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# Population estimates, standard errors and hypothesis tests from the 1987-88 National Oral Health Survey of Australia

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# Population estimates, standard errors and hypothesis tests from the 1987–88 National Oral Health Survey of Australia

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The AIHW Dental Statistics and Research Unit is custodian of the unit record file of the data from NOHSA. The secondary analysis reported in this publication was conducted by AIHW DSRU, which operates under an agreement between the Australian Institute of Health and Welfare and The University of Adelaide.

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# TABLE OF CONTENTS

# LIST OF TABLES

# 1 Abstract

This publication presents a secondary analysis of the 1987–88 National Oral Health Survey of Australia (NOHSA). The analysis aimed to provide population estimates and 95% confidence intervals (95% CIs) for key oral status indicators that relate to Health Targets for the Year 2000, and to statistically evaluate differences in those indicators among States/Territories and between metropolitan and non-metropolitan areas. The NOHSA was a cross-sectional survey in which a random sample of residents aged 5+ years was selected from the six States and the Australian Capital Territory using a multi-stage stratified and clustered sampling design. Oral examinations conducted among 14,430 people provided information about tooth loss and caries experience which was used to compute the prevalence of edentulism and indices for the deciduous dentition (dmft) and the permanent dentition (DMFT). This analysis used SUDAAN software which employed a Taylor series approximation to compute standard errors adjusted for clustering of subjects within the census collector's districts (CDs) that were the primary sampling units in the sampling design. In addition, it was necessary to use the finite population correction factor to allow for large sampling fractions (10 per cent or more) of CDs within four sampling strata. The analysis confirmed the previously reported conclusion that the two health targets for children (35 per cent of 5–6-year-olds with dmft=0 and mean 12-year-old DMFT=1.0) and the target for 65+-year-olds (edentulism prevalence=40 per cent) clearly had not been achieved at the national level. However, the national finding for edentulism prevalence (6.2 , 95% CI=5.1–7.3 per cent) encompassed the health target of 7.0 per cent, and therefore it was uncertain whether or not the target had been achieved. State/Territory-specific results led to some anomalous conclusions, particularly for children's health targets. For example, there was uncertainty about whether or not South Australia and Western Australia had achieved the health target for 5–6-year-olds despite the fact that those States had higher rates of caries than the national figure where it was clear that the health target had not been achieved. This was attributable primarily to wide State/Territory-specific confidence intervals, which in turn was due to modest sample sizes for State/Territory estimates, most notably for the specific age-groups of children. This analysis also revealed poorer oral health status in non-metropolitan areas which had significantly higher rates of edentulism, missing teeth and untreated decay compared with metropolitan areas.

# 2 Introduction

Development of health targets and monitoring of oral health status are two important components of the public health strategy for improving oral health in the Australian population. Targets and monitoring activities provide tangible evidence that oral health is an integral part of Federal and State/Territory health policy. They also motivate governments and the dental profession to organise programs, allocate resources and promote oral health in ways that effectively work towards the achievement of targets. In addition, monitoring activities can reveal subgroups of the Australian population that may be disadvantaged in the achievement of health targets.

In 1988, the Health Targets and Implementation Committee (1988) proposed four targets for the Year 2000 that relate to oral health.

1. To reduce the prevalence of dental caries (percentage of children with one or more decayed, missing or filled teeth) to 35 per cent or less for children aged 5–6 years. (In practice, this can be interpreted to mean dental caries of deciduous teeth, since so few children in this age range have caries experience in permanent teeth.)

2. To reduce the mean index of decayed, missing or filled permanent teeth (DMFT) to 1.0 or less in children aged 12 years.

3. To reduce the proportion of people having no natural teeth to 7 per cent in adults aged 35–44 years.

4. To reduce the percentage of people having no natural teeth to 40 per cent or less in adults aged 65 years or more.

Subsequently, a set of five “proposed targets” for the Year 2000 was formulated by Nutbeam *et al.* (1993). The proposed targets also refer to edentulism and DMFT, and in addition they contain goals concerning prevalence of untreated decay and the mean number of missing teeth. The distinguishing feature of the proposed targets of Nutbeam *et al.* (1993) is that they refer to population sub-groups: people in rural communities; Aboriginal and Torres Strait Islanders; and low socioeconomic groups.

Baseline data relating to the oral health targets were generated through the National Oral Health Survey of Australia (NOHSA) in 1987 and 1988. The NOHSA came about through the co-ordinated efforts of Federal and State/Territory Governments together with the Australian Dental Association. The survey selected a national probability sample of 16,897 persons aged 5+ years. Participants completed an interview containing 11 demographic and behavioural questions and 14,430 of them had an oral examination conducted in their home by one of many hundreds of volunteer dentists.

Descriptive statistics from the NOHSA have been published as a single monograph (Barnard, 1993). The findings that relate to the four health targets proposed by the Health Targets and Implementation Committee were:

- 41.5 per cent of 5–6-year-olds had caries experience (dmft>0) [Target=35 per cent or less];

- the mean 12-year-old DMFT was 1.8 [Target=1.0 or less];

- 6.2 per cent of people aged 35–44 years were edentulous [Target=7 per cent or less]; and

- 50.2 per cent of people aged 65+ years were edentulous [Target=40 per cent or less].

The monograph concluded that "...it is likely that all targets will be met prior to the Year 2000 if preventive measures and dental service utilisation continue to improve." (Barnard, 1993).

Additional publications from the NOHSA include abstracts examining use of dental services (Barnard and Sivaneswaran, 1991), dental insurance (Sivaneswaran *et al*, 1994) and relationships between insurance, use of dental services and oral status (Sivaneswaran *et al*, 1995). Socioeconomic variations in oral health status have been analysed indirectly by linking NOHSA data to area-level census-derived socioeconomic indicators (National Health Strategy, 1992). The data have also been used in a report on oral health care for older adults (NHMRC, 1994). Unit record data from the NOHSA are held in archive by the AIHW Dental Statistics and Research Unit.

There are three critical elements that have been omitted from previous reports that limit the conclusions that can be drawn from the NOHSA concerning the proposed oral health targets of the Health Targets and Implementation Committee (1988) or Nutbeam *et al.* (1993).

1. The reports did not contain standard errors or confidence intervals for oral health status statistics.

2. The monograph (Barnard, 1993) did not report statistics for the group aged 5–6 years – instead data were reported separately for 5-year-olds and 6-year-olds. (The prevalence of 41.5 per cent cited above was obtained from re-analysis of unit-record data.)

3. Some State/Territory-specific data relating to the proposed health targets were not reported (5- and 6-year-old prevalence of caries experience, and 12-year-old mean DMFT) and some metropolitan/extra-metropolitan comparisons were not reported.

The omission of appropriate standard errors and confidence intervals is problematic because it is not possible to quantify the margins of error that are inherent in sample surveys, where only a proportion of the population is examined. Consequently, it has not been possible to conclude whether 1987–88 NOHSA estimates differed significantly from the proposed health targets. Furthermore, it would not be possible to determine if the 1987–88 results differed significantly from studies done at other places or times. In this context, a significant difference would be one that is unlikely due to chance. The omission of standard errors also precludes the opportunity to conduct hypothesis tests about differences among States/Territories. Hence, it is not possible to ascertain whether observed differences among States/Territories are statistically significant.

The NOHSA monograph (Barnard, 1993) contains an Appendix tabulating relative standard errors for proportions. However, the calculations assumed simple random sampling and they related to all interviewed subjects. Standard errors for means and proportions that are adjusted for the complex sampling design and that relate to examined persons for the ages involved in specific health targets were not reported.

The NOHSA sampling design can be regarded as complex, because it entailed a multi-stage, stratified, clustered random sample of Australian residents. "Clusters" were census collector's districts, which are areas of varying geographic size that contain approximately 200 to 250 residential households, while strata were defined by State / Territory and whether subjects lived in the State / Territory capital or in extra-metropolitan localities. Standard errors for this type of sampling design differ in two important ways from simple random samples:

1. People in different strata and clusters have different probabilities of selection, and consequently, sampling weights must be used in the computation of standard errors. (Weights were used in the monograph to compute percentages and means, but not to compute relative standard errors.)

2. The extent of variation among people within clusters is expected to be different from the variation among people from different clusters, and consequently it is necessary to adjust standard errors for intra-cluster correlation.

While the statistical theory for calculating standard errors in complex sampling designs has been established for some time (Cochran, 1977), it has been only recently that software for efficient computation has become available (Shah, 1989). As the Year 2000 approaches, and as plans for a second National Adult Dental Survey 1999 are being formulated, it is appropriate to re-evaluate oral health targets from the baseline 1987–88 NOHSA study to include standard errors, 95% confidence intervals (95% CIs) and formal hypothesis tests. Hence, the aim of this publication was to present 1987–88 population estimates, standard errors and 95% CIs for key oral status indicators that relate to National Health Targets. In addition, the paper aimed to statistically evaluate differences in those indicators among States / Territories and between metropolitan and non-metropolitan areas.

# 3 Methods

This paper reports findings from a secondary analysis of data from the 1987–88 NOHSA. The methods of data collection have been described previously (Barnard, 1993) and are briefly summarised here. The sample was a multi-stage, stratified, clustered random sample of Australian residents aged 5+ years selected from the six States and the Australian Capital Territory. There were four stages in the sampling design:

1. Thirteen strata were defined. Twelve of the strata were obtained by dividing each of the six States into a metropolitan area (corresponding to the capital city) and an extra-metropolitan area, while the thirteenth stratum was the Australian Capital Territory (an entirely metropolitan stratum). In four of the States, the extra-metropolitan stratum consisted of all communities with populations of 3,000 or more people. However in Western Australia, the extra-metropolitan stratum consisted of all communities outside Perth, while in Tasmania, Launceston was the single community comprising the extra-metropolitan stratum.

2. A random sample of CDs was selected from each stratum. According to the original description of the selection process the Australian Bureau of Statistics "selected CDs to ensure a balance of socioeconomic levels", although the method is not explained in additional detail.

3. Within each CD, a random sample of eight households was selected by consulting a map of each CD, selecting a starting grid-point at random and then systematically selecting subsequent households along a pre-determined route using a pre-determined skip interval.

4. Finally, all persons within the household were invited to take part in the interview and examination.

The sampling design, sample selection and fieldwork were conducted by the Australian Bureau of Statistics. Participants in the study underwent an interview, consisting of three demographic questions and eight behavioural questions, and they were invited to take part in an examination. Examinations were conducted by volunteer dentists who were instructed in the survey protocol during a period of one or two nights. The examination was based on the World Health Organization's protocol (WHO, 1987) and included information about: edentulism (loss of all natural teeth); tooth loss and caries experience of deciduous and permanent teeth; and treatment needs for caries and periodontal disease. Approximately 840 volunteer dentists were recruited by State / Territory health agencies to conduct examinations. There were no rigorous clinical training exercises conducted prior to examinations, and there were no replicate examinations to assess inter-examiner reliability.

As previously reported, interviews were conducted with 16,897 people and 14,430 of them (85.4 per cent) had an oral examination (Barnard, 1993). Interview and examination data were keypunched and validated, estimated resident population (ERP) statistics were included for each subject, and the data were written to ASCII files contained on two diskettes that are retained by the AIHW Dental Statistics and Research Unit. The ERP, which was taken from the 1986 Population Census, was the estimated number of people in the Australian population corresponding to each sampled person's State, metropolitan locality (categorised into two strata, metropolitan and extra-metropolitan), age (categorised into 14 five-year age strata in the range 5–74 years, and a fifteenth stratum of people aged 75+ years) and sex (two strata).

## 3.1 Analysis

The unit record data were read using the SAS statistical package, which was used to compute oral health status variables and population weights, and to sort and store the dataset for subsequent statistical analysis. When computing the number of missing teeth, the WHO protocol was used: for people aged 30 years or less, only those teeth that were recorded as missing due to caries contributed to the total count of missing teeth while for people aged over 30 years, all teeth recorded as missing contributed to the total count of missing teeth. The DMFT index used information from all 32 permanent teeth. Population weights were computed for each subject by dividing the estimated resident population (supplied on the unit record dataset) by the post-stratum sample size (PSS) for the corresponding stratum defined by metropolitan / extra-metropolitan residence, age and sex. The PSS variable was computed in SAS by counting the number of persons within each of those strata.

Statistical analysis was conducted using SUDAAN software (Shah *et al*, 1995), which required prior specification and quantification of the sampling design. As described above, there were four stages in the sampling design: stratification of States; selection of primary sampling units (CDs); selection of secondary sampling units (households); and finally, selection of persons. Under the assumptions of the Taylor series approximation (Woodruff, 1971) used in SUDAAN, it is sufficient to consider intra-cluster variation only within primary sampling units. In the NOHSA, CDs were the primary sampling units. In order to specify the design, it was also necessary to calculate sampling fractions of CDs within the 13 strata. While the ASCII data set could be used to compute the number of CDs sampled for each stratum, the data set did not contain the total number of CDs for each stratum's population. Consequently, those data were obtained from the Australian Bureau of Statistics (ABS, 1986). For metropolitan strata, the "Major Urban" section of State was used to provide a count of CDs in the capital city. In four States, the "Other Urban" section of State was used to provide the count of CDs, while for Western Australia all "Other Urban", "Localities" and "Rural Balance" CDs were used, and for Tasmania all Launceston CDs were used. These data are presented in Appendix A.

CD sampling fractions were inspected for each stratum, revealing four strata where more than 10 per cent of CDs were selected (non-metro South Australia, metro Tasmania, non-metro Tasmania and the Australian Capital Territory) – see Appendix A. Consequently, it was necessary to invoke the finite population correction factor for the entire sample. In SUDAAN, this is achieved by specifying a "without replacement" design for the selection of primary sampling units, and the program then requires additional input of the numerators and denominators that produce the sampling fractions. However, the sampling fraction of households within CDs was assumed to be small, since only 8–12 households per CD were selected. Hence, the finite population correction factor was not invoked for the second stage. The sampling design statements for the SUDAAN procedure are reproduced in Appendix B.

Point estimates for proportions and means, along with their corresponding standard errors (se), were generated for oral health status indicators that related to health targets. Ninety-five per cent confidence intervals were obtained using the formula: $y \pm t_{(n-1)} \cdot se$, where y=the point estimate, $t_{(n-1)}$ corresponds to the 95th percentile of the t-distribution with n-1 degrees of freedom, and n=number of subjects for the point estimate. Hypothesis tests were conducted to evaluate State / Territory differences and metropolitan / non-metropolitan differences using the Chi-square statistic (for bivariate differences in proportions), logistic regression (for multivariate differences in proportions) and analysis of variance (for bivariate and multivariate differences in means).

When drawing conclusions about the attainment of specific health target (x), lower and upper confidence intervals ($y_l$, $y_u$ respectively) for a point estimate (y) were interpreted as follows:

1. if $y_l > x$ then it was clear (with 95% certainty) that the health target had not been achieved;

2. if $y_u < x$ then it was clear (with 95% certainty) that the health target had been achieved;

3. however, if $y_l < x < y_u$ then it was inconclusive as to whether the target had or had not been achieved.

# 4 Results

Data processing identified 10 examined subjects, ranging in age from 58 to 84, for whom all 32 permanent teeth were recorded as missing, although they were recorded as dentate. Consequently, those subjects were recoded as edentulous persons. Data processing also identified one male in the Australian Capital Territory who was the sole person sampled from his census collectors' district. This subject, who was interviewed but not examined, was eliminated from the analysis because he did not meet the sampling criteria (since at least eight households in each CD should have been identified) and because his presence in the dataset meant that variance calculations for the entire sample could not be performed. (For the Taylor series approximation, it is necessary to calculate for all CDs the amount of within-CD variance, and within-CD variance cannot be calculated when there is only one observation.) Consequently, the total number of interviewed people was reduced to 16,896. However the sample of 14,430 examined people was identical to that reported in the NOHSA manuscript.

Table 1 presents prevalence of caries experience in deciduous teeth (percentage of children with dmft=1+) for children aged 5–6 years. The national figure of 41.5 per cent exceeded the Year 2000 target of 35 per cent and the lower limit of the 95% CI (36.6–46.4) indicated with 95% certainty that the target had not been achieved. However, among individual jurisdictions, Queensland was the only State which had a prevalence rate that clearly did not achieve the target, as demonstrated by its 95% CI of 39.3–58.2. In four other States and the Australian Capital Territory, 95% CIs encompassed the target prevalence of 35 per cent, and therefore it was inconclusive as to whether or not the target had been achieved. This was despite the finding that the point estimates in two of those States (South Australia=43.6 and Western Australia=43.8 per cent) exceeded the national point estimate. Tasmania was the one State in which the 95% CI of 7.3–32.4 clearly excluded the target, and hence it was possible to conclude that the target had been achieved in that State. To a large extent, the inconclusive findings for the majority of States in Table 1 reflect the width of confidence intervals which were 17 percentage points or more for individual jurisdictions. In other words, there was substantial variation within the State/Territory prevalence estimates. For example, State/Territory-specific standard errors were at least twice as large as the national standard error. Another consequence of this variation was the finding that, despite a more than two-fold difference in prevalence among States (Tasmania=19.9 per cent, Queensland=48.8 per cent), the overall differences were not statistically significant (P=0.09).

**Table 1: Caries prevalence (% of children with dmft>0) among 5–6-year-olds**

| State/Territory | No. of persons | % with dmft>0* | se | 95% CI |
|---|---|---|---|---|
| New South Wales | 101 | 39.3 | 5.2 | 29.0 – 49.5 |
| Victoria | 146 | 40.8 | 4.5 | 31.9 – 49.6 |
| Queensland | 116 | 48.8 | 4.8 | 39.2 – 58.3 |
| South Australia | 61 | 43.6 | 6.8 | 30.0 – 57.1 |
| Western Australia | 72 | 43.8 | 7.7 | 28.5 – 59.1 |
| Tasmania | 58 | 19.9 | 6.3 | 7.3 – 32.4 |
| Australian Capital Territory | 79 | 35.5 | 5.9 | 23.8 – 47.1 |
| All | 633 | 41.5 | 2.5 | 36.6 – 46.4 |

* Chi-square=11.1 (6df), P=0.09

When caries experience of deciduous teeth was expressed as mean dmft (Table 2), there was some similarity in the ranking of States/Territories, with Queensland recording the highest mean (2.04, 95% CI=1.49–2.59) and Tasmania the lowest (0.45, 95% CI=0.14–0.75). For this measure of caries experience, differences among States/Territories were statistically significant (P<0.01). There is no target for the Year 2000 relating to mean dmft.

**Table 2: Mean dmft among 5–6-year-olds**

| State/Territory | No. of persons | dmft Mean* | se | 95% CI |
|---|---|---|---|---|
| New South Wales | 101 | 1.35 | 0.28 | 0.80 – 1.90 |
| Victoria | 146 | 1.70 | 0.26 | 1.19 – 2.22 |
| Queensland | 116 | 2.04 | 0.28 | 1.49 – 2.59 |
| South Australia | 61 | 1.61 | 0.39 | 0.84 – 2.38 |
| Western Australia | 72 | 1.27 | 0.23 | 0.82 – 1.72 |
| Tasmania | 58 | 0.45 | 0.15 | 0.14 – 0.75 |
| Australian Capital Territory | 79 | 0.86 | 0.18 | 0.49 – 1.23 |
| All | 633 | 1.55 | 0.14 | 1.29 – 1.82 |

* ANOVA F=6.50 (6df), P<0.01

Caries experience in the permanent dentition among 12-year-olds is presented in Table 3, indicating that the target of 1.0 for the Year 2000 had not been achieved at the national level (mean=1.79, 95% CI=1.50–2.08). As was the case for Tables 1 and 2, State/Territory means for the permanent dentition revealed the highest level of caries experience in Queensland (mean=2.55, 95% CI=1.95–3.16) and the lowest in Tasmania (mean=1.02, 95% CI=0.27–1.76). However, estimates for New South Wales, Western Australia, Tasmania and the Australian Capital Territory had 95% CIs that encompassed the target of 1.0, and hence it was inconclusive as to whether or not those four jurisdictions had reached the Year 2000 target. As noted with respect to Table 1, this conclusion can be attributed primarily to the width of 95% CIs which were 1.04 or greater for each State/Territory.

**Table 3: Mean DMFT among 12-year-olds**

| State/Territory | No. of persons | DMFT Mean* | se | 95% CI |
|---|---|---|---|---|
| New South Wales | 41 | 1.43 | 0.29 | 0.84 – 2.03 |
| Victoria | 57 | 1.78 | 0.29 | 1.20 – 2.36 |
| Queensland | 65 | 2.55 | 0.30 | 1.95 – 3.16 |
| South Australia | 31 | 1.72 | 0.27 | 1.17 – 2.27 |
| Western Australia | 33 | 1.53 | 0.31 | 0.91 – 2.15 |
| Tasmania | 21 | 1.02 | 0.36 | 0.27 – 1.76 |
| Australian Capital Territory | 37 | 1.41 | 0.26 | 0.89 – 1.93 |
| All | 285 | 1.79 | 0.15 | 1.50 – 2.08 |

* ANOVA F=2.3 (6df), P=0.04

The point estimate of 6.2 per cent for edentulism prevalence among 35–44-year-olds was less than the national target of 7.0, although the confidence interval of 5.1–7.3 included the target (Table 4). Consequently, it was uncertain whether or not the target had been achieved at the national level. In New South Wales, Western Australia and the Australian Capital Territory, the target clearly had been achieved, while for the remaining States, 95% CIs encompassed the target. There was a conspicuous range in prevalence of edentulism (Australian Capital Territory=2.0 per cent, 95% CI=0.5–3.6; Tasmania=9.9 per cent, 95% CI=4.1–15.7), and the State / Territory differences were statistically significant (P<0.01).

**Table 4: Prevalence of edentulism among 35–44-year-olds**

| State/Territory | No. of persons | % edentulous* | se | 95% CI |
|---|---|---|---|---|
| New South Wales | 344 | 3.1 | 0.9 | 1.3 – 4.9 |
| Victoria | 427 | 9.3 | 1.4 | 6.7 – 12.0 |
| Queensland | 460 | 8.4 | 1.3 | 5.9 – 10.9 |
| South Australia | 265 | 7.3 | 1.5 | 4.3 – 10.2 |
| Western Australia | 337 | 2.8 | 0.8 | 1.3 – 4.4 |
| Tasmania | 188 | 9.9 | 2.9 | 4.1 – 15.7 |
| Australian Capital Territory | 291 | 2.0 | 0.8 | 0.5 – 3.6 |
| All | 2312 | 6.2 | 0.6 | 5.1 – 7.3 |

* Chi-square=43.8 (6df), P<0.01

The Australian Capital Territory also had the lowest prevalence of edentulism among people aged 65+ (31.1 per cent – Table 5), although it was uncertain whether it had achieved the target of 40 per cent (95% CI=19.0–43.2). New South Wales (46.0 per cent edentulous, 95% CI=39.5–52.4) was the only other jurisdiction where there was uncertainty about the achievement of the health target. However, for all other States and at the national level, point estimates exceeded 50 per cent, and the lower limits of confidence intervals excluded the target, and so it was possible to conclude that the target clearly had not been achieved.

**Table 5: Prevalence of edentulism among 65+-year-olds**

| State/Territory | No. of persons | % edentulous* | se | 95% CI |
|---|---|---|---|---|
| New South Wales | 247 | 46.0 | 3.3 | 39.5 – 52.4 |
| Victoria | 239 | 50.4 | 4.0 | 42.4 – 58.3 |
| Queensland | 383 | 52.8 | 2.7 | 47.4 – 58.2 |
| South Australia | 270 | 59.3 | 3.3 | 52.9 – 65.7 |
| Western Australia | 205 | 54.6 | 3.9 | 46.8 – 62.4 |
| Tasmania | 193 | 67.3 | 3.6 | 60.3 – 74.4 |
| Australian Capital Territory | 66 | 31.1 | 6.1 | 19.0 – 43.2 |
| All | 1603 | 50.6 | 1.7 | 47.2 – 54.0 |

* Chi-square=32.8 (6df), P<0.01

The remaining tables examine oral disease indices in metropolitan and non-metropolitan areas, combining data from all States and the Australian Capital Territory. Consequently, the results provide a basis for quantifying baseline statistics that relate to some of the proposed health targets for the Year 2000. The prevalence of edentulism for four age groups was significantly greater in non-metropolitan areas compared with metropolitan areas (Table 6, P<0.01, after controlling for age). For the three age groups greater than 44 years old, the prevalence rate was at least 9 per cent higher in non-metropolitan areas compared with metropolitan areas.

**Table 6: Prevalence of edentulism among metropolitan and non-metropolitan residents**

| | Metropolitan | | | Non-metropolitan | | |
|---|---|---|---|---|---|---|
| Age | No. of persons | % edentulous | 95% CI | No. of persons | % edentulous | 95% CI |
| 35–44 years | 1583 | 4.6 | 3.4 – 5.8 | 729 | 9.1 | 6.7 – 11.5 |
| 45–54 years | 1047 | 13.6 | 10.9 – 16.3 | 438 | 22.3 | 17.4 – 27.2 |
| 55–64 years | 854 | 22.3 | 18.6 – 26.0 | 509 | 37.2 | 31.7 – 42.7 |
| 65+ years | 977 | 47.0 | 42.3 – 51.7 | 626 | 56.6 | 51.9 – 61.3 |

**Logistic regression analysis**

| Source | df | Adj Wald F | P |
|---|---|---|---|
| Age group | 3 | 208.1 | <0.01 |
| Metropolitan | 1 | 37.6 | <0.01 |

The mean number of missing teeth among dentate people was also significantly greater in non-metropolitan areas compared with metropolitan areas (Table 7, P<0.01 after controlling for age). The magnitude of difference was as much as 2.0 missing teeth (35–44 and 45–54-year-olds).

**Table 7: Mean number of missing teeth among dentate metropolitan and non-metropolitan residents**

| | Metropolitan | | | Non-metropolitan | | |
|---|---|---|---|---|---|---|
| Age | No. of persons | Mean | 95% CI | No. of persons | Mean | 95% CI |
| 15–19 years | 916 | 0.2 | 0.1 – 0.2 | 390 | 0.4 | 0.1 – 0.6 |
| 20–24 years | 740 | 0.3 | 0.2 – 0.4 | 299 | 1.0 | 0.7 – 1.3 |
| 25–29 years | 721 | 1.5 | 1.2 – 1.8 | 448 | 2.0 | 1.6 – 2.5 |
| 30–34 years | 815 | 3.6 | 3.2 – 4.0 | 412 | 5.1 | 4.5 – 5.8 |
| 35–44 years | 1505 | 6.1 | 5.7 – 6.5 | 652 | 8.1 | 7.5 – 8.8 |
| 45–54 years | 893 | 9.2 | 8.5 – 9.9 | 336 | 11.2 | 10.3 – 12.1 |
| 55–64 years | 642 | 13.1 | 12.1 – 14.0 | 314 | 14.8 | 13.8 – 15.9 |
| 65+ years | 493 | 16.2 | 15.3 – 17.2 | 269 | 18.0 | 17.1 – 18.9 |

**Least squares regression analysis**

| Source | df | F | P |
|---|---|---|---|
| Age group | 7 | 6.25 | <0.01 |
| Metropolitan | 1 | 7.99 | <0.01 |

Although less consistent, the age-specific prevalence of decayed permanent teeth (that is, percentage of people with D>0) generally was higher in non-metropolitan areas (Table 8). The largest difference was observed for 30–34-year-olds, where the prevalence in metropolitan areas was 48.4 per cent (95% CI=42.9–53.9 per cent) compared with 62.3 per cent (95% CI=56.2–68.4 per cent) in non-metropolitan areas. The exceptions were the youngest and oldest groups, where prevalence rates were very similar in metropolitan and non-metropolitan areas. Nonetheless, the overall effect was a significant difference between metropolitan and non-metropolitan areas (P<0.01) after controlling for age.

**Table 8: Prevalence of untreated decay among dentate metropolitan and non-metropolitan residents**

| | Metropolitan | | | Non-metropolitan | | |
|---|---|---|---|---|---|---|
| **Age** | **No. of persons** | **% with D>0** | **95% CI** | **No. of persons** | **% with D>0** | **95% CI** |
| 15–19 years | 916 | 40.3 | 35.2 – 45.4 | 390 | 40.5 | 34.6 – 46.4 |
| 20–24 years | 740 | 48.6 | 43.3 – 53.9 | 299 | 58.8 | 52.1 – 65.5 |
| 25–29 years | 721 | 55.6 | 50.3 – 60.9 | 448 | 61.3 | 56.0 – 66.6 |
| 30–34 years | 815 | 48.4 | 42.9 – 53.9 | 412 | 62.3 | 56.2 – 68.4 |
| 35–44 years | 1505 | 49.2 | 45.3 – 53.1 | 652 | 55.0 | 50.3 – 59.7 |
| 45–54 years | 893 | 49.8 | 45.5 – 54.1 | 336 | 52.0 | 45.3 – 58.7 |
| 55–64 years | 642 | 50.4 | 44.5 – 56.3 | 314 | 54.8 | 48.7 – 60.9 |
| 65+ years | 493 | 53.7 | 47.4 – 60.0 | 269 | 51.2 | 43.6 – 58.8 |

**Logistic regression analysis**

| Source | df | Adj Wald F | P |
|---|---|---|---|
| Age group | 7 | 6.00 | <0.01 |
| Metropolitan | 1 | 7.95 | <0.01 |

# 5 Discussion

As noted in the introduction, this secondary analysis of the 1987–88 NOHSA resulted in point estimates of oral disease prevalence which were more-or-less identical to the estimates obtained in the original monograph (Barnard, 1993). The exceptions concern prevalence of caries experience in deciduous teeth for 5–6-year-olds (not previously reported) and the prevalence of edentulism for people aged 65+ years (in which the rate here was slightly higher because 10 people who had 32 missing teeth were recoded as edentulous for this analysis). The substantive new information from this analysis concerns the standard errors and confidence intervals associated with those point estimates. Confidence intervals permit inferences to be drawn about differences between the observed rates of oral disease and their corresponding health targets. At a national level, the results confirm three of the conclusions reached in the original monograph: namely, the caries target for 5–6-year-olds and for 12-year-olds and the edentulism target for 65+-year-olds clearly had not been achieved. However, this analysis indicates that the results for 35–44-year-olds were inconclusive: namely, it is uncertain whether or not the edentulism target was achieved.

These findings add to the previous conclusions in two important ways. First, this analysis has been able to establish confidence intervals for prevalence estimates. Hence, it is now possible to conclude that, for three age groups, the 1987–88 prevalence differed significantly from the Year 2000 target. In this context, a significant difference means that there is a probability of less than 5 per cent that the true population prevalence had achieved the Year 2000 target. This 5 per cent probability level is the level conventionally used for statistical inferences. It indicates that, even after allowing for the imprecision that is inherent in surveys that examine only a sample of the population, it is virtually certain that oral disease rates had not achieved the Year 2000 targets for 5–6-year-olds, 12-year-olds and 65+-year-olds.

The second benefit of this analysis is the reporting of State/Territory-specific estimates and their associated confidence intervals. However, in the case of the two targets for children, State/Territory estimates yielded many inconclusive results, despite the clear evidence that the national target had not been achieved. For example, it was uncertain whether or not New South Wales, Western Australia and the Australian Capital Territory had achieved targets both for 5–6- and 12-year-olds: this conclusion is based on the finding that 95% CIs encompassed the respective oral health targets. However, this can be attributed primarily to the relatively large standard errors (and correspondingly large confidence intervals) associated with State/Territory-specific estimates. For example, State/Territory specific standard errors in Tables 1 and 3 were about twice the magnitude of the national standard errors. Consequently, in the case of mean DMFT for 12-year-olds (Table 3), the New South Wales estimate of 1.43 DMFT had a wide confidence interval of 0.84–2.03, thereby encompassing the target of 1.0. The wide confidence interval indicated relatively high statistical imprecision in the point estimate for DMFT in New South Wales. If the 95% CI for New South Wales was as narrow as the range of 0.58 that was obtained for the national estimate (95% CI=1.50–2.08), the lower limit for New South Wales would have excluded 1.0, and it would be concluded that the Year 2000 target had not been achieved.

It must be emphasized that confidence intervals for national estimates necessarily are narrower than confidence intervals for individual States/Territories, simply because the national estimate is based on a larger number of persons. Indeed, the mathematical relationship specifies that confidence intervals are inversely proportional to the square root of the sample size. (In principle, a quadrupling of sample size results in a halving of the width of a confidence interval if standard deviations and sampling design effects are held constant.) So, while State / Territory estimates necessarily have higher imprecision than national estimates, the current findings reveal the problem of very high levels of imprecision, particularly for the two children's targets. This in turn can be related to the modest numbers of children upon whom the estimates are based, ranging from 21 twelve-year-olds in Tasmania to 146 five- to six-year-olds in Victoria.

The interpretation about health targets for adults appeared to be less problematic. For 35–44-year-olds, it was uncertain whether or not the target for edentulism had been achieved in four of the States (Victoria, Queensland, South Australia and Tasmania) and at the national level. This is not surprising, since the point estimates for those States (ranging from 7.3 to 9.9 per cent – Table 4) did not differ markedly from the target of 7.0 per cent. In contrast, New South Wales, Western Australia and the Australian Capital Territory had conspicuously lower prevalence rates (2.0 to 3.0 per cent), and there it was possible to conclude that the target had been achieved. The results for older adults were conclusive nationally and for the majority of States (Table 5). However for the Australian Capital Territory, where the point estimate was conspicuously low, the 95% CI included the target, therefore resulting in an inconclusive interpretation. This phenomenon in the Australian Capital Territory was due primarily to the very large standard error (6.1 per cent). Nonetheless, for most State / Territory estimates, the phenomenon of relatively wide State / Territory standard errors in Tables 4 and 5 did not appear to lead to the anomalous conclusions that were created by that same phenomenon in Tables 1 and 3.

In addition to quantifying the precision of previously-reported levels of oral disease, the current analysis has revealed a fairly consistent trend of poorer oral health in non-metropolitan areas which had significantly higher rates of edentulism (Table 6), missing teeth (Table 7) and untreated decay (Table 8) compared with metropolitan areas. The non-metropolitan areas in this analysis include any areas outside the capital city of each State, and consequently they are not synonymous with the "rural communities" specified in the proposed health targets. Nonetheless, these findings provide a useful baseline by demonstrating a general differential in oral health status between capital cities and remaining parts of Australia.

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# Appendix A

**Table A.1: Number of census collectors districts (CDs) and sampling fractions for 13 strata**

| State/Territory | Area | No. of CDs in population | No. of CDs sampled | % of CDs sampled |
|---|---|---|---|---|
| New South Wales | Metro | 6124 | 68 | 1.1 |
| New South Wales | Extra-metro | 1819 | 56 | 3.1 |
| Victoria | Metro | 4608 | 83 | 1.8 |
| Victoria | Extra-metro | 1264 | 52 | 4.1 |
| Queensland | Metro | 2223 | 76 | 3.4 |
| Queensland | Extra-metro | 1429 | 88 | 6.2 |
| South Australia | Metro | 1595 | 77 | 4.8 |
| South Australia | Extra-metro | 411 | 50 | 12.2 |
| Western Australia | Metro | 1546 | 113 | 7.3 |
| Western Australia | Extra-metro | 493 | 14 | 2.8 |
| Tasmania | Metro | 231 | 59 | 25.5 |
| Tasmania | Extra-metro | 169 | 34 | 20.1 |
| Australian Capital Territory | Metro | 375 | 107 | 28.5 |

# Appendix B

## Syntax for SUDAAN statements

The following statements produced the data for Table 1. SUDAAN keywords appear in normal typeface and user supplied variables are in italics. While some other tables used different procedures (proc descript, proc regress, proc logistic), all of the procedures had identical specifications for the design, nest, totcnt and weight statements.

```
proc crosstab data="nohsa87" filetype=sas design=wor;
   nest state metro cd / psulev=3;
   totcnt _zero_ cdn _minus1_;
   weight wt;
   subpopn (age = 5 or age = 6) / name="Aged 5–6 yrs";
   subgroup state dmftdcat;
   levels 7 2;
   tables state*dmftdcat;
   setenv colwidth=6
   decwidth=3 colspce=2 linesize=78;
   print nsum rowper serow deffrow chisq chisqdf
        chisqp / style=nchs wsumfmt=f9.0 nsumfmt=f9.0;
```

The variables in the nohsa87 SAS dataset that relate to this procedure are:

- *state* is a variable with seven values (1=New South Wales, 2=Victoria, 3=Queensland, 4=South Australia, 5=Western Australia, 6=Tasmania, 7=Australian Capital Territory)

- *metro* is a variable with two values (1=Metropolitan, 2=Extra-metropolitan)

- *cd*=census collectors' district code

- *cdn*=number of census collectors' districts for 13 strata (defined by State and metro) obtained from 1986 Census (ABS, 1986)

- *wt*=$ERP_{ijkl}$ / $PSU_{ijkl}$ where: $ERP_{ijkl}$=Estimated resident population (from 1986 census) for strata defined by i=7 States / Territories (New South Wales, Victoria, Queensland, South Australia, Western Australia, Tasmania and the Australian Capital Territory), j=2 localities (metropolitan and extra-metropolitan), k=15 age groups (5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, and 75+ years) and l=two sexes.
  $PSU_{ijkl}$=Number of persons sampled for those same strata.

- *dmftdcat* is a dichotomous variable coded 1 if dmft= 0 and 2 otherwise

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