MINISTRY OF HEALTH
MANATŪ HAUORA

New Zealand Government

Sample Design from 2015/16

New Zealand Health Survey

New Zealand Health Survey

Released 2016 **health.govt.nz**

Authors

This report was written by Robert Clark (National Institute for Applied Statistics Research Australia, NIASRA, University of Wollongong, Australia), with input from Steven Johnston (Health and Disability Intelligence Group, Ministry of Health).

Citation: Ministry of Health. 2016. *Sample Design from 2015/16: New Zealand Health Survey*. Wellington: Ministry of Health.

Published in December 2016
by the Ministry of Health
PO Box 5013, Wellington 6140, New Zealand

ISBN 978-0-947515-90-4 (online)
HP 6520

This document is available at health.govt.nz

Contents

List of Tables

List of Figures

1 Introduction

The New Zealand Health Survey (NZHS) is an important data collection tool, used to monitor population health and provide supporting evidence for health policy and strategy development. The NZHS is the source for eight Tier 1 statistics, which are the most important official statistics for understanding how well New Zealand is performing. The survey operates under the principles and protocols for producers of Tier 1 Statistics (Statistics New Zealand 2007).

The Health and Disability Intelligence Group, within the Ministry of Health's (the Ministry's) Client Insights and Analytics business unit, is responsible for designing, analysing and reporting on the NZHS.

The NZHS has been in continuous operation since July 2011. Before this, the NZHS was a stand-alone survey conducted once every three or four years. A previous report, *The New Zealand Health Survey: Sample design, years 1–3 (2011–2013) (*Ministry of Health 2011), describes the sample design for years 1–3 of the continuous survey (July 2011 to June 2013). Year 4 of the survey (2014/15) used essentially the same design as years 1–3. This report describes the sample design for year 5 of the survey (2015/16) onwards.

1.1 Sample design

The continuous NZHS sample design was developed in collaboration with the National Institute for Applied Statistics Research Australia (NIASRA), University of Wollongong, Australia. The Ministry has contracted a professional survey company, CBG Health Research Ltd, to conduct the survey field activities.

The NZHS sample is selected using a dual-frame design, with an area component covering the general population and an electoral roll component restricted to addresses where at least one adult has indicated Māori descent on the electoral roll. Both components use stratified multi-stage area designs: selecting a sample of areas from each district health board (DHB), a sample of households from each selected area, and a sample of one adult and up to one child from each selected household.

This report describes in detail the sample design and the selection of areas for the year 5 (2015/16) NZHS. The major changes from the years 1–4 design are as follows.

- The first stage of the sample selection is a sample of areas. The areas used for this purpose are Statistics New Zealand's (SNZ's) household surveys frame primary sampling units (PSUs). In years 1–4, the areas selected were SNZ's meshblocks. SNZ PSUs are groups made up of one or more meshblocks. There have also been some associated changes to the selection probabilities and the number of dwellings selected from each PSU.
- PSU selection is now conducted using the SNZ coordinated selection facility to manage overlaps between various government household surveys and minimise the number of households being revisited for the NZHS in particular.
- PSUs in the area component of the sample are now used on two separate occasions in the same calendar year but in different reporting years.

1.2 Survey content

The survey involves face-to-face computer-assisted personal interviews (CAPIs) with adults aged 15 years and older and children aged 0–14 years, the latter through a parent or legal guardian, who acts as a proxy respondent.

The objectives and topic areas for the NZHS are summarised in *The New Zealand Health Survey: Objectives and topic areas August 2010* (Ministry of Health 2010). The survey comprises a set of core questions that are always asked and a flexible programme of rotating topic modules, which change every or 12 months.

Details of the current survey questionnaire can be found in the *Content Guide 2015/16* (Ministry of Health 2016). In addition to the questionnaire, the survey includes a range of objective tests, which currently measure height, weight and blood pressure.

The use of a continuous survey with core and module questions allows content to be more flexible and information to be updated more frequently. The ability to add survey questions on a range of topics of emerging policy interest and to monitor outcomes before and after different periods enhances the survey's contribution to the evidence base for health policy.

1.3 Reporting

Since 2011/12, key health indicators have been compiled using annual NZHS data. Regional and DHB statistics have also been produced by pooling data from up to three years of the survey to improve the range and statistical quality of analyses that can be undertaken at that level. Pooling annual data sets can also improve the statistical precision of estimates for Māori and ethnic minorities (including Pacific and Asian ethnic groups).

2 Sample design objectives

The main objectives of the sample design are to:

- provide estimates for a range of prevalences, including health behaviours and health conditions
- provide estimates for children and adults
- provide estimates by ethnic group
- provide estimates by geographical region, including DHB regions, with age, sex and ethnicity breakdowns where feasible
- support analysis of the survey data by multiple users.

The objective of providing reasonable estimates for Māori, Pacific and Asian ethnic groups is a particular priority. These groups are a minority of the population, and would have only a small sample size if a typical multi-stage area-based sample design were used, leading to inadequate precision for statistics for these groups. As a result, the main focus of the sample design is to ensure adequate estimates for these subpopulations while preserving reasonable precision at the national level.

In order to boost the Māori sample size, a dual-frame approach is used. This combines an area-based sample from New Zealand as a whole with a list-based sample of addresses from the electoral roll. In addition, the area-based sample has been targeted at the ethnic groups of interest by assigning higher probabilities of selection to PSUs that are known to have higher concentrations of these groups.

A different approach was used in the 2006/07 survey. For that survey, a subset of the selected households was designated as an ethnic 'oversample', which meant that only residents who were identified as Māori, Pacific or Asian through a doorstep screening process could be selected. This kind of screening has not been used in the continuous NZHS from 2011 because it was felt that asking the initial contact to report on the ethnicity of all household members might create a barrier to people's participation in the survey. Moreover, this type of screening is not always reliable, particularly for the Māori population, of whom about 20 percent are not identified by the approach.

3 Determining sample size

The sample size was set to approximately 14,000 adults and 5000 children when the NZHS became a continuously operating survey in 2011. These sample sizes were based on both the budget available and an assessment of the required precision for annual levels and changes in key national and Māori indicators.

The NZHS sample size is more than adequate for sufficiently precise national and Māori indicators. However, the survey is used for more than just national indicators, and comparisons between subgroups are important outputs. We find that for understanding differences and inequalities within New Zealand, the current sample size supports some comparisons of interest but not others. The current sample size remains a reasonable compromise between the budget available and survey users' requirements.

Table 1 summarises the precision of the national indicators. The table shows estimated prevalences and standard errors for annual level and movement estimates for some of the most important national adult indicators. Statistics for these indicators are published in the annual Tier 1 report.

Table 1: Achieved standard errors for the 2014/15 year national prevalences and annual changes from 2013/14 to 2014/15

Indicator	2014/15 year prevalence (%)	Standard errors (%)	
		2014/15 year	Change from 2013/14 to 2014/15
Poor or very poor self-assessed health	10.7	0.44	0.56
Current smoking	16.4	0.38	0.59
Hazardous drinker	18.0	0.54	0.72
Obesity	30.8	0.63	0.83
Psychological distress	6.1	0.32	0.47
Unmet need for GP due to cost	13.7	0.41	0.61
Unfilled prescription due to cost	6.4	0.30	0.43

Table 2 contains information on the precision of age-group-by-sex indicators. These are important because Tier 1 statistics broken down by age (for seven age groups), sex, ethnicity and deprivation index are published each year. Table 2 shows the maximum standard error across 14 age-group-by-sex cells for the same set of national indicators as Table 1. The table shows maximum standard errors for the 2014/15 year prevalences and 2013/14 to 2014/15 changes. The maximum cell standard errors for level and movement are 1.4–2.8 percent across the seven key indicators.

In the executive summary of the 2014/15 annual update (Ministry of Health 2015), differences between age groups are discussed for a number of indicators. Table 2 also shows the maximum standard error of the difference in prevalence between two age groups, for each indicator. These range from 1.9–3.7 percent.

Table 2: Maximum achieved standard errors across 14 age-group-by-sex cells for the 2014/15 year prevalences and annual changes from 2013/14 to 2014/15

Indicator	2014/15 year prevalence (%)	Maximum standard error (%)		
		2014/15 year by age group and sex	Change from 2013/14 to 2014/15 by age group and sex	Differences between age-group-by-sex cells in the 2014/15 year
Poor or very poor self-assessed health	10.7	1.98	2.71	2.52
Current smoking	16.4	2.06	2.80	2.92
Hazardous drinker	18.0	2.31	3.11	3.04
Obesity	30.8	2.77	3.83	3.74
Psychological distress	6.1	1.61	2.18	2.11
Unmet need for GP due to cost	13.7	1.96	2.60	2.63
Unfilled prescription due to cost	6.4	1.38	1.69	1.88

Table 3 shows standard errors of prevalence estimates for the Māori population. For the 2014/15 year prevalences, the standard errors range from 0.8–1.4 percent. For 2013/14 to 2014/15 changes, the standard errors are between 1.3 and 2.0 percent.

Table 4 summarises standard errors for comparing Māori adults with others, Pacific adults with others and the least and most deprived meshblocks (New Zealand deprivation index 2013 – NZDep 2013). These types of comparisons are also drawn in the 2014/15 annual update executive summary. The median standard errors across the seven indicators were 1.1 percent for Māori compared with others, 1.9 percent for Pacific compared with others and 1.6 percent for most compared with least deprived areas.

The annual update also compares regions. Table 5 shows maximum standard errors across DHBs for the 2014/15 year prevalences and annual movements from 2013/14 to 2014/15. The largest standard error for a difference in prevalence between any two DHBs is also shown. These range from 3.5–12.0 percent, so only large differences between DHBs are detectable. They represent the worst case across all pairs of DHBs – some DHB comparisons are more precise, for example, between two of the larger DHBs. In order to improve the precision of DHB statistics, these estimates will usually be based on pooling multiple years of survey data, leading to much lower standard errors than those shown in Table 5.

Table 3: Achieved standard errors for the 2014/15 year Māori population prevalences and annual changes from 2013/14 to 2014/15

Indicator	2014/15 year prevalence (%)	Standard errors (%)	
		2014/15 year	Change from 2013/14 to 2014/15
Poor or very poor self-assessed health	14.5	0.82	1.28
Current smoking	37.7	1.39	1.95
Hazardous drinker	33.1	1.30	1.91
Obesity	46.7	1.43	1.92
Psychological distress	9.8	0.90	1.28
Unmet need for GP due to cost	19.9	1.04	1.53
Unfilled prescription due to cost	14.2	0.81	1.25

Table 4: Achieved standard errors of differences in the 2014/15 year prevalences between Māori/non-Māori, Pacific/non-Pacific and highest/lowest NZDep 2013 quintile

Indicator	2014/15 year prevalence (%)	Standard error of differences in prevalences (%)		
		Māori/non-Māori	Pacific/non-Pacific	High/low NZDep 2013
Poor or very poor self-assessed health	10.7	1.04	1.55	1.74
Current smoking	16.4	1.37	1.64	1.23
Hazardous drinker	18.0	1.28	1.91	1.55
Obesity	30.8	1.41	2.29	2.22
Psychological distress	6.1	0.88	1.28	0.99
Unmet need for GP due to cost	13.7	1.06	1.96	1.57
Unfilled prescription due to cost	6.4	0.85	1.96	0.94

Table 5: Maximum achieved standard errors for the 2014/15 year DHB prevalences and annual changes from 2013/14 to 2014/15

Indicator	2014/15 year prevalence (%)	Maximum standard error (%)		
		2014/15 year by DHB	Change from 2013/14 to 2014/15 by DHB	Differences between DHBs in 2014/15
Poor or very poor self-assessed health	10.7	3.16	4.05	4.83
Current smoking	16.4	10.60	11.24	10.91
Hazardous drinker	18.0	10.88	11.26	11.96
Obesity	30.8	5.79	8.11	7.42
Psychological distress	6.1	3.59	3.74	3.95
Unmet need for GP due to cost	13.7	4.78	8.20	6.22
Unfilled prescription due to cost	6.4	2.38	5.88	3.51

4 Sample design

4.1 Survey population

The survey population includes the New Zealand 'usually resident' population of all ages, including those living in aged-care facilities and student accommodation. Other non-private dwellings such as prisons, hospitals, hospices and dementia care units are excluded from the survey population.

The survey sample consists of an area component and an electoral roll component, which are then combined to form the complete sample. These two components are described more fully below.

4.2 Area component

A multi-stage design is used. The initial stage of selection is a sample of SNZ PSUs, followed by a sample of households from each selected PSU, then a sample of one adult and (up to) one child from each selected household. For an overview of multi-stage and other sample designs, see Lohr (1999).

Selecting primary sampling units

Meshblocks are the smallest geographical unit used by SNZ for producing statistics. Information on New Zealand's meshblocks is publicly available from SNZ.

SNZ PSUs are small geographic areas consisting of around one to three meshblocks on average. PSUs are the main sampling unit that SNZ have developed and maintain for their own household surveys. They are designed to be geographically contiguous in most cases and to be more even in population and numbers of dwellings than meshblocks. There are approximately 40,000 meshblocks and 20,000 PSUs in New Zealand. SNZ update the PSU pattern after each census. The 2014 PSUs are currently being used; these are based on the 2013 Census.

PSUs are selected with probability proportional to their size (PPS). The measure of size is based on the number of occupied dwellings according to the most recent census. Approximately equal numbers of households are then selected from each selected PSU. This ensures every household in the population has the same probability of being selected. This type of design is sometimes referred to as 'self-weighting' and is statistically efficient, particularly when the initial sampling units vary considerably in size.

This approach was modified using a targeting factor to give higher probabilities of selection to areas where Pacific or Asian people are more populous. Māori populations are not considered in this approach because an evaluation conducted as part of the years 1–3 sample design found that it is more statistically efficient to oversample the Māori population using the electoral roll component rather than via unequal probability sampling in the area component. In contrast, the Pacific and Asian populations cannot be effectively oversampled using the electoral roll, and area-based targeting is the only option for these groups.

The probability assigned to PSU *i* is:

Formula 1

$$\pi_i = m_h N_i^* f_i \; / \left(\sum_{i \in h} N_i^* f_i \right)$$

where N_i^* is the number of occupied dwellings in PSU *i* according to the most recent census data available, m_h is the required sample size of PSUs in DHB *h* and f_i is a 'targeting factor' by which areas with more Pacific or Asian people are expected to be oversampled.

The targeting factor was calculated using a combination of the Pacific and Asian densities at the PSU and area unit (AU) levels. AUs are larger geographic units than PSUs, consisting of a group of meshblocks; there are approximately 1900 AUs across New Zealand.

The formula for f_i is:

Formula 2

$$f_i = 0.03 + 0.40\sqrt{\left(\text{Pacific PSU density} + \text{Pacific AU density}\right)/2} + \\ +0.12\sqrt{\left(\text{Asian PSU density} + \text{Asian AU density}\right)/2}$$

This targeting factor was designed to:

- target the PSU selection at areas with higher proportions of the population belonging to the Pacific or Asian ethnic groups
- reflect the uncertainty attached to Pacific and Asian PSU data from the previous census (which is out of date to some degree) by making use of AU densities that would be more stable over time
- avoid nil or very small probabilities of selection for PSUs with no Pacific or Asian populations in the last census
- avoid excessive variation in selection probabilities, which would result in increased standard errors (Kish 1992).

The exact weightings used in Formula 2 were obtained by an analysis combining NZHS data and census data. Details of the methodology used may be found in Appendix 1 of *The New Zealand Health Survey: Sample design, years 1–3 (2011–2013)* (Ministry of Health 2011) and Clark (2013). For further information about the approach, see Clark (2009, 2010), Clark et al (2009), Clark and Templeton (2014) and Clark et al (2013).

The DHB sample sizes, m_h, are proportional to the square root of the DHB population. This is an example of power allocation (Bankier 1998) and is designed to be a compromise between the best design for national estimates (which would have DHB sample sizes roughly proportional to their populations) and the best design if all DHB estimates are equally important (which would suggest equal DHB sample sizes). This is the same approach as taken in years 1–4. However, the resulting allocation has changed because of population movements and the merger of the Otago and Southland DHBs, which resulted in there now being 20 rather than 21 DHBs.

Selecting households from the primary sampling units

An equal probability sample of households is selected from each selected PSU, with a sampling fraction of the smaller of c/N_i^* and ½, where *c* is the target within-PSU sample size. If the number of dwellings in the PSU is still the same as at the census, then *c* households are selected. The number of households selected is different from *c* to the extent that the current PSU size has changed from N_i^* (the PSU size in the 2013 Census). Within-PSU sampling fractions are constrained to be ½ or less for area component PSUs, so that non-overlapping samples of households can be selected from these PSUs in two different quarters (for more information, see section 5.3 Re-using area component primary sampling units).

The target within-PSU sample size, *c*, is a trade-off between cost and sampling error. If *c* is large, then the sample is highly clustered. This means that relatively few PSUs need to be selected to achieve a given sample size of households. This reduces interviewer travel costs but increases the sampling error because there is more chance of selecting an unrepresentative sample of PSUs. If *c* is small, then travel costs are higher, but sampling errors are lower.

The best *c* value depends on the indicator to be estimated, in particular, its 'intra-class correlation' (a measure of the indicator's geographical clustering). The higher the intra-class correlation, the smaller the cluster size should be, which implies a lower *c* value.

The *c* value for the NZHS has been set to 21. This is larger than is common for many household surveys, but is thought to be appropriate for the NZHS for the following reasons.

- Intra-class correlations for most rare health condition indicators are small, and therefore a larger cluster size is appropriate. Intra-class correlations for health behaviour indicators are higher, but prevalences for these indicators are also higher, and so their standard error targets can be achieved more easily (see Table 6).
- Cluster sizes for subpopulations such as Māori, Pacific or Asian people are generally significantly smaller than 21 since not all respondents from a PSU will belong to a given subpopulation.

The net result of the sampling of PSUs and this within-PSU sampling method is that household probabilities of selection are proportional to the targeting factor, f_i, within DHBs.

Selecting one adult and one child from selected households

In the final stage of selection, one adult (15 years and over) and one child (0–14 years, if any) is selected at random from each selected household.

Including residents of non-private dwellings

Any aged-care facilities in the selected PSUs are identified and included in the area-based sample, with 'accommodation units' taking the place of households. Accommodation units have been defined based on operational convenience and typically comprise either individuals or couples living together in an institution. Accommodation units are listed with other households in selected areas and are selected systematically. One adult is selected from each selected household and accommodation unit.

Students living away from home in university hostels and boarding schools are eligible to be selected via their family's house, if they still consider this to be their home. If selected, arrangements are made to survey them either when they are next at home or at their student accommodation.

Table 6: Summary of selected design indicators

Indicator	Weighted mean	Estimated intra-meshblock correlation (2014/15 year)		Estimated intra-PSU correlation (2015/16 quarter 1)*		Deff due to clustering**
		Unconditional	Conditional on ethnicity, age group and sex	Unconditional	Conditional on ethnicity, age group and sex	
Poor or very poor self-assessed health	0.111	0.020	0.016	0.028	0.026	1.55
Current smoking	0.166	0.076	0.035	0.067	0.039	1.81
Hazardous drinker	0.177	0.056	0.036	0.027	0.013	1.28
Obesity	0.307	0.070	0.032	0.042	0.021	1.45
Psychological distress	0.062	0.028	0.025	0.021	0.016	1.33
Unmet need for GP due to cost	0.137	0.051	0.042	0.056	0.044	1.93
Unfilled prescription due to cost	0.065	0.078	0.047	0.060	0.041	1.86

* Intra-PSU correlations were estimated using data from quarter 1 of the 2015/16 year, because this was the only data available at the time of writing that was selected using PSUs. 2014/15 year data are used for all other calculations in this report, as this was the most recent complete year of data available at the time of writing.

** Approximate design effects (Deffs) due to clustering (defined as the factors by which the variances of estimates are inflated) were calculated using the conditional intra-class correlation, assuming exactly 21 households were selected in each PSU.

4.3 Electoral roll component

The electoral roll is used to obtain a sample of eligible addresses, where at least one person has self-identified as having Māori ancestry. This electoral roll list is obtained quarterly.

Sampling from the electoral roll

Stratified three-stage sampling is used to select the sample from the electoral roll.

The first stage involves selecting a sample of PSUs within each stratum (DHB), with probability proportional to the number of eligible addresses. The sample of PSUs is selected so that it does not overlap with the sample for the area-based sample. PSUs with four or less eligible addresses are given nil chance of selection in the roll sample. This does not result in undercoverage of people in these PSUs because they still have a chance of selection in the area component and the combined sample is weighted to reflect the combined probability of selection.

PSU sampling is carried out once a year for the following calendar year. Each year, the probabilities of selection are recalculated using the most recent electoral roll available. This is in contrast to the area-based sample, where the probabilities of selection are calculated from census counts that do not change from year to year.

The second stage involves selecting a random sample of 14 eligible addresses from each selected PSU (or all eligible addresses if the PSU contains less than 14).

Finally, one adult (15 years and over) and one child (0–14 years, if any) is selected at random from each selected address.

The electoral roll has been used in order to increase the recruitment rate of Māori into the sample. However, the household contact process and selection of an adult and child are carried out exactly as for the area-based sample. In particular, an adult and a child (if any) can be selected even if one or both are non-Māori and even if some other household members are Māori. This ensures that probabilities of selection can be correctly calculated for all respondents.

4.4 Summary of sample sizes

Table 7 summarises the expected quarterly and annual sample sizes for the NZHS, assuming a 70 percent response rate.

Table 7: Expected quarterly and annual sample sizes

	Quarterly sample size			Annual sample size
	Area-based sample	Electoral roll sample	Total	
Expected number of PSUs	180	70	250	1000
Approximate number of households approached	3780	980	4760	19,040
Expected number of adult interviews to be completed*	2646	686	3332	13,328
Expected number of child interviews to be completed*	1058	274	1332	5328

* Allowing for 30 percent non-response.

5 Sample selection process

5.1 Selecting primary sampling units

Selection probabilities for both the area and roll components are calculated for each PSU in New Zealand (see section 4 Sample design). PSUs whose DHB is listed as 99 are excluded from selection; these represent about 0.1 percent of all dwellings. These selection probabilities are then passed to SNZ each year, generally around November, to select the PSUs that will be used in the NZHS for the following calendar year.

SNZ select 360 PSUs for the area sample, minimising overlap with PSUs recently selected in SNZ and other subscribing New Zealand government household surveys (including previous NZHS samples). Only 360 PSUs are selected, representing two quarters of selections because area PSUs will each be surveyed twice (for more details, see sections 5.3 and 6.3 Re-using area component primary sampling units).

SNZ then select 280 electoral roll PSUs that do not overlap with the 360 selected area PSUs and that have minimal overlap with previous SNZ and other New Zealand government household surveys.

The 360 selected area PSUs are allocated to the first two quarters of the calendar year by ordering the PSUs by DHB and population, and then assigning quarters 1 and 2 to alternating PSUs. The 280 electoral roll PSUs are ordered by DHB and number of eligible electoral roll households, and quarters 1 to 4 are then assigned to alternating PSUs.

5.2 Selecting households within primary sampling units

The following process is used to select households in the NZHS.

Let $c_{area} = 21$ and $c_{roll} = 14$ be the target sample sizes of households in each PSU, in the area-based and electoral roll samples, respectively.

Let N_i^* be the number of dwellings in PSU i according to the most recent census. Let $N_{i(roll)}$ be the number of dwellings in PSU i where there is one or more residents who nominated Māori ancestry on the electoral roll, according to the snapshot of the electoral roll used to determine the PSU probabilities of selection.

The household skip for PSU i for the area-based sample is calculated as:

$$k_{i(area)} = \max\left(N_i^* / c_{area}, 2\right)$$

The household skip for PSU i for the electoral roll sample is calculated as:

$$k_{i(roll)} = \max\left(N_{i(roll)} / c_{roll}, 1\right)$$

If a PSU *i* is selected in the area-based sample, with a skip of *k*, the process used can be described as follows.

1. Occupied dwellings in the selected PSU are listed and numbered, ordered by street name, then house number within the street.
2. A random start, *r*, between 0 and *k* is selected, with *r* also being a non-round number (ie, *r* is generated from the uniform distribution between 0 and *k*, or equivalently, from the uniform [0, 1] distribution multiplied by *k*).
3. The households to be selected are identified by the numbers given by rounding *r*, $r + k$, $r + 2k$, ..., up to the next integer (eg, 3 remains as 3, but 3.1 is rounded up to 4).

   For example, if the skip $k = 1.4$, the random start $r = 0.7$ and 10 dwellings were listed, then the households to be selected would be obtained by rounding up 0.7, 2.1, 3.5, 4.9, 6.3, 7.7 and 9.1, and so dwellings 1, 3, 4, 5, 7, 8 and 10 would be selected.
4. If subsequent occupied dwellings are discovered, they are added to the end of the list, and additional selections are made using the same rule.

   In the example described above, suppose four further dwellings were found. The additional selections would be given by rounding up 10.5, 11.9 and 13.3, so the new dwellings 11, 12 and 14 would be selected.

For the electoral roll sample, the process is identical, except that dwellings are restricted to those with one or more residents who nominated Māori ancestry on the electoral roll.

The lists of addresses in area PSUs are obtained from New Zealand Post's Postal Address File (PAF) and supplemented by interviewers check-enumerating on the ground. For roll PSUs, lists of eligible addresses are taken from a quarterly extract from the electoral roll. In both cases, the number of addresses can be different from the counts used to calculate PSU probabilities of selection and skips. The original skips are applied to the updated lists to maintain the designed probabilities of selection.

5.3 Re-using area component primary sampling units

Section 5.1 Selecting primary sampling units described the selection of area PSUs for quarter 1 and quarter 2 of the calendar year. The quarter 1 PSU sample is used again in quarter 3 and the quarter 2 PSU sample again in quarter 4.

Different households are selected in the PSU on the second use. This is accomplished by incrementing the random start in the within-PSU selection by 1 and using the same within-PSU skip. As discussed in section 4 Sample design, skips are constrained to be 2 or more so that it is always possible to select a different set of households in the second quarter of enumeration for a PSU.

The PSUs are allocated to quarters in such a way that PSUs are used twice in the same calendar year (eg, 2016) but only once in each reporting year (eg, 2015/16) (see also section 6.3 Re-using area component primary sampling units).

Re-using PSUs means that the NZHS visits fewer PSUs each year, making it easier for SNZ to manage any overlaps between the NZHS and other government household surveys.

6 Major changes from the years 1–4 sample design

6.1 Using Statistics New Zealand primary sampling units rather than meshblocks

The initial stage of selection was the meshblock in the 2006/2007 and 2011–2015 surveys, changing to the SNZ PSU from year 5 onwards (ie, since July 2015). The main reason for the change is to enable areas to be sampled using SNZ's overlap management system.

In multi-stage samples, such as the NZHS, the sample tends to be geographically clustered. This results in standard errors of most estimates being larger than would occur if the same number of households were a geographically unclustered simple random sample from across New Zealand. Multi-stage designs are used in many face-to-face interviewer surveys because they reduce interviewer travel costs and it is easier to create or update a list of addresses for a sample of PSUs than for a whole country.

The factor by which variances are inflated using a complex sample design, relative to simple random sampling, is called the 'design effect'. The component of the design effect due to clustering depends on both the average number of households selected per first stage unit (the 'average within-cluster sample size') and the correlation between values of the indicator of interest for people living in the same first stage unit (the 'intraclass correlation').

The change from meshblocks to PSUs as the initial stage of selection will impact on the design effect to some degree. The number of PSUs selected each quarter in 2015/16 is smaller than the number of meshblocks selected per quarter in the first four years of the continuous NZHS, with a similar sample size of people. This suggests that the sample is now more geographically clustered than in the past, with a higher within-cluster sample size, which may lead to a higher design effect. On the other hand, because PSUs are larger areas than meshblocks, the intraclass correlations within PSUs are expected to be smaller. Thus the net effect of the change to PSUs could be to increase or decrease design effects.

To ensure that design effects did not increase, the within-cluster sample size was raised only slightly compared with years 1–4. The target within-PSU sample size was set to 21 for area PSUs and to 14 for electoral roll PSUs. In years 1–4, the corresponding within-meshblock targets were 20 and 10 respectively. This represents increases of 5 percent and 40 percent for the area and electoral roll components respectively.

The approximation formula developed by Brewer et al (1977) suggests that indicators whose within-meshblock correlation is 0.050 will have within-PSU correlation of 0.030 (a 40 percent decrease). If this approximation is accurate, then design effects will decrease for the area component and stay about the same for the electoral roll component.

6.2 Participation in the Statistics New Zealand household survey selections management system

Before 2015/2016, the Ministry contracted the University of Wollongong Australia to select the meshblocks to be surveyed in the NZHS. Full details of this selection process are contained in *The New Zealand Health Survey: Sample design, years 1–3 (2011–2013) (*Ministry of Health 2011).

SNZ controlled overlap with their surveys by setting aside 20 percent of the meshblocks on their household frame for NZHS use and a further 10 percent for shared use when needed. This approach was revised for 2015/16 for the following reasons.

- Assigning 20–30 percent of meshblocks to the NZHS's use was becoming problematical for SNZ as it did not leave meshblocks for other surveys conducted by SNZ and other agencies. This was exacerbated by the fact that NZHS used meshblocks whereas most SNZ surveys use SNZ PSUs.
- It was becoming more difficult to manage the overlap of each new year's NZHS sample with past NZHS selections within the meshblocks set aside for NZHS use. There was an overhead in maintaining and extending NZHS-specific code for this purpose.
- SNZ developed an overlap control system designed to manage selections across SNZ and other government household surveys. This system uses a similar methodology to the NZHS system for managing self-overlap but allows greater flexibility in cross-agency overlap control. Because the new system is able to be used for SNZ and other household surveys across government, SNZ has been able to invest in software that is both more general and more intensively maintained.

From 2015/16, the Ministry is providing SNZ with PSU probabilities of selection for the area and electoral roll components each year, and SNZ perform the selections. To fit better with the SNZ system, SNZ PSUs are now used as the first stage of selection rather than meshblocks. As in the past, systematic unequal probability sampling is used, with area PSUs ordered by DHB and population and roll PSUs by DHB and number of eligible households.

To reduce the NZHS footprint in SNZ's cross-agency overlap control, area component PSUs are now surveyed on two occasions.

6.3 Re-using area component primary sampling units

PSUs are larger areas than meshblocks, with roughly twice the average population. The target within-PSU sample size of 21 for the area component means that less than half of the dwellings in a typical PSU will be surveyed in one quarter. Area component PSUs can therefore be sampled in two different quarters without revisiting the same households. This will also help SNZ to manage overlap across surveys by reducing the number of NZHS PSUs to be quarantined from future selections for the NZHS and other surveys.

A disadvantage of re-using PSUs is that fewer PSUs will be selected over time, leading to a more clustered sample, and possibly higher standard errors. A staggered selections plan is used to moderate this effect, as illustrated in Figure 1 below.

- When PSU sampling was first introduced, an area sample was selected for the second half of the 2015 calendar year that consisted of 360 PSUs. Each of these PSUs was assigned to be surveyed in just one quarter, either the September-2015 quarter or the December-2015 quarter.
- An area sample for the 2016 calendar year was selected in November 2015 that consisted of 360 PSUs. These PSUs are to be surveyed in two separate quarters in the 2016 calendar year, either (a) both the March-2016 and September-2016 quarters or (b) both the June-2016 and December-2016 quarters.
- The area sample for the 2017 calendar year will similarly be selected in November 2016, and PSUs will be allocated to (a) the March-2017 and September-2017 quarters or (b) the June-2017 and December-2017 quarters. The same process will be followed for each calendar year's selections.

The above scheme means that selected PSUs are surveyed twice each calendar year (eg, 2016), but each PSU appears only once in a reporting year (eg, 2015/16). So the re-use of PSUs will make the calendar year samples more clustered, but the reporting years will be unaffected.

Estimates for some subpopulations, such as DHBs or particular ethnicities, will be based on pooling several years' worth of data. These pooled samples will be more clustered due to the re-use of PSUs than they would have been if PSUs were surveyed only once, leading to increased design effects. However, the increase in design effects will be small relative to the improvement in precision associated with pooling over multiple years.

Figure 1: PSU selections timing and re-use plan

Component	Selection date	Number of PSUs selected	Number of quarters used in	2015/16 reporting year				2016/17 reporting year					
				Jul-Sep 2015	Oct-Dec 2015	Jan-Mar 2016	Apr-Jun 2016	Jul-Sep 2016	Oct-Dec 2016	Jan-Mar 2017	Apr-Jun 2017	Jul-Sep 2017	Oct-Dec 2017
Area sample	Apr 2015	180	1										
		180	1										
	Nov 2015	180	2										
		180	2										
	Nov 2016	180	2										
		180	2										
Roll sample	Apr 2015	70	1										
		70	1										
	Nov 2015	70	1										
		70	1										
		70	1										
		70	1										
	Nov 2016	70	1										
		70	1										
		70	1										
		70	1										

Note: Selections made in April 2015, November 2015 and November 2016 are shown in blue, orange and green respectively.

References

Bankier MD. 1998. Power allocations: determining sample sizes for subnational areas. *The American Statistician* 42(3): 174–7.

Brewer KRW, Foreman EK, Mellor RW, et al. 1977. Use of experimental design and population modelling in survey sampling. *Bull Internat Statist Inst* XLVII: 173–90.

Clark RG. 2009. Sampling of subpopulations in two stage surveys. *Statistics in Medicine* 28(29): 3697–717.

Clark RG. 2010. *Preliminary Sample Design for the New Zealand Health Survey 2010*. Report provided to the New Zealand Ministry of Health March 2010. URL: http://ro.uow.edu.au/infopapers/751 (accessed 2 November 2016).

Clark RG. 2013. Sample design using imperfect design data. *Journal of Survey Statistics and Methodology* 1(1): 6–23.

Clark RG, Forbes A, Templeton R, et al. 2009. Sampling for subpopulations in household surveys with application to Māori and Pacific sampling. *Official Statistics Research Series* (4). URL: www.statisphere.govt.nz/sitecore/content/statistics/Home/about_us/who-we-are/home-statisphere/research-series/2009-v4.aspx (accessed 2 November 2016).

Clark RG, Templeton RT. 2014. Sampling the Māori population using proxy screening, the electoral roll and disproportionate sampling in the New Zealand Health Survey. Chapter 22, in *Hard-to-Survey Populations*. Cambridge: Cambridge University Press.

Clark RG, Templeton R, McNicholas A. 2013. Developing the design of a continuous national health survey for New Zealand. *Population Health Metrics*, 11: 25. URL: www.pophealthmetrics.com/content/11/1/25 (accessed 2 November 2016).

Kish L. 1992. Weighting for unequal P_i. *Journal of Official Statistics* 8(2): 183–200.

Lohr SL. 1999. *Sampling: Design and Analysis*. United States: Duxbury Press.

Ministry of Health. 2010. *The New Zealand Health Survey: Objectives and topic areas August 2010*. Wellington: Ministry of Health. URL: www.health.govt.nz/publication/new-zealand-health-survey-objectives-and-topic-areas-august-2010 (accessed 2 November 2016).

Ministry of Health. 2011. *The New Zealand Health Survey: Sample design, years 1–3 (2011–2013)*. Wellington: Ministry of Health. URL: www.health.govt.nz/publication/new-zealand-health-survey-sample-design-years-1-3-2011-2013 (accessed 2 November 2016).

Ministry of Health. 2015. *Annual Update of Key Results 2014/15: New Zealand Health Survey*. Wellington: Ministry of Health. URL: www.health.govt.nz/publication/annual-update-key-results-2014-15-new-zealand-health-survey.

Ministry of Health. 2016. *Content Guide 2015/16: New Zealand Health Survey*. Wellington: Ministry of Health.

Statistics New Zealand. 2007. *Principles and Protocols for Producers of Tier 1 Statistics*. Wellington: Statistics New Zealand. URL: www.statisphere.govt.nz/tier1-statistics/principles-protocols.aspx (accessed 2 November 2016).