

NZDep2023 Index of Socioeconomic Deprivation: Research Report

**June Atkinson¹, Clare Salmond², Peter Crampton³,
Helen Viggers⁴, Kura Lacey⁵**

31 October 2024

¹ Senior Data Analyst, Department of Public Health, University of Otago, Wellington

² Biostatistician, Private contractor, Wellington

³ Professor of Public Health, Kōhatu, Centre for Hauora Māori, University of Otago, Dunedin

⁴ Research Fellow, He Kāinga Oranga, Housing and Health, University of Otago, Wellington

⁵ Lecturer, Kōhatu, Centre for Hauora Māori, University of Otago, Dunedin

E-mail: june.atkinson@otago.ac.nz
clare.salmond@xtra.co.nz
peter.crampton@otago.ac.nz
helen.viggers@otago.ac.nz
kura.lacey@otago.ac.nz

Address: PO Box 7343, Wellington, New Zealand

Suggested citation:

Atkinson J, Salmond C, Crampton P, Viggers H, and Lacey K (2024).

NZDep2023 Index of Socioeconomic Deprivation: Research Report, 31

October 2024. Wellington: University of Otago.

Contents

The authors	5
Acknowledgements	7
Ethics and confidentiality	7
Executive Summary	8
Introduction	10
NZDep methodological papers	11
NZDep research reports	12
Atlases	12
Aim	13
Purpose of indexes	13
Cautions	14
The indicator becomes the reality	14
Area versus individual measures	14
Relative versus absolute socioeconomic deprivation	15
Apparent simplicity	15
Longitudinal comparisons	15
Constructing the index	16
Overview	16
Data sources	16
Defining small areas	16
Choice of variables for inclusion in NZDep2023	18
The effect of mitigation	18
Variables in NZDep2023	18
Unchanged variables	19
Slightly modified variables	19
Creating the index	23
Validation	24

Results	25
Defining small areas	25
NZDep2023 scores	27
Comparison of NZDep2023 and NZDep2018	27
The NZDep2023 Index of Socioeconomic Deprivation	29
Variation within communities	30
Standardisation	31
Validation	32
Mapping	34
Glossary of terms and abbreviations	37
Appendix 1: Source populations	39
Individual form data	39
Dwelling form data	39
Why do we use two different source populations?	40
Appendix 2: Description of unchanged NZDep variables	41
Appendix 3: Standardisation	44
Age and sex	44
Indirect standardisation	45
Ethnicity	46
Structural zeros	47
Not specified	47
Appendix 4: Longitudinal analyses	48
Introduction	48
Comparing areas over time	49
Comparing relationships with deprivation over time	55
Appendix 5: Future versions of NZDep	57
References	60

List of tables

Table 1: Variables included in NZDep2023	19
Table 2: Illustrations of two approaches to income equivalisation	21
Table 3: Crowding index	23
Table 4: Number of SA1s per NZDep2023 small area	25
Table 5: Distribution of the population in NZDep2023 small areas	26
Table 6: Weights for the first principal component of the NZDep2023 variables for the administrative/historical level of mitigation	27
Table 7: Weights on the first principal components for NZDep2018 and NZDep2023	28
Table 8: Comparison of the NZDep score distributions from 1996 to 2023	52

List of figures

Figure 1: Distribution of NZDep2023 scores, with the NZDep2023 decile scale superimposed	30
Figure 2: Variation in NZDep2023 profiles	31
Figure 3: Regular smoking by deciles of NZDep2023, with those for NZDep2018 and NZDep2013 shown for comparison	33
Figure 4: NZDep2023 distribution in the North Island of New Zealand	35
Figure 5: NZDep2023 distribution in the South Island of New Zealand	36
Figure 6: Comparing deprivation deciles over time using hypothetical outcome data	56

The authors

June Atkinson (NZC Statistics) is a Senior Data Analyst in the Department of Public Health, University of Otago, Wellington. Her specialities are statistical programming and data management, analysis, integration, visualisation, ethics, confidentiality and security. She has extensive experience working with large datasets, especially those linked to the Census. Statistics New Zealand made her an Accredited Researcher in 2011. June joined the NZDep team in 2006.

Clare Salmond (BSc (Hons); MSc) is a former member of the Department of Public Health, University of Otago, Wellington. Clare retired from her position as Senior Lecturer in Biostatistics in that Department in 2004 but has maintained her active association with the NZDep project. Clare had thirty-five years' experience working as a biostatistician at the Wellington Hospital Epidemiology Unit and at the University of Otago (in both Dunedin and Wellington) before retiring. She has published extensively in the epidemiology and medical research literature. Clare has been part of the NZDep team since the beginning when she was one of the four researchers who applied for a grant to create NZDep91.

Peter Crampton (CNZM; MB ChB; PhD; MPH; FNZCPHM; FRNZCGP) is a Professor of Public Health in Kōhatu, the Centre for Hauora Māori, at the University of Otago. He researches and teaches Māori health, health systems and public health. He started his professional life as a general practitioner and later specialised in public health medicine. His academic career has spanned a variety of roles including serving as Pro-Vice-Chancellor of Health Sciences and Dean of the Otago Medical School. His research is focused on social indicators and social epidemiology, health care policy, health care organisation and funding, and Māori health. Peter has been part of the NZDep team since the beginning when he was one of the four researchers who applied for a grant to create NZDep91.

Helen Viggers (BE(Hons); GDipApplStat; DPH; PhD) is a Research Fellow in the Department of Public Health, University of Otago, Wellington. She has worked for over twenty years in He Kāinga Oranga, the Housing and Health Research programme. Her work covers areas such as the impact of home warmth

interventions, severe housing deprivation, dwelling size, and access to energy.

This is her first time working on NZDep.

Kuramaiki Lacey (BDS) is a lecturer in Hauora Māori in Kōhatu, the Centre for Hauora Māori at the University of Otago. Kura is a general dentist, currently specialising in dental public health. Kura delivers the Hauora Māori curriculum across several undergraduate and postgraduate dental programmes at the Faculty of Dentistry. Her research focuses on Māori oral health equity, whānau and community dentistry, and the integration of oral health into chronic disease management. This is her first time working on NZDep.

Acknowledgements

The original NZDep91 project, on which NZDep96, NZDep2001, NZDep2006, NZDep2013, NZDep2018 and NZDep2023 are based, was carried out at the Health Services Research Centre at Victoria University of Wellington and was funded by the Health Research Council of New Zealand. We are grateful to the Health Services Research Centre for supporting this work, originally, and to the Ministry of Health for supporting the production of NZDep2001, NZDep2006, NZDep2013, NZDep2018 and NZDep2023. Of central importance has been the tremendous and consistent support that Stats NZ has provided over the past thirty plus years without which we could not have produced the NZDep indexes.

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 Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the Data and Statistics Act 2022. The results presented in this study are the work of the authors, not Stats NZ or individual data suppliers.

Copyright: This work is licensed under the Creative Commons Attribution 4.0 International licence. You are free to copy, distribute, and adapt the work, as long as you attribute the work to the University of Otago and abide by the other licence terms.

Liability: While all care and diligence has been used in processing, analysing, and extracting data and information in this publication, the University of Otago gives no warranty it is error free and will not be liable for any loss or damage suffered by the use directly, or indirectly, of the information in this publication.

Executive Summary

NZDep2023 is an updated version of the NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013 and NZDep2018 indexes of socioeconomic deprivation. NZDep2023 combines nine variables from the 2023 census which reflect eight dimensions of deprivation. NZDep2023 provides a deprivation score for each inhabited Statistical Area 1 [SA1], and its constituent meshblocks, in New Zealand.

Meshblocks are the smallest geographical units defined by Stats NZ. They are the building blocks for their SA1 geographies, which generally contain between 100 and 200 people. These areas, and sometimes combinations of them, were used as the basis from which NZDep2023 was calculated.

The NZDep2023 index of socioeconomic deprivation has two forms—an ordinal scale and a continuous score.

- The NZDep2023 index of socioeconomic deprivation ordinal scale ranges from 1 to 10, where 1 represents the areas with the least socioeconomically deprived scores and 10 the areas with the most socioeconomically deprived scores.
- The NZDep2023 index of socioeconomic 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 NZDep2023 10-point scale is derived from this interval variable.

The NZDep2023 scale of socioeconomic 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 socioeconomically deprived 10 percent of our small areas in New Zealand, according to the NZDep2023 scores.

It should be noted that NZDep2023 socioeconomic-deprivation scores apply to areas rather than individual people.

NZDep2023 combines the following census data (calculated as proportions for each small area):

Dimension of socioeconomic deprivation	Description of variable
Communication	People with no access to the internet at home
Income	People aged 18 – 64 receiving a main means tested benefit
Income	People living in equivalised ^a 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 < 75 living in a sole-parent family
Living space	People living in equivalised ^a households below a bedroom occupancy threshold (i.e. overcrowded)
Living condition	People living in dwellings that are always damp and/or always have mould greater than A4 size

^aEqualisation: methods used to control for household composition.

Frequently asked questions about use of the index can be found in the *NZDep2023 Index of Socioeconomic Deprivation: User's Manual* on the University of Otago website.

Introduction

This report describes the development of NZDep2023. The methods used in the creation of NZDep2023 are based on very similar methods used in the creation of NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013 and NZDep2018. 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); *NZDep2013 Index of Deprivation* (Atkinson et al., 2014); and *NZDep2018 Index of Deprivation* (Atkinson et al., 2019)

Small changes have been made to some details in the creation of NZDep2023 compared to NZDep2018. Three variables in the index have had minor adjustments; one increasing the upper age limit (sole-parent family), changed income categories in the Census form (low income), and using gender not sex in the crowding calculations. Descriptions and explanations of these changes are given in the methods section. NZDep2023 was created using early access to the 2023 census data within the secure Stats NZ environment.

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, its various uses, and comparisons with other socioeconomic indexes 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>
- Whitehead J, Atkinson J, Davie G, De Graaf B, Eggleton K, Crengle S, Miller R, Blattner K, Crampton, and Nixon G** (2023). Comparison of the sociodemographic composition of rural and urban Aotearoa New Zealand: Insights from applying the Geographic Classification for Health to the 2018 Census. *New Zealand Population Review*, 49, 27-69.

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.otago.ac.nz and www.moh.govt.nz.

Salmond C, Crampton P (2007). *NZDep2006 Index of Deprivation*. Wellington,

Department of Public Health, University of Otago, Wellington, www.otago.ac.nz and www.moh.govt.nz.

Atkinson J, Salmond C and Crampton P (2014). *NZDep2013 Index of*

Deprivation. Wellington, Department of Public Health, University of Otago, Wellington, www.otago.ac.nz and www.moh.govt.nz

Atkinson J, Salmond C and Crampton P (2019). *NZDep2018 Index of*

Deprivation. Wellington, Department of Public Health, University of Otago, Wellington, www.otago.ac.nz and www.moh.govt.nz.

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.

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, NZDep2018 and NZDep2023 have been developed with three principal purposes in mind: resource allocation, research, and advocacy.

1. Indexes of socioeconomic deprivation have application in funding formulas. For example, NZDep was used in the population-based funding formula for the former District Health Boards and in funding formulas for social services in other sectors.
2. Indexes of socioeconomic deprivation have application in research and planning 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 socioeconomic deprivation are associated with higher mortality rates, and higher rates of many diseases.
3. Indexes of socioeconomic 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

Several 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 socioeconomically-deprived NZDep scores' rather than 'the most socioeconomically-deprived areas'.

Area versus individual measures

Please note that NZDep is a small area measure of socioeconomic 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 socioeconomic deprivation

A view is sometimes expressed in reference to NZDep that ‘it is disgraceful that still 10% of areas are most socioeconomically deprived’. Please note that 10% of areas will *always* fall into the most socioeconomically-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, 2012b), 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, NZDep2018 and NZDep2023). These difficulties are discussed in detail in Appendix 4.

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

NZDep2023 was created from data from the 2023 Census of Population and Dwellings. The variables included in NZDep2023 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 Stats NZ geographic variable ‘Statistical Area 1’ for their usual residence can be ascribed, whether present in their usual residence on census night or not (4.99 million).
- 2) Dwelling forms from private dwellings, which yielded 4.57 million records, one for each person usually resident in a private dwelling.

More details concerning the source populations are given in Appendix 1.

Defining small areas

The small areas used to create the index of socioeconomic deprivation are unique to this socioeconomic-deprivation project (NZDep2023 small areas).

In versions of NZDep up to NZDep2013 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, if necessary, within Statistics New Zealand's internal primary sampling unit boundaries.

As in 2018, in the 2023 data we have used the Statistics New Zealand's Statistical Area 1 [SA1] geography as the 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. We were able to use 32,523 SA1 geographies, which were contained in 2321 Statistical Area 2 [SA2] geographies.

In 2018, the census data contained several levels of mitigation to compensate for missing data. Extensive exploration of the effect of the various types of mitigation led us to create NZDep2018 from data mitigated with historic data (from the 2013 census) and administrative data (from the Integrated Data Infrastructure) (see Atkinson *et al*, 2019, page 21).

We have continued to use the historic/administrative mitigation level for NZDep2023. Thus, we based our agglomeration process on the number of residents usually living in each SA1 mitigated at the administrative/historical level. For maximum robustness, we used the residents living in private dwellings for the agglomeration since several NZDep variables are restricted to people in private dwellings.

To combine smaller SA1s within SA2s, we used SA1 boundary information (supplied by Dylan Paterson at Stats NZ) 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, if possible. We allowed for agglomerating into whole SA2s if necessary. Further agglomeration was not used since any resulting small area would no longer be 'small'.

Choice of variables for inclusion in NZDep2023

The effect of mitigation

As in 2018, Stats NZ improved the 2023 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 2023 from alternative sources – 2018 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 first configured by Statistic New Zealand for use with 2018 New Zealand census data.

After extensive investigation, the final version of NZDep2018 used the administrative/historical level of alternative sources. We have continued to use that in the creation of NZDep2023.

Variables in NZDep2023

The NZDep2023 index of socioeconomic deprivation reflects eight dimensions of material and social deprivation. These dimensions reflect a lack of income, employment, communication, support, qualifications, owned home, living space and dry living conditions. A list of the variables used in NZDep2023 is given in Table 1.

Table 1: Variables included in NZDep2023

Variable (proportions in small areas) in order of decreasing weight in the index
People aged 18 – 64 receiving a main means tested benefit
People aged 18 – 64 without any qualifications
People living in households below an equivalised ^a bedroom occupancy threshold (i.e. overcrowding)
People living in households with equivalised ^a income below an income threshold
People aged < 75 living in a sole-parent family
People not living in own home
People with no access to the internet at home
People living in homes with severe damp and/or mould
People aged 18 – 64 unemployed

^aEquivalisation: methods used to control for household composition.

Unchanged variables

A short description of each of the six unchanged variables in NZDep2023 – means-tested benefits, no qualifications, dwellings not owner occupied, no internet access, severe damp and/or mould, and unemployed – have been extracted from *NZDep2018 Index of Deprivation* (Atkinson et al., 2019) and placed in Appendix 2.

Slightly modified variables

Three variables included in previous versions of NZDep – household income, sole-parent family, and bedroom occupancy – have been very slightly modified as described below.

Household income

Background

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, NZDep2013 and NZDep2018 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), NZDep2018 *Index of Deprivation* (Atkinson et al., 2019)]. This threshold is maintained for NZDep2023, although we updated our Jensen equivalisation formula in 2018 to that used by Statistics New Zealand (2017) (see also, Jensen, 1978, and Jensen, 1988). The latest version of Jensen equivalisation uses the actual ages of any children as well as how many there are in the household.

Low Jensen-equivalised income threshold for NZDep2023

The 2023 cut-off is again derived from the equivalised incomes calculated using the Jensen formula. The threshold is that equivalised income that cuts off the nearest proportion of people less than, or equal to, 15 percent. People living in a household with an equivalised household income at or below this threshold are

considered to be income-deprived. In 2023 this amounted to 14.88% of people whose household income could be established.

An alternative low OECD-equivalised income threshold

An alternative OECD equivalisation formula used elsewhere, but which we have not switched to, uses one adult with no dependents as the reference household instead of Jensen's two adults with no dependents. The OECD formula is a weighted sum of the individuals in the household. It counts 1.0 for the first adult; adds 0.5 for the second and each subsequent person aged 14 and over; and adds 0.3 for each child under 14. Comparing the Jensen and OECD equivalised-income weightings shows that the relative needs of some households are classified differently by the two approaches, as illustrated in Table 2.

Table 2: Illustrations of two approaches to income equivalisation

Household composition		Equivalisation factor (when compared to ONE adult)	
Adults	Children aged 9	Jensen	OECD
1	2	1.74	1.6
2	0	1.54	1.5
2	2	2.15	2.1
4	0	2.37	2.5
6	4	3.88	4.7

Smaller households, especially those with primary aged children, are assumed to need relatively more income for a similar standard of living under the Jensen formula than under the OECD one; conversely larger households are assumed to need relatively more income for a similar standard of living under the OECD formula than the Jensen formula. Thus, if these households are near the income cut-off, then they may be differentially classified, and changing the equivalisation method would change the composition of families defined as in hardship.

Note, also, that the OECD formula requires total household income. By implication this includes all children of any age in the household. However, the NZ census collects income information only from those aged 15 years and over, so that 14-year-olds and younger cannot be included in the household income total.

Sole-parent families

Our definition of the proportion of sole-parent families variable is ‘people less than 75 years in a sole-parent family with dependent children less than 18, as a proportion of all people under 75 years’. Previously, we used a cut-off of 65 years, but exploration showed that there were sufficient sole-parents (which includes grandparents acting in a parent role) aged 65 to 74 in 2023 to warrant a change to the upper age limit. The denominator includes everyone aged less than 75 years (i.e. those considered eligible of being in a sole-parent family). This variable is restricted to those aged less than 75 years to avoid inflation of the denominator by large numbers of elderly people who are less likely to be in a sole-parent family with dependent children.

In the 2023 census, as in the 2018 census, some of the family relationships were unclear and we may have been conservative in defining sole-parent families with dependent children.

Bedroom occupancy

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

For NZDep2001, NZDep2006, NZDep2013, NZDep2018 and NZDep2023 the Canadian National Occupancy Standard formula for calculating occupancy was used. This formula is 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 age, sex and relationships of its members (Statistics New Zealand, 1998, p.79). In 2023 we have updated the criteria, very slightly, by using ‘gender’ (male, female, other) instead of ‘sex’ (male, female). The six criteria are now:

- 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 a different gender, may reasonably share a bedroom.
- Children under 18 years of the same gender may reasonably share a bedroom.
- A child aged five to 17 years should not share a bedroom with one under five of a different gender.
- Single adults 18 years and over and any unpaired children require a separate bedroom.

We have used this definition in 2023 (previously the definition used sex at birth). Approximately 12.08 percent of people in private dwellings do not have sufficient bedrooms by this definition and are considered socioeconomically deprived (Table 3).

Table 3: Crowding index

'Spare' bedrooms ^a	Percent of people in private dwellings ^b	Cumulative percent	
< - 2	1.81	1.81	<i>Deprived</i>
- 2	2.67	4.48	
- 1	7.60	12.08	
0	24.70	36.78	<i>Not deprived</i>
+ 1	31.62	68.40	
+ 2	22.61	91.01	
> + 2	8.99	100.0	

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

^b Percentages are based on counts that were fixed random rounded to base 3.

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).

NZDep2023 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 NZDep2023 is given in Appendix 3.

Technical difficulties, encountered occasionally when an NZDep2023 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 4 (*Structural zeros*). Other technical difficulties involving ‘not specified’ codes were treated as before and are also described in Appendix 4 (*Not specified*).

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, 2013 and 2018 indexes (Salmond & Crampton, 2002b; Salmond et al., 2007; Atkinson et al., 2014; Atkinson et al., 2019).

As in 1996, 2006, 2013 and 2018 we were able to validate the NZDep2023 index against individual smoking data contained in the relevant census.

Results

Defining small areas

The final small areas were either SA1s or, if necessary, agglomerated SA1s that were coterminous and within an SA2 boundary. 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 NZDep2023 value is considered unreliable and has been withheld.

The distribution of the number of SA1s incorporated in each NZDep2023 small area is shown in Table 4.

Table 4: Number of SA1s per NZDep2023 small area

Number of SA1s in NZDep2023 small area	Percentage of NZDep2023 small areas	Total number of SA1s accounted for
1	94.80	29,059
2	4.54	1,393
3	0.49	149
4	0.12	37
5 to 9	0.05	14
Total	100.00	30,652

The population distribution in the NZDep2023 small areas is shown in Table 5.

Table 5: Distribution of the population in NZDep2023 small areas

Usually-resident population	Overall ^a		In private dwellings ^a	
	Number of NZDep2023 small areas ^b	Percent	Number of NZDep2023 small areas ^b	Percent
0 - 29	42	0.14	41	0.13
30 - 69	15	0.05	38	0.12
70 - 79	22	0.07	247	0.81
80 - 89	483	1.58	1,199	3.91
90 - 99	1,229	4.01	1,786	5.83
100 - 149	11,740	38.30	13,672	44.60
150 - 199	11,373	37.10	10,296	33.59
200 - 299	5,266	17.18	3,098	10.11
300 - 399	312	1.02	183	0.60
> 399	170	0.55	81	0.26
Missing			11	0.04
Total	30,652	100.00	30,652	100.00

^a Percentages are based on counts of usual residents. However, we also included people living elsewhere on census night in the derivation of NZDep2023 if they could be repatriated to their usual residence.

^b The target size for NZDep2023 small areas was a minimum of 100 persons usually resident in private dwellings, where possible. A small number of people usually resident are not accounted for in NZDep2023 because they live in small off-shore islands, inlets, etc.

In total, 51 small areas do not have a published NZDep2023 value. For 23 of these small areas, which were individual SA1s, there were no or very few usual residents. For the remaining 28 small areas, the value was withheld because the information available was based on an inadequate number of observations. These 28 small areas were complete SA2s, involving 51 SA1s and approximately 1,092 usual residents (this number being the sum of their fixed random rounded counts). Three-quarters of these SA1s involved an island, a coast, an inlet, a port, or were 'oceanic'.

The 28 SA2s that have had their NZDep2023 values withheld are:

108400 110600 112001 113700 118800 128700 147300 147700 149600 152700
161700 166600 166801 189500 203300 216200 226200 238200 258500 258900
303701 306401 314400 326400 332601 350801 357000 363400

NZDep2023 scores

We used principal components analysis to create the index from the nine variables listed in Table 1, using their administrative/historical level of mitigation (Table 6).

Table 6: Weights for the first principal component of the NZDep2023 variables for the administrative/historical level of mitigation

Proportion of people (with a lack of something) ^a	Weight
People aged 18 – 64 receiving a means tested benefit	0.397
People aged 18 – 64 without any qualifications	0.350
People living in households below an equivalised ^b bedroom occupancy threshold (i.e. overcrowding)	0.348
People living in households with equivalised ^b income below an income threshold	0.333
People aged < 75 living in a sole-parent family	0.327
People not living in own home	0.320
People with no access to the internet at home	0.319
People living in homes with severe damp and/or mould	0.304
People aged 18 – 64 unemployed	0.290

^a Ordered by the weights.

^b Equivalisation: methods used to control for household composition.

The variance explained by the first principal component is 52.7 percent. Its eigenvalue was 4.75. The eigenvalues for the second and subsequent principal components, being less than 1, indicate that each one explains less variation than an average single variable would, illustrating the utility of the first principal component scores for our index of socioeconomic deprivation for small areas.

The first principal component yields the NZDep2023 score.

Comparison of NZDep2023 and NZDep2018

Some changes in the weights between NZDep2018 and NZDep2023 are evident in Table 7.

Table 7: Weights on the first principal components for NZDep2018 and NZDep2023

Proportion of people (with a lack of something) ^a	NZDep2018	NZDep2023
People aged 18-64 receiving a means tested benefit	0.384	0.397
People living in households with equivalised ^b income below an income threshold (same threshold definitions)	0.360	0.333
People with no access to the internet at home	0.356	0.319
People aged 18-64 without any qualifications	0.329	0.350
People aged < 65 living in a sole-parent family (aged < 75 for NZDep2023)	0.328	0.327
People not living in own home	0.315	0.320
People living in households below an equivalised ^b bedroom occupancy threshold (same threshold)	0.314	0.348
People aged 18-64 unemployed	0.304	0.290
People living in homes with severe damp and/or mould	0.301	0.304
Proportion of variance explained	57.9%	52.7%

^a Ordered by the weights in 2018 for ease of comparison.

^b Equivalisation: methods used to control for household composition.

Although part of the observed small differences may be a result of improved mitigation of missing information in 2023, the three largest (but small) changes in the weights warrant further comment.

The greatest change (0.037, third row) is the reduced weight for ‘lack of access to the internet at home’ in 2023. This may be a consequence, at least partly, of the ever-increasing availability of such access. The increase in weight for bedroom occupancy (0.034, seventh row) in 2023 probably reflects recent cost of living and housing pressures. The reduced weight for low equivalised household income (0.027, second row) may be a consequence of cost-of-living pressures affecting more people in 2023 than in 2018, so that the 15 percent cut-off used for indicating income deprivation may be set too low in 2023. However, given that the previous six NZDep indexes used 15 percent as the target cut-off for indicating socioeconomic deprivation (a number backed by research), we have not changed the cut-off in 2023.

The decreased amount of overall variance explained by the first principal component (from which the NZDep index is derived) is difficult to interpret.

Possible reasons include pressures arising for many people from the Covid19 pandemic, and/or pressures arising from the Auckland floods in January 2023 and cyclone Gabrielle in February 2023, and/or falling interest in the Census with a consequent drop in the quality of the source data.

The NZDep2023 Index of Socioeconomic Deprivation

An NZDep2023 scale of socioeconomic deprivation has been produced from the distribution of the NZDep2023 scores. This scale has values from 1 to 10. It 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 socioeconomically-deprived 10 percent of NZDep2023 small areas in New Zealand.

Figure 1 (page 30) shows the relationship between the NZDep2023 scores and the NZDep2023 scale from 1 to 10. The skewed distribution illustrates clearly that NZDep2023 reflects a continuum from ‘least socioeconomic deprivation’ to ‘most socioeconomic deprivation’, rather than from ‘affluence’ to ‘deprivation’. This was intended, as all the variables in NZDep2023 reflect a lack of something.

Note that the decile cut-points of the NZDep2023 scale are not equally spaced, and the difference between deciles 8 and 9, and between deciles 9 and 10, are much larger than between the other consecutive deciles. Other scales can be created from the NZDep2023 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 NZDep2023 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.

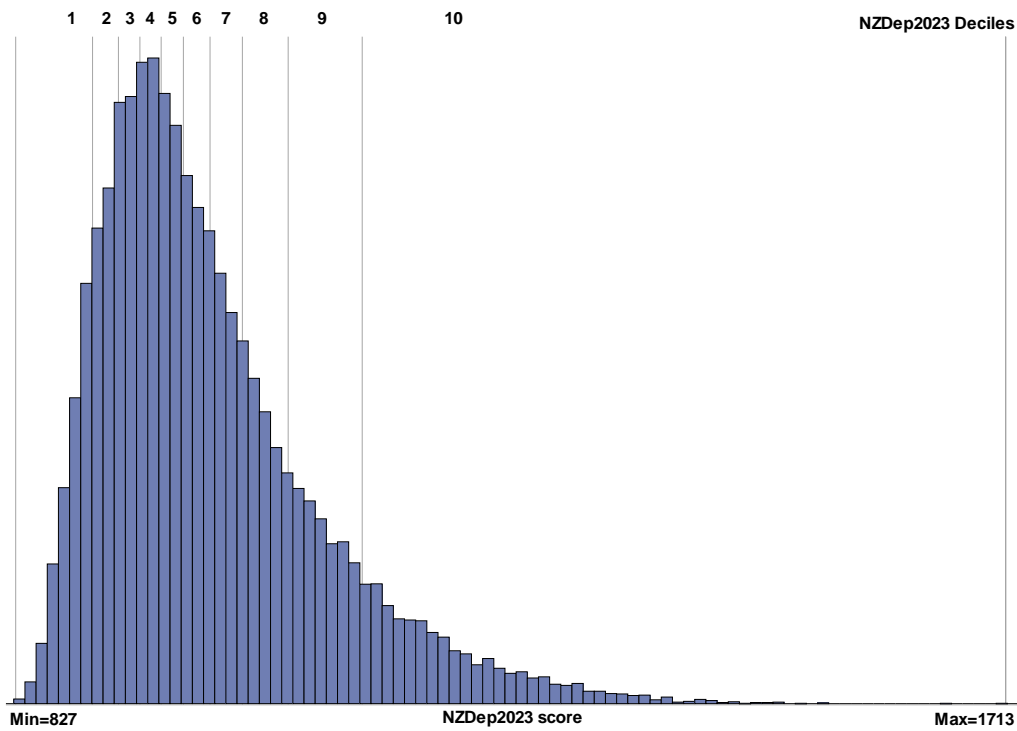


Figure 1: Distribution of NZDep2023 scores, with the NZDep2023 decile scale superimposed

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 socioeconomically-deprived areas and relatively non-socioeconomically-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.

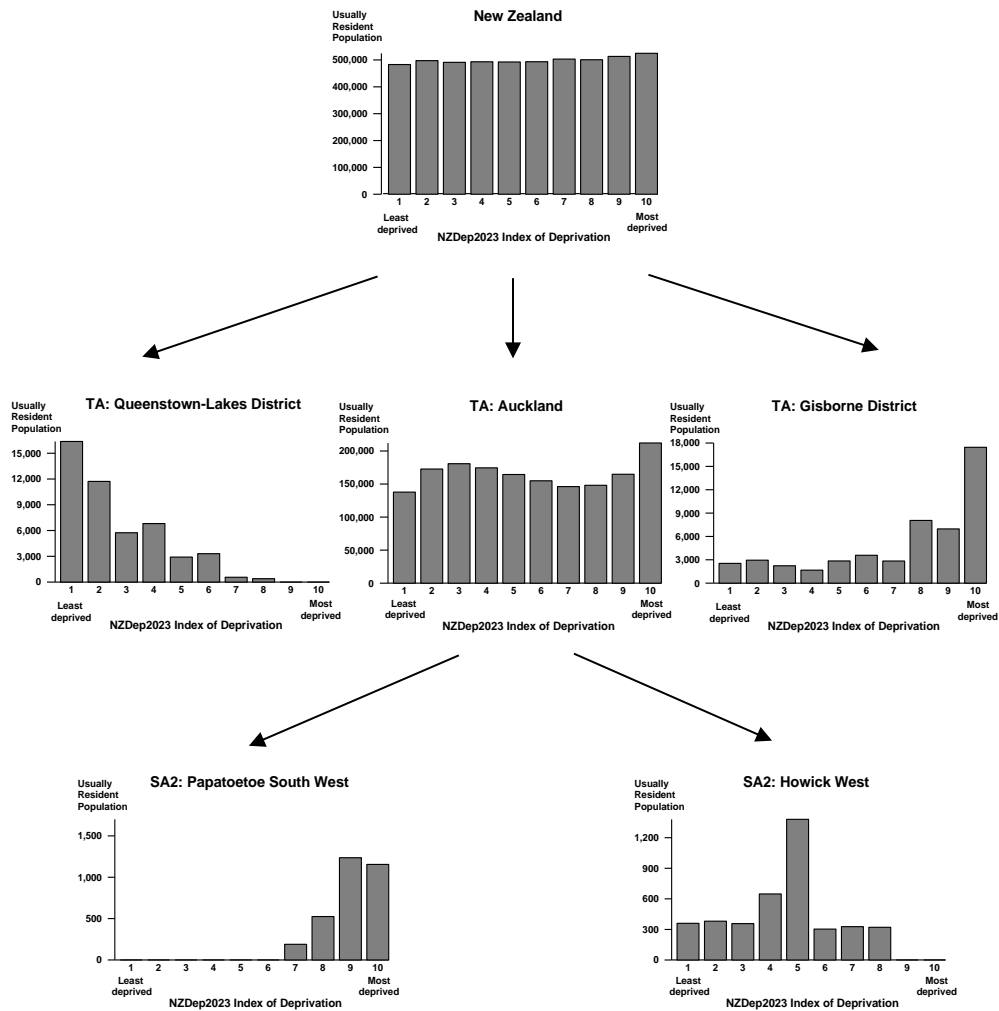


Figure 2: Variation in NZDep2023 profiles

When three Territorial Authorities (TA) are compared in Figure 2, marked differences in their NZDep2023 profiles are observed. Again, when two smaller geographical areas – Statistical Area 2s (SA2) – in Auckland are compared, there are clear differences in their NZDep2023 profiles.

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 3.

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, 2013 and 2018 censuses there was a further opportunity to validate the NZDep index of socioeconomic 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 2023 Census.

There is good evidence in the literature that smoking patterns are strongly correlated with socioeconomic position (Wilson et al., 2006). Therefore, if NZDep2023 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 cigarette smokers was calculated using only those individuals who provided information on their census forms. The strong relationship between smoking and the NZDep2023 index of socioeconomic deprivation is shown in Figure 3. The even stronger relationships in 2013 and

2018 are also shown. Clearly the rates of cigarette smoking have declined in each NZDep decile in each successive census.

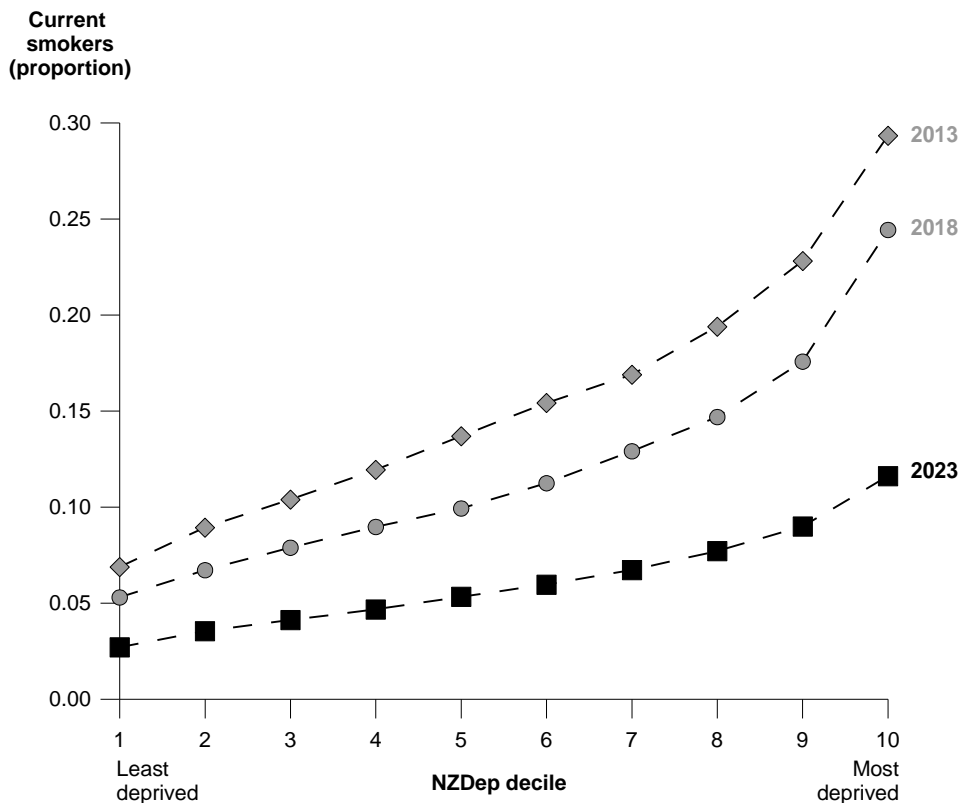


Figure 3: Regular smoking by deciles of NZDep2023, with those for NZDep2018 and NZDep2013 shown for comparison

The strong validation of NZDep2023 as a measure of socioeconomic deprivation is clearly in line with that observed in 2018 (Atkinson et al., 2019) and is also consistent with the 1996 validation based on 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) and 2013 (Atkinson et al., 2014). The relationship between area socioeconomic 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., 2012a).

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 NZDep2023 are shown instead of deciles.

Two maps are shown on the following pages. They show the NZDep2023 quintiles for the North and South Islands in five shades of orange.

NZDep2023 quintiles

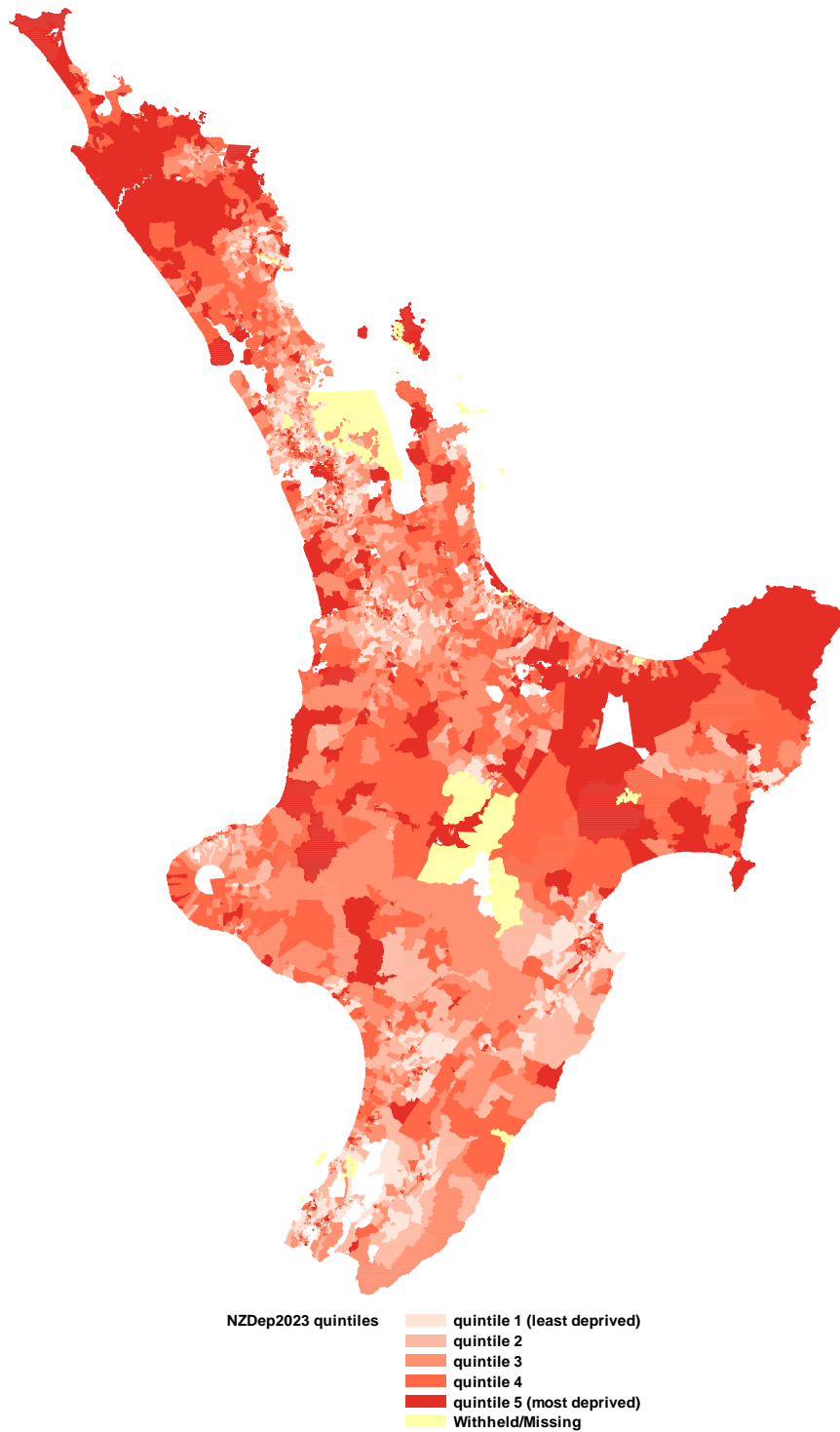


Figure 4: NZDep2023 distribution in the North Island of New Zealand

Yellow areas either had no one, or very few people, usually resident or a withheld NZDep2023 value due to very small numbers of residents providing information.

NZDep2023 quintiles

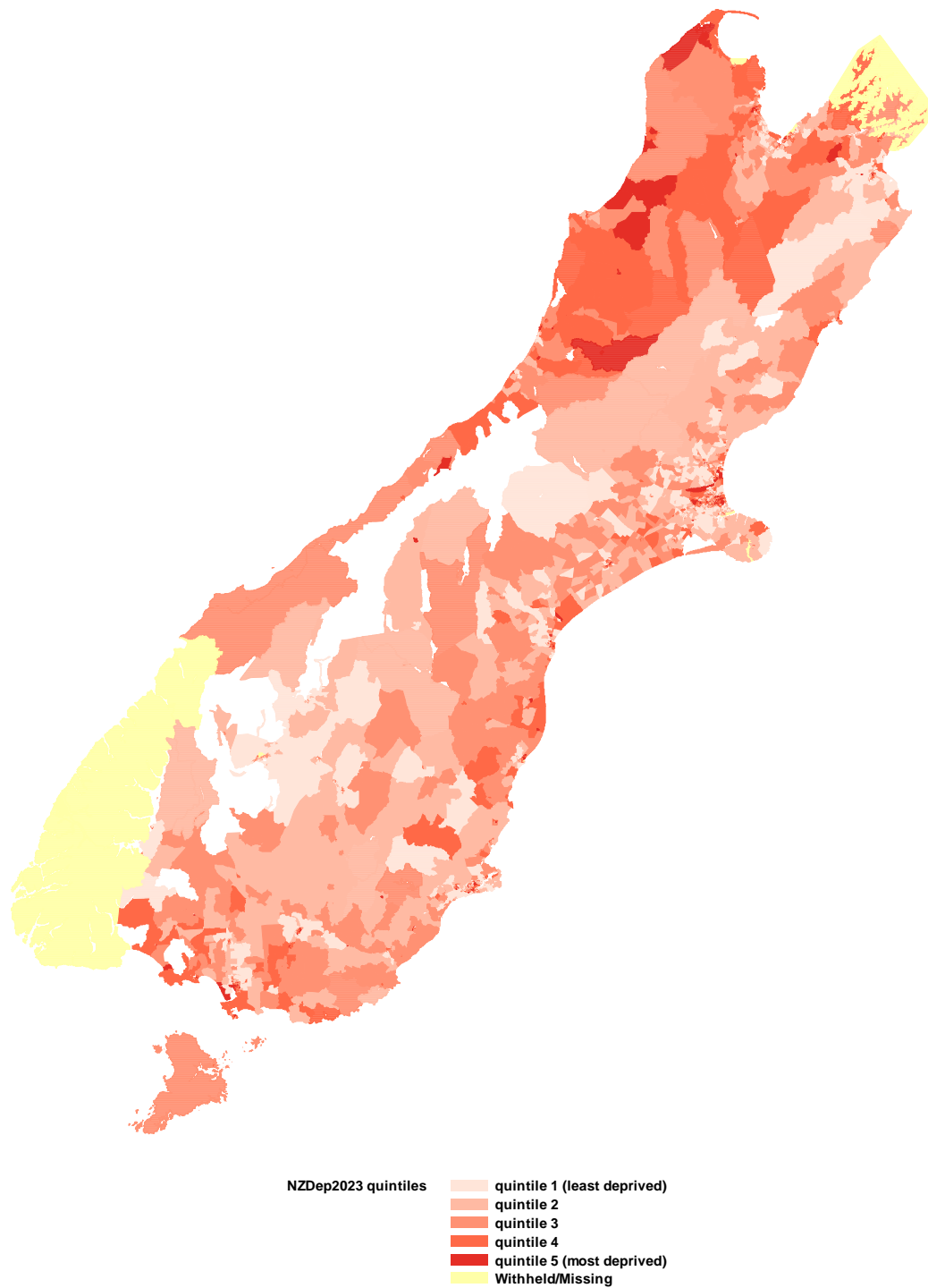


Figure 5: NZDep2023 distribution in the South Island of New Zealand

Yellow areas either had no one, or very few people, usually resident or a withheld NZDep2023 value due to very small numbers of residents providing information.

Glossary of terms and abbreviations

Agglomeration	Combining areas that are geographically connected.
Fixed random rounding	A fixed process whereby all data analyses will produce the same rounded value for the same count. To preserve confidentiality Stats NZ uses rounding to base 3 and suppresses very small numbers.
Meshblock	Meshblocks are the smallest administrative areas used by Stats NZ.
NZDep2023 scale	A ten-category ordinal scale from 1 (assigned to the 10% of NZDep2023 small areas with the least socioeconomically deprived NZDep2023 scores) to 10 (assigned to the 10% of NZDep2023 small areas with the most socioeconomically deprived NZDep2023 scores). (Note the wording to avoid 'reification'—see <i>The indicator becomes the reality</i> , page 14).
NZDep2023 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' socioeconomically 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 NZDep2023. The suite is a product of SAS Institute.
Socioeconomic deprivation	Socioeconomic 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.

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, socioeconomic deprivation of area of residence, etc.
Statistical Area 1 (SA1)	Census SA1s are administrative areas defined by Stats NZ that generally contain between 100 and 200 residents. They are built from meshblocks.
Statistical Area 2 (SA2)	SA2s are administrative areas defined by Stats NZ and built from SA1 areas.
Statistical Area 3 (SA3)	SA3s are administrative areas defined by Stats NZ and built from SA2 areas.
Territorial Authority (TA)	TAs are larger administrative areas defined by Stats NZ.

Appendix 1: 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 were temporarily absent from their usual residence, as long as they could be repatriated to their usual residence. Such people 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 those individual-form people who are living in occupied 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 2023, 0.58 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 2: Description of unchanged NZDep variables

Nine deprivation-related variables have been used to create NZDep2023. Three have already been described above because they included changes since the 2018 version of the index. These changes are the household income threshold, the sole-parent family upper age limit and the overcrowding variable definition (see page 19 onwards). The remaining six variables are described below.

Internet access

In 2013, the internet access variable was restricted to those under 65. In 2018, the age restriction was removed (after testing) since the internet has become increasingly necessary for everyday activities like trading, banking, interacting with government departments, and so on. There is again no age restriction in 2023.

Means tested benefit status

This variable is obtained for those people aged 18 to 64. The means-tested benefits we included in 2023 are the same as those included in 2018: supported living payment, sole-parent support, and job-seeker support (Ministry of Social Development, 2019a and 2019 b). The benefits are described below.

- *Supported living payments*, consisting of the old invalid's benefit and the old DPB for care of the sick and infirm. We needed to include both.
- *Sole-parent support* consisting 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.
- *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 receiving 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.

Unemployed

In the 2023 Census, taken on 7 March, unemployment is defined for all people aged 15 years and over who, during the week ended Sunday 5 March 2023, were without a paid job, were available for work, and had actively sought work in the past four weeks. For NZDep2023, the unemployed variable refers only to the 18 to 64-year age group.

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 the proportion of people in dwellings not owner occupied. For the purposes of NZDep we considered dwellings that were held in a family trust by the occupier to be owner-occupied, as well as those directly owned. Households whose members occupied dwellings that they neither owned nor paid rent for were 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).

Mould and/or Damp

People living in dwellings that are always damp and/or always have mould greater than A4 size are considered to have ‘severe’ mould and/or damp issues. This variable was examined and introduced first in 2018 (see *NZDep2018 Index of Deprivation* (Atkinson et al., 2019, page 23)).

Appendix 3: 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 2023 entitlement to state retirement income, as well as 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.

In 2023, the question on sex was split into two questions, one focusing on sex at birth (male/female), and the other on gender identity (male/female/other). We used the sex at birth in our standardisation process since there are rarely enough people in our small areas to allow for an overall increase in standardisation categories from 8 (2 sexes, 4 age groups) to 12 (3 genders, 4 age groups).

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

We did not standardise the proportions by ethnicity. Small numbers in some ethnic groups in NZDep small areas preclude standardisation by ethnicity as well as age and sex.

Appendix 4: 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 small area.

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 small area 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's and excluding them. The bias when 'not-specified's are included is always negative, whereas the sign of the bias can vary when the 'not-specified's are left out.

Appendix 4: Longitudinal analyses

Introduction

The NZDep2023 index of socioeconomic deprivation is the seventh census-based NZDep index to be produced (the earlier ones were NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013 and NZDep2018). 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 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. In 2023 we increased the upper cut-off for sole-parent families to age 75 instead of age 65.

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 socioeconomic deprivation and some other variable (e.g. mortality) over time.

Our conclusions are that:

- COMPARISONS OF AREAS as small as single meshblocks and SA1s) across time may not be meaningful. Comparisons of areas at a higher aggregation, such as Territorial Authorities or SA2s, 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 55.

Note that each NZDep index of relative deprivation (NZDep91, NZDep96, NZDep2001, NZDep2006, NZDep2013, NZDep2018 and NZDep2023) divides the country into 10, where the highest value indicates the 10 percent of NZDep[year] small areas with the most socioeconomically-deprived NZDep[year] scores. It is important to remember that *by definition 10 percent of small areas will always fall into the most socioeconomically-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 SA1s (and larger geographic areas such as SA2s) can change socioeconomic 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 or SA1 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 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. There were further changes to the boundaries in 2023.

These substantive changes can thus give rise to new meshblocks and 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 as 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-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 was the additional change to SA1s as the starting blocks for any necessary agglomeration. The Statistics New Zealand SA1 boundaries formed a new standard geography for which they are 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 were different from those used before. In 2023, we created 30,629 NZDep2023-specific small areas, which were obtained from 32,523 SA1 2023-geographies. 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 (page 52) shows a close agreement on the form of the various NZDep distributions, where each has been derived with a *mean* of 1000 and a *standard deviation* of 100.

Table 8: Comparison of the NZDep score distributions from 1996 to 2023

Quantile ^a	NZDep96 score	NZDep2001 score	NZDep2006 score	NZDep2013 score	NZDep2018 score	NZDep2023 score
100% (most deprived)	1528	1521	1619	1549	1552	1713
99%	1315	1307	1320	1314	1327	1321
95%	1202	1199	1203	1203	1201	1199
90%	1140	1141	1138	1141	1138	1137
80%	1073	1075	1072	1074	1069	1071
70%	1032	1034	1030	1030	1029	1030
60%	1000	1002	999	1000	999	1001
50% (median)	975	976	974	974	976	977
40%	954	953	953	954	956	957
30%	936	934	935	934	937	938
20%	917	916	918	917	919	919
10%	897	895	899	898	897	896
0% (least deprived)	830	834	838	833	823	827

^a 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. Midpoints from the Household Economic Survey income bounds 2023 have been used as the medians in 2023. 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 cut off 13.9% of

households; the 2001 cut-off was 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 cut off 15.00% of people, as it had been in 2013. In 2023, the threshold cut off 14.88% of people.

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 values.

- d) *One further variable—occupancy—was deliberately changed between the 1996 and 2001 censuses. It was consistent from 2001 to 2018 but was changed slightly in 2023.*

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 to 2018 indexes we 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 *Bedroom occupancy*, page 23). This has resulted in a better performance for the indicator in the principal

component analysis. In 2023 we updated the Canadian definition by referring to the new variable ‘gender’ rather than the previous variable ‘sex’. 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). The weights in 2013 and 2018 (0.303 and 0.314) were again in close alignment with the other weights in those years (ranges 0.286 – 0.372 and 0.301 – 0.384). This situation continues in 2023, where the weight is 0.348 and the range is 0.290 – 0.397.

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 NZDep2001, NZDep2006, NZDep2013, and NZDep2018 indexes, followed by a slight change for NZDep2023 (described above).

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 at a particular time is a relative one. It essentially compares one small area to another relative to the overall distribution of socioeconomic 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 socioeconomic deprivation of a meshblock or SA1 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 socioeconomic-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, that continued in 2023, both being partly mitigated by the use of administrative data. If non-response was unevenly distributed across the socioeconomic-deprivation deciles, then, if they could have been included, they might have changed the decile cut-off values on the underlying first principal component in 2023. Thus, if a small area socioeconomic-deprivation score lay close to a boundary between one decile and the next in 2018, it is possible that the decile value may have changed in 2023 due to the distribution of the 2023 non-response.

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 socioeconomic-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 socioeconomic-deprivation deciles, and the nationally-defined socioeconomic-deprivation deciles have a nearly consistent meaning, on a relative scale, regardless of time.

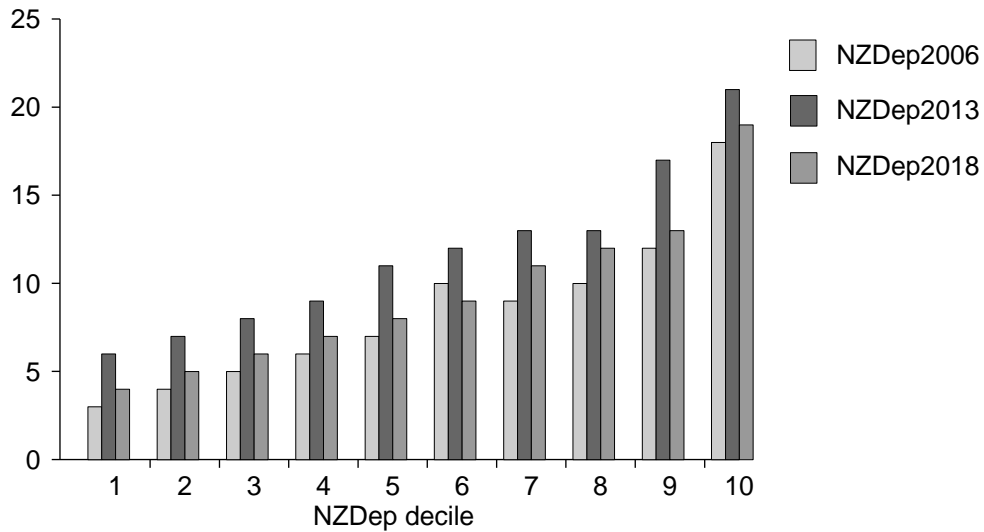


Figure 6: Comparing deprivation deciles over time using hypothetical outcome data

We conclude that

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

Appendix 5: Future versions of NZDep

The NZDep indexes use anonymised information from the five-yearly census returns. In 2023, Stats NZ floated the idea that the expensive census data collection process should be replaced, in whole or in part, by administratively collected data stored in their Integrated Data Infrastructure (IDI). The NZDep team responded to Stats NZ's request for submissions on the future of the census with the following letter. A decision about the future of the Census is expected in early/mid-2025.

15 June 2024

Re: submission re the approach to the 2028 Census

Thank you for the opportunity to provide a submission about the content and nature of the 2028 Census. Our submission is written specifically in the context of our work on the NZDep small-area index of relative socioeconomic deprivation, and our data needs for future iterations of the index.

Who we are

We are the team working on the production of the NZDep2023 index of socioeconomic deprivation. This work is funded by Te Manatū Hauora (Ministry of Health) and by Ōtākou Whakaihu Waka (University of Otago) and is being carried out in close collaboration with Statistics New Zealand.

Clare Salmond and Peter Crampton have been involved in the production of the NZDep indexes since the first iteration, NZDep91, which was based on the 1991 Census. The 2023 version of the index is the seventh iteration. June Atkinson has been involved in the creation of NZDep since 2006, and Kura Lacey and Helen Viggers have joined the team this year.

Since its creation in the mid-1990s, NZDep has been widely used in Aotearoa as a tool for resource allocation, planning, needs assessment, community-based advocacy and research. The index is widely accepted as a tool both for highlighting the social and health needs of communities and for directing resources into those communities. It will be included on the StatsNZ website as an output of the 2023 Census in October this year when we have finalised its production.

Purpose of this submission

In this submission we highlight our data needs in the context of the production of NZDep and, more generally, the unique ability of the Census to count everyone,

particularly those living in communities that are socially or economically marginalised. Our priority is to create a tool that captures aspects of the living conditions of those most in need of effective social, economic, education and health policies so that they are not *further* marginalised by the processes of policy development and resource allocation that are intended to address their needs.

We acknowledge the rapidly changing social and demographic landscape that forms the backdrop for the 2028 Census, and the challenges associated with data collection, social licence, iwi data sovereignty, and the changing data needs of iwi, communities and policy makers. While these challenges make for a highly complex context for the 2028 Census, because of these challenges we believe that, from a policy perspective, the requirement for regular, high quality, comprehensive, universal data collection is now stronger than ever.

Our need for data in the 2028 Census

In order to create the NZDep index of socioeconomic deprivation we require Census data that cover all individuals and households. Survey data are of no use for the production of NZDep as they do not cover the entire population and we cannot use data imputation for our purposes. In any case, surveys are likely to under-represent those individuals, whānau and communities most in need. To expand on this point slightly, in order to create NZDep we need accurate data for very small geographies (SA1), because the small size of the small areas is intended to locate small pockets of relative socioeconomic deprivation. Many of the areas that we use are single SA1s (87% of small areas in NZDep2018 were 1 SA1; 12% were 2 SA1s). Survey data do not provide SA1-level data; only Census data achieve that level of resolution and accuracy.

Administrative data sources provide us with some of the variables we require, but are lacking in terms of:

1. Household enumeration;
2. Household and family relationships (currently administrative data do not define satisfactorily household and family relationships, especially current ones, which are very important in creating NZDep);
3. The ability to calculate household-level variables such as equivalised household income and household crowding;
4. Quality of housing data (e.g. damp and mould);
5. Access to the internet at home (in previous versions of the index this has emerged as an important variable that reflects access to resources, goods and services and opportunities for participation in society);
6. Housing tenure; and

7. Smoking status (which we use as an external criterion variable for validating the index).

The input variables used in the NZDep indexes have evolved slightly from Census to Census as the underlying social meaning of variables changes over time. For your information, the following table shows the variables that were included in the 2018 version of the index and whether, or not, they are available in the IDI. We have been exploring other variables that are available in the IDI but not available in the Census. There are very few likely candidate variables in the IDI that are 1) consistent with the theoretical underpinning of the NZDep index and 2) likely to be salient and useful to us.

Variables included in NZDep2018 and their potential for inclusion in NZDep

NZDep2018 variables	Available in: <ul style="list-style-type: none"> • Other IDI sources also, or • Census only
People with no access to the internet at home	Census only
People aged 18 - 64 receiving a means tested benefit	Other IDI sources also
People living in equivalised households with income below an income threshold	Census only (we can obtain income from other IDI sources, but because other IDI sources do not define household and family relationships, we are not able to calculate equivalised household income)
People aged 18 - 64 unemployed	Other IDI sources also
People aged 18 - 64 without any qualifications	Other IDI sources also for some of the population, but not for older adults or those with only overseas qualifications
People not living in own home	Status unclear for majority of population
People aged < 65 living in a sole-parent family	Census only
People living in households below a bedroom occupancy threshold	Census only (because other IDI sources do not define satisfactorily household and family relationships (people, ages, relationships) and number of bedrooms in the dwelling, we are not able to calculate equivalised bedroom occupancy)
People living in dwellings that are always damp and/or always have mould greater than A4 size	Census only (because other IDI sources do not define household and dwelling conditions (mould, damp etc), we are not able to measure the quality of living conditions)

References

- Atkinson J, Salmond C and Crampton P** (2014). *NZDep2013 Index of Deprivation*. Wellington, Department of Public Health, University of Otago, Wellington. www.otago.ac.nz and www.moh.govt.nz.
- Borman B** (1992). *The Standardisation of Rates*. Wellington, Department of Health.
- Carr-Hill R and Chalmers-Dixon P** (2002). *A review of methods for monitoring and measuring social inequality, deprivation, and health inequality* (June 2002 Edition). <http://www.sepho.org.uk/HealthInequalities/carrhill/empty.htm>
- Crampton P, Salmond C and Sutton F** (1997a). NZDep91: a new index of deprivation. *Social Policy Journal of New Zealand*, 9, 186-193.
- Crampton P, Salmond C and Sutton F** (1997b). *Research Report No. 5: NZDep91 Index of Deprivation*. Wellington, Health Services Research Centre.
- Crampton P, Salmond C and Sutton F** (1997c). *NZDep91 Index of Deprivation Instruction Book*. Wellington, Health Services Research Centre.
- Crampton P, Salmond C and Sutton F** (1997d). *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.
- Crampton P and Davis P** (1998). Measuring deprivation and socioeconomic status: why and how. *The New Zealand Public Health Report*, 5, 81-84.
- Crampton P, Salmond C, Kirkpatrick R, Scarborough R and Skelly C** (2000a). *Degrees of Deprivation in New Zealand: An atlas of socioeconomic difference*. Auckland, David Bateman Ltd.
- Crampton P, Salmond C, Woodward A and Reid P** (2000b). Socioeconomic deprivation and ethnicity are both important for anti-tobacco health promotion. *Health Education and Behaviour*, 27, 317-327.

- Crampton P and Salmond C** (2000c). Socioeconomic deprivation and hospitalisation rates in New Zealand. *Australasian Epidemiologist*, 7, 20-24.
- 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.
- 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>
- Jensen J** (1978). *Minimum income levels and income equivalence scales.* Wellington, Department of Social Welfare.
- Jensen J** (1988). *Income equivalences and the selection of family expenditures on children.* Wellington, Department of Social Welfare.
- Kirkwood B** (1988). *Essentials of Medical Statistics.* Oxford, Blackwell Scientific Publications.
- Ministry of Social development** (a). Changes to benefit categories from 15 July 2013. <https://www.msd.govt.nz/about-msd-and-our-work/publications-resources/statistics/benefit/#Impactof2013WelfareReformonbenefittrends4> (accessed September 2019)
- Ministry of Social development** (b). Benefit fact sheets.
<https://www.msd.govt.nz/about-msd-and-our-work/publications-resources/statistics/benefit/benefit-factsheet-changes-2013.html#Howdotheoldbenefitcategoriescomparewiththenewcategories2> (accessed September 2019)
- Morrison P** (1994). Housing occupancy and the changing size of households and dwellings in New Zealand 1951-1991. *New Zealand Population Review*, 20, 69-100.
- Salmond C, Crampton P and Sutton F** (1998c). *Research Report No. 8, NZDep96 Index of Deprivation.* Wellington, Health Services Research Centre.

- Salmond C, Crampton P and Sutton F** (1998d). NZDep91: a new index of deprivation. *Australian and New Zealand Journal of Public Health*, 22, 95-97.
- Salmond C, Crampton P, Hales S, Lewis S and Pearce N** (1999). Asthma prevalence and deprivation: a small area analysis. *Journal of Epidemiology and Community Health*, 53, 476-480.
- Salmond C and Crampton P** (2000). *Deprivation and Health*, in Howden-Chapman, P. and Tobias, M. (eds.), *Social Inequalities in Health: New Zealand 1999*. Wellington, Ministry of Health.
- 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** (2002a). Heterogeneity of deprivation within very small areas. *Journal of Epidemiology and Community Health*, 56, 669-670.
- Salmond C and Crampton P** (2002b). *NZDep2001 Index of Deprivation*. Wellington, Department of Public Health, Wellington School of Medicine and Health Sciences.
- Salmond C and Crampton P** (2002c). *NZDep2001 User's Manual*. Wellington, Ministry of Health.
- 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.
- Salmond C, Crampton P and Atkinson J** (2007). *NZDep2006 Index of Deprivation*. <http://www.otago.ac.nz/wellington> and <http://www.health.govt.nz>
- Salmond C, Crampton P, Atkinson J and Edwards R** (2012a). A decade of tobacco control efforts in New Zealand (1996-2006): impacts on inequalities in census-derived smoking prevalence. *Nicotine & Tobacco Research* 2012;14(6):664-673. doi: 10.1093/ntr/ntr264.
- Salmond CE and Crampton P** (2012b). 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 and Crampton P** (2012c). Measuring socioeconomic position in New Zealand, *J Prim Health Care*, 4(4), 271-280.
- Statistics New Zealand** (1998). *New Zealand Now: Housing*. Wellington, Statistics New Zealand.
- Statistics New Zealand** (2017). *Investigating different measures of energy hardship in New Zealand*. Wellington, Statistics New Zealand.
- Stephens R and Waldegrave C** (2001). The effectiveness of the transfer and tax system in reducing poverty in 1998. *Social Policy Journal of New Zealand*, 16, 76-107.
- Tobias M, Salmond C, Crampton P, Chan M, Marmot M and Reid P** (2001). *Life Expectancy and Small Area Deprivation in New Zealand*. Public Health Intelligence Occasional Bulletin No. 6, Wellington, Ministry of Health.
- Townsend P** (1987). Deprivation. *Journal of Social Policy*, 16, 125-146.
- Ulrich Cloher, D and Murphy L** (1994). *Maori housing needs (Northland)*. Housing Research Conference Proceedings 1994, Ministry of Housing.
- White P, Gunston J, Salmond C, Atkinson J and Crampton P** (2008). *Atlas of Socioeconomic Deprivation in New Zealand: NZDep2006*. Wellington, Ministry of Health.
- Whiteford P** (1983). A family's needs: equivalence scales and social security. *Social Security Journal*, December, 54-61.
- Whitehead J, Atkinson J, Davie G, De Graaf B, Eggleton K, Crengle S, Miller R, Blattner K, Crampton, and Nixon G** (2023). Comparison of the sociodemographic composition of rural and urban Aotearoa New Zealand: Insights from applying the Geographic Classification for Health to the 2018 Census. *New Zealand Population Review*, 49, 27-69.
- Wilson N, Blakely T and Tobias M.** (2006). What potential has tobacco control for reducing health inequalities? The New Zealand situation. *International Journal for Equity in Health*, 5, 14.