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Sampling the Māori Population in the 2006/2007 New Zealand Health Survey

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Abstract

The 2006/2007 New Zealand Health Survey sample was designed to meet a range of objectives, the most challenging of which was to achieve sufficient precision for subpopulations of interest, particularly the indigenous Māori population. About 14% of New Zealand's population are Māori. This group is geographically clustered to some extent, but even so most Māori live in areas which have relatively low proportions of Māori, making it difficult to sample this population efficiently. Disproportionate sampling and screening were used to achieve sufficient sample size while maintaining low design effects.

KEY WORDS: Rare populations; Screening; Household surveys; Indigenous statistics; Sample design

1. Introduction

The New Zealand (NZ) Ministry of Health conducts a national health survey approximately every three years to collect detailed information on health status, health risks and protective factors, and utilisation of health care services. The sample for the survey is selected using multi-stage sampling from an area frame, and the survey is conducted using computer-assisted personal interviewing (CAPI) in respondents' homes. The 2006/2007 New Zealand Health Survey (NZHS) is being conducted over a 12-month period from September 2006 and will include around 12,500 adults and 5000 children.

The main objectives of the survey design were:

i. Adult and child estimates broken down by age group (0-4, 5-9, 10-14, 15-24, 25-44, 45-64, 65+ years).
ii. Sufficient data to allow for small area estimation at District Health Board (DHB) level.
iii. National prevalence estimates for identified key conditions need to be sufficiently precise. Variables chosen for specific consideration in the design were obesity, tobacco use, GP visit in past 12 months, diabetes, asthma, problem gambling and stroke. Table 1 shows the target SEs for these variables.
iv. Sufficiently precise prevalence estimates for these same variables are required by ethnicity (Māori, Pacific, Asian, European/Other). The relative precision of Māori estimates should be as close as possible to that of national estimates (see Table 2).
v. To achieve a reasonable level of precision for estimates by ethnicity, some increased sampling of Māori, Pacific and Asian peoples is needed. This should be done in such a way as to avoid excessive variation in the selection probabilities across the sample. Too much variation in selection probabilities reduces the precision of estimates, and can even make increased sampling counter-productive in extreme cases.

The last two objectives are the most challenging. The NZ Ministry of Health is committed to the principle of 'equal explanatory power' for Māori health data, whereby Māori estimates have the same relative precision as non-Māori estimates (Te Rōpū Rangahau Hauora a Eru Pōmare 2002). This principle reflects the NZ Government's partnership relationship with Māori as the indigenous people of New Zealand. In addition, equal explanatory power supports the 1840 Treaty of Waitangi principle of protection for Māori, contained in the Royal Commission on Social Policy 1989, in which the Government committed itself to working to ensure Māori have the same level of health as non-Māori (Ministry of Health 2005). Although the final data will not exactly achieve the same level of relative standard

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error for Māori as non-Māori, it is the closest practical attempt at 'equal explanatory power' in a national health survey given the budget constraints. Estimates for the Asian and Pacific Peoples populations are also a priority for the survey.

Kalton and Anderson (1986) described a range of strategies for sampling rare subpopulations. Screening and disproportionate sampling were used for the NZHS because these methods can be applied when there is no reliable frame of the subpopulation of interest. Screening involves selecting a large sample and collecting data to determine whether respondents are members of the subpopulation or not. Disproportionate sampling involves dividing the population into strata and assigning different sampling fractions to different strata based on the proportion of the stratum population belonging to the subpopulation of interest.

Table 1: Target SEs for National Prevalence Estimates

Variable	Approximate Prevalence (%)	Target SE (%) of Movement between Two NZHS's [a]	Target SE (%) for 2006/2007 NZHS [b]	Target Minimum Detectable Change(%) [c]
Obesity	21	2.0	1.41	5.6
Tobacco	23	2.0	1.41	5.6
GP visit in past 12 months	75	5.0	3.54	14.0
Diabetes	4	0.5	0.35	1.4
Asthma	25	2.0	1.41	5.6
Problem Gambling	1	0.5	0.35	1.4
Stroke	2	0.5	0.35	1.4

a: This refers to movement between two NZ Health Surveys, assuming that both are designed in the same way as the 2006/2007 survey.
b: This is equal to the required SE for movement divided by 1.41.
c: Minimum change between two NZ Health Surveys which would have an 80% probability of being found to be significant at 0.05 level, assuming that both surveys are designed in the same way as the 2006/2007 survey.

Table 2: Target SEs for Prevalence Estimates for the Māori Population

Variable	Approximate Prevalence	Target SE (%) of Movement between Two NZHS's [a]	Required SE (%) for 2006/2007 NZHS [b]	Minimum Detectable Change (%) [c]
Obesity	30	3.0	2.12	8.4
Tobacco	50	5.0	3.54	14.0
GP visit in past 12 months	60	4.2	2.97	11.8
Diabetes	8	0.8	0.57	2.2
Asthma	23	2.0	1.41	5.6
Problem Gambling	3	0.3	0.21	0.8
Stroke	2	0.2	0.14	0.6

a, b, c: see footnotes to Table 1.

Kalton and Anderson (1986) considered the case where only the subpopulation is of interest, but the NZHS sample needed to support both national, Māori and other subpopulation estimates. To meet all of these aims, the sample was a combination of a core sample and a screening sample. The core sample was a multi-stage sample, and all persons were eligible for inclusion regardless of their ethnicity. In the screening sample, ethnicity of all household members were initially identified, and only Māori, Pacific Peoples and Asians were eligible for selection for the full survey interview. The combined sample will be used for all estimates. Varying the relative size of the screening sample and the core sample corresponds to placing different priorities on national and subpopulation estimates.

Section 2 of this paper summarises the sample design including the approach to screening and disproportionate sampling. Section 3 describes how the relative sizes of the screening and core samples were determined. Section 4 summarises the final design and Section 5 suggests future research.

2. Overview of Sample Design

2.1 Area-Based Sampling

Area-based multi-stage sampling was used. The first stage consisted of a sample of primary sampling units (PSUs). Meshblocks (MBs), which are the basic geographic building block in NZ's statistical system, were used as PSUs. Meshblocks vary considerably in size, with a mean number of dwellings of about 40 and a standard deviation of about 25. The second stage of sampling was a sample of dwellings from selected meshblocks and the third stage was a sample of one adult and one child (where available) from the selected dwellings. For the theory and practice of multi-stage area sampling, see for example Hansen et al (1953).

2.2 First Stage: Sample of Meshblocks

NZ is divided into 21 District Health Boards (DHBs) which are responsible for providing, or funding the provision of, health and disability services in their district. These are administrative regions used by the NZ Ministry of Health. A probability proportional to size sample of PSUs was selected, stratified by DHB. Within each stratum, the probabilities of selection for each PSU were proportional to the number of dwellings in the meshblock as recorded in the 2001 NZ Census. PPS sampling is appropriate where PSUs vary considerably in size, although weighting and selections are more complex than designs where PSUs are selected with equal probability. An alternative approach would have been to group MBs to form larger PSUs with less variation in size, and to use equal probability sampling of these larger PSUs. This was not done as developing a grouping of MBs would be a substantial project and was not feasible in the time available.

The number of meshblocks selected from each DHB was also proportional to the total number of dwellings multiplied by the square root of the proportion of residents of the DHB who are Māori (according to the 2001 Census). The rationale for this approach will be explained in Section 2.4.

2.3 Stages 2 and 3: Sample of Dwellings within Meshblocks and of People within Dwellings

The sample of dwellings within each meshblock is in two parts. A core sample with an expected sample size of 9.5 dwellings is selected; of these about 70% are expected to respond giving approximately 6.7 dwellings. One adult (15 years or over) and one child (if the dwelling contains any children) are selected from each dwelling in the core sample.

The process of within-dwelling selection is for the interviewer to collect at least the name and ethnicity of all members of the household. This is done by proxy reporting, where any adult reports name and ethnicity of all usual residents. One adult and one child is then selected randomly from all household members.

The other part of the sample is a screening sample of approximately 12-15 dwellings per meshblock. Again the interviewer collects information on all residents of the dwelling, by surveying one adult contact. Māori, Pacific and Asian people are eligible to be selected for the full survey interview. One eligible adult and one eligible child are selected from all eligible people (if any) in the dwelling. This approach relies on any adult household member being able to report on the ethnicity of all adults and children in the household. While this proxy reporting is not always accurate, the full survey interview confirms the ethnicity of the selected adult. The impact of mis-reporting of ethnicity at the screening stage would be a decrease in the Māori sample size but no actual bias since Māori also have a chance of selection in the core sample.

This design results in Māori, Pacific and Asian people having increased representation in the sample, relative to their population numbers. The probability of selection for Māori, Pacific and Asian people is approximately 2.5 times that of the rest of the population. This ensures that adequate precision is achieved for these subpopulations.

The rationale of the choice of the core sample size of 9.5 and the screening sample size of 12-15 will be discussed in Section 3.

2.4 Disproportionate Sampling

The PSU probabilities of selection were set to be proportional to the total number of dwellings in the PSU multiplied by the square root of the proportion of the DHB population who are Māori. The probability of a dwelling being selected in the core sample is equal to 9.5 divided by the total number of dwellings in the PSU. The probability of a dwelling being selected is the product of these two probabilities. This probability is therefore proportional to the square root of the proportion of the DHB population who are Māori. Thus the design of the core sample gives a higher probability of selection to areas which contain a greater concentration of Māori. The screening sample and the combined sample have a similar property.

This approach is a special case of disproportionate allocation which was one of the methods for sampling rare subpopulations described by Kalton and Anderson (1986). This paper derived the optimal allocation to two strata to give best precision of subpopulation means subject to a fixed cost, using a simple cost model. Where the costs of screening were high relative to the cost of the full interview, the optimal design had the stratum probabilities of selection proportional to the square root of the stratum population who belonged to the subpopulation (see first paragraph, p.71). As the costs of screening decrease, the optimal probabilities of selection become more and more equal between the two strata. In our case there were 21 strata rather than two, but the result is easy to generalize to the case of many strata.

It is possible to further increase the Māori sample size by making the probabilities of selection proportional to the concentration of Māori in the DHB, rather than to the square root. Kalton and Anderson's result shows that this is counter-productive. The subpopulation sample size can be increased, but the variances of estimators would be higher than for the optimal design. This is because the design effect due to unequal probabilities of selection increases by a greater factor than the subpopulation sample size.

Different screening sample sizes were used in different DHBs. A target screening sample size of 15 was used in ten DHBs with a relatively high proportion of Māori residents (Northland, Waitamata, Auckland, Counties Manukau, Waikato, Lakes, Bay of Plenty, Tairawhiti, Hutt Valley, Capital and Coast). A target screening sample size of 12 was used in all other MBs.

3. Deciding on the Relative Sizes of the Core and Screening Samples

To decide on the appropriate core sample size and screening sample size in each meshblock, ten alternative designs were evaluated. For each design, 6 households are selected in the core sample from each selected MB. The designs differ in two aspects. Designs 1 to 5 have no targeting of MBs. The MB probabilities of selection are proportional to the MB population size (according to the 2001 NZ Census). Designs 6 to 10 have disproportionate sampling with strata given by DHB. The MB probabilities of selection are proportional to the MB population size multiplied by the square root of the concentration of Māori in that DHB. The other difference between the designs is in the size of the screening sample in each selected MB. Sample sizes of 0, 6, 12 and 18 households are considered, as well as selecting all available households in the MB.

Table 3 compares the ten designs. The designs have been constructed to have roughly equal cost, based on the following cost model:

$$\text{cost} \propto 2 * (\#\text{MBs in sample}) + 1 * (\#\text{households in core sample}) + 0.4 * (\#\text{households in screening sample}).$$

This cost structure was not based on real cost information, but is still useful for rough comparison of the alternative designs.

The table is based on estimating a prevalence where the population prevalence is 0.04 nationally and 0.08 for the three ethnic subpopulations. The intraclass correlation was assumed to be 0.05.

The table shows that the following occurs as the screening sample size increases:

- The number of Māori interviews increases, as would be expected.
- In contrast, the number of MBs and the total sample size decreases, because the cost constraint means that the extra screening interviews must be compensated for in this way.
- The design effect for Māori estimates increases, although not dramatically except where all households are selected in each MB. This is because the sample is more clustered (more interviews per MB).
- The design effect for total estimates increases, more so than the design effect for Māori estimates. This is partly because the sample is more clustered. It is also because Māori have higher probability of selection than non-Māori, so that the increasing variation in probabilities of selection and therefore estimation weights leads to higher design effects.
- The net effect of these factors is that SEs reduce for Māori, and increase for total estimates.

The table also shows that the effect of disproportionate sampling is:

- Māori sample sizes are increased by about 15%, while total sample size is unaffected.
- Both Māori and total design effects increase.
- Māori SEs are reduced while total SEs are slightly increased.

Based on Table 3, we concluded that disproportionate sampling was clearly of benefit in improving Māori SEs with only a slight penalty to national SEs, so this was adopted. The choice of screening sample size depended on the perceived importance of SEs for Māori and national statistics. It was concluded that a screening sample size of around 12 was a reasonable compromise between the different objectives.

The evaluation of alternative designs suggested a core sample of 6 responding households and a screen sample of 12 responding households in each MB. A subsequent decision to use proxy reporting of ethnicity for screening purposes meant that a somewhat smaller screening sample size could be used. The final design used 9.5 approached core households (implying 6.7 responding households) and 12-15 approached screening households (implying 8.4-10.5 screen households).

Table 3: Alternative Sample Designs

Design	Disprop	Screen HHs	MBs in Sample	Sample Size (Adults)			Number of Screening Interviews		Design Effects		Standard Errors (%)	
				Total	Core	Māori	Total	Māori	Total	Māori	Total	Māori
1	no	0	2188	13125	13125	1420	0	0	1.88	1.61	0.234	0.915
2	no	6	1687	12273	10125	2175	10000	1080	2.27	1.75	0.267	0.771
3	no	12	1380	11754	8283	2633	16141	1737	2.66	1.91	0.295	0.730
4	no	18	1176	11406	7056	2930	20231	2166	3.03	2.06	0.319	0.720
5	no	all	621	10285	3727	3529	31328	3126	5.17	3.30	0.440	0.829
6	yes	0	2188	13125	13125	1625	0	0	2.00	1.73	0.242	0.884
7	yes	6	1688	12380	10126	2488	9997	1235	2.44	1.87	0.275	0.745
8	yes	12	1381	11924	8286	3010	16130	1985	2.88	2.03	0.304	0.705
9	yes	18	1177	11617	7061	3347	20212	2473	3.29	2.19	0.330	0.694
10	yes	all	622	10540	3732	4006	31311	3544	5.65	3.46	0.454	0.797

4. Summary of Final Sample Design

Table 4 shows the sample sizes of adults that are expected to be achieved from the final design. Approximately 13,177 households will be approached for the core sample and 18,514 households will be approached for the screen sample. This will result in approximately 9,783 achieved interviews in the core sample, and 2,796 achieved interviews in the screen sample, based on a response rate of 70%. The total sample size will be approximately 12,578 adults, including about 3000 Māori, 1000 Pacific Peoples and over 1000 Asians. In addition, the primary caregivers of approximately 4920 children will be interviewed, resulting in data from 1200 Māori children, 450 Pacific children and 500 Asian children.

The table also shows the design effect expected for typical variables for each ethnic subpopulation. The effective sample size is also shown. This measure is equal to the sample size divided by the design effect. The effective sample size of Māori is almost 40% of the national effective sample size. If there was no screening or targeting, the effective sample size of Māori would be only 10-15% of the national effective sample size. This indicates the priority placed on Māori statistics in this sample design, and the high quality that is anticipated for these statistics.

Table: 4 Adult Sample Sizes by Ethnicity from Core and Screen Samples

Ethnicity	Dwellings Approached		Achieved Interviews			Design Effect [a]	Effective Sample Size
	core	screen	core	screen	total		
Māori			1400	1539	2939	1.77	1665
Pacific			469	536	1005	1.76	570
Asian			626	721	1347	1.68	803
Other			7288	0	7288	1.84	3964
Total	13177	18514	9783	2796	12578	2.80	4493

a: assuming an intra-meshblock correlation of 0.05, and a design effect due to one adult per dwelling sampling of 1.5

Table 5 shows how the approximate standard errors for the final design compare to the target standard errors in Tables 1 and 2. The SEs were calculated assuming that the intraclass correlation is 0.05 and that the design effect due to sampling within households is 1.5.

The table suggests that the required SEs will be achieved for total population estimates. The total population requirement closest to not being achieved is diabetes (required SE 0.0035, expected SE 0.0030). Most of the required SEs for Māori estimates will be achieved. The exceptions are diabetes, problem gambling and stroke. These are relatively rare conditions, and to achieve the target SEs for problem gambling and stroke would require the Māori sample size to be increased by a factor of more than 4.

A minimum sample size of 100 adults from each DHB was applied, so that adequate sample will be available for use in small area estimation for DHBs.

Table 5: Standard Errors for Key Prevalences

Variable	Total population			Māori		
	Approx. Prevalence (%)	Target SE (%)	Expected SE (%)	Approx. Prevalence (%)	Target SE (%)	Expected SE (%)
Obesity	21	1.41	0.61	30	2.12	1.12
Tobacco	23	1.41	0.63	50	3.54	1.23
GP visit in past 12 months	75	3.54	0.65	60	2.97	1.20
Diabetes	4	0.35	0.29	8	0.57	0.66
Asthma	25	1.41	0.65	23	1.41	1.03
Problem Gambling	1	0.35	0.15	3	0.21	0.42
Stroke	2	0.35	0.21	2	0.14	0.34

5. Further Work

Efficient sampling of the Māori population is the most significant sample design challenge for many NZ national surveys on health topics. Some possible avenues for future research are:

Disproportionate Sampling at a Finer Level than District Health Board
DHBs are very broad regions, with only 21 DHBs in NZ. Disproportionate sampling could be done at a finer level as NZ Census counts of population by ethnicity are available at MB level. The broad level of DHB was used in the 2006/2007 NZHS design because the Census data was about 5 years old at the time of the design, so there may have been significant changes in population composition at a fine level such as MB. In contrast a larger region such as DHB would be expected to be more stable. Analysis of counts from several censuses would help to identify the finest geographical level for which population composition is reasonably stable over time. Disproportionate sampling based on this level could be more efficient than using DHB as strata.

Dual Frame Approaches
In the NZ political system, Māori may choose to enrol in the Māori electoral roll or the general electoral roll but not both. Approximately 200,000 Māori are registered on the Māori electoral roll, which is only 56% of the Māori population aged 18 years or over, and ethnicity is not recorded on the general electoral roll. The Māori electoral roll is thus a partial list of the Māori population, however its coverage is not high enough to allow it to be used as the sole frame for sampling Māori. The list could be used in combination with area sampling, to improve the efficiency of sampling Māori. A study of the feasibility this approach is planned for 2007.

More Flexible Sample Designs
The 2006/2007 NZHS design used a target screen sample size of 12 approached households per PSU in some strata and 15 per PSU in others. These sample sizes could be set to be different in each PSU, or in each strata, based on the concentrations of Māori in different areas. A project in 2007 will develop optimal designs along these lines, based on simple cost models, and evaluate these empirically using Census and NZHS data.

A substantial proportion of the budget of many NZ health survey is devoted to screening samples and other measures to boost the effective sample size for the Māori population. A similar situation occurs in many surveys internationally where statistics for ethnic subpopulations or indigenous populations are of particular importance. Improvements in methodology for targeting these subpopulations within national surveys could therefore have a high payoff both in survey costs and in the quality of information for these populations.

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