 partly due to the higher-than-expected non-response in 2018, particularly if the small area lay close to a boundary between one decile and the next.

As a result of all of the above, we conclude:

- COMPARISONS OF AREAS as small as single meshblocks (or SA1s) across time may not be meaningful. Comparisons of areas at a higher aggregation, such as Territorial Authorities, or Area Units (or SA2s), should be reasonable, although we advise caution in interpreting small changes over time as being practically meaningful.

Comparing relationships with deprivation over time

It is reasonable to compare relationships between deprivation deciles and a given outcome over time, for the same aggregated area, using graphical approaches, time series regressions, etc. The hypothetical data in the figure below illustrate how such comparisons might be undertaken graphically. Each of the bars

represents people living in areas which are in nationally-defined deprivation deciles, and the nationally-defined deprivation deciles have a nearly consistent meaning, on a relative scale, regardless of time.

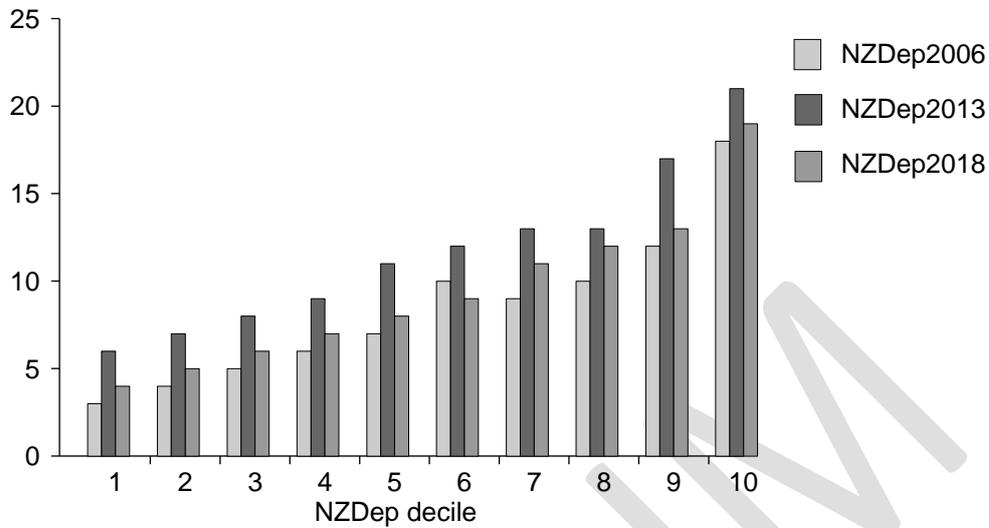


Figure 6: Comparing deprivation deciles over time using hypothetical outcome data

We conclude that

- COMPARING RELATIONSHIPS between deprivation and another variable, over time, is reasonable.

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