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ORIGINAL RESEARCH

Building a stronger child dental health system in Australia: statistical sampling masks the burden of dental disease distribution in Australian children

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ABSTRACT

Introduction: In Australia, over the past 30 years, the prevalence of dental decay in children has reduced significantly, where today 60–70% of all 12-year-olds are caries free, and only 10% of children have more than two decayed teeth. However, many studies continue to report a small but significant subset of children suffering severe levels of decay.

Methods: The present study applies Monte Carlo simulation to examine, at the national level, 12-year-old decayed, missing or filled teeth and shed light on both the statistical limitation of Australia's reporting to date as well as the problem of targeting high-risk children.

Results: A simulation for 273 000 Australian 12-year-old children found that moving from different levels of geographic clustering produced different statistical influences that drive different conclusions. At the high scale (ie state level) the gross averaging of the non-normally distributed disease burden masks the small subset of disease bearing children. At the much higher acuity of analysis (ie local government area) the risk of low numbers in the sample becomes a significant issue.

Conclusions: The results clearly highlight the importance of care when examining the existing data, and, second, opportunities for far greater levels of targeting of services to children in need. The sustainability (and fairness) of universal coverage systems needs to be examined to ensure they remain highly targeted at disease burden, and not just focused on the children that are easy to reach (and suffer the least disease).

Key words: childhood, computational mathematics, dental decay, dental public health, Monte Carlo.

Introduction

In dental public health, particularly in Australia, there is an ongoing debate about the extent of remaining dental disease in children. In Australia, over the past 30 years, the prevalence of dental decay in children has reduced significantly, where today 60–70% of all 12-year-olds are caries free, and only 10% of children have more than two decayed teeth[1]. This improvement is in no small part a result of the near universal population-level exposure to topical fluoride (be it water or toothpaste)[2]. However, many studies[1,3] continue to report a small but significant subset of children suffering severe levels of decay, and this is typified by demands for general anaesthesia, in order to treat gross decay in children. This debate has and continues to be promulgated with data in the literature supporting both arguments[3].

The real challenge facing society today, in this environment, is to find ways to target the sub-group of children at greatest risk with additional preventive (and treatment) strategies. School-based dental services with universal coverage have been the norm in Australia for at least 30 years[4]; but with the significant resources needed for these universal services, targeting becomes a real economic/healthcare debate and in the changed disease environment this debate needs to happen in an open and transparent manner. The reporting of childhood caries rates at the near-individual or high resolution is not made available for independent research in Australia; it remains shrouded in confidentiality agreements between state governments and federal analytical organisations.

In this study, a simulation approach was taken to recreate the baseline child-by-child data using methods previously published to overcome these closed data hurdles[5]. The present study applies Monte Carlo simulation[5] to examine, at the national level, 12-year-old decayed missing or filled teeth (DMFT) and shed light on both the statistical limitation of Australia's reporting to date as well as the problem of targeting high risk.

Methods

All data was from open sources and therefore no ethics approval was required for the study[6-9]. All data collected and reported is for 12-year-olds unless otherwise stated. Based on previous studies it is accepted that dental decay in Australian children is strongly linked to socioeconomic strata; poorer children suffer greater levels of decay. In addition, it has been previously clearly identified by the authors of this study (and others) that Indigenous children suffer greater levels of decay than other children[10-15]. Against this backdrop these two factors (socioeconomics and Indigenous status) were chosen as the drivers of the simulations to generate child-by-child DMFT for 12 year-olds living in Australia. The process of simulation has been previous published and will not be covered in detail here[5]. In short, the simulation rests on the application of rates of decay (and missing and filled teeth) for different subsets of the population (as published in the literature) applied in a randomly seeded approach to the entire population (in this case all Australian 12-year-olds). In this simulation of socioeconomic status, Indigenous status and population numbers were collected from the most recent census (where complete data is available – 2006) to drive the simulation[6-15]. The simulation was completed using personally developed software (Visual Basic v6.0; http://msdn.microsoft.com/en-au/vbrun/ms788229.aspx). All resultant data was outputted to CSV (comma-separated values) format and imported into MySQL (community edition, Oracle USA; http://www.mysql.com) for analysis. The outcomes of the simulations were clustered at various geographic levels, and these were imported into QGIS (v1.8.0, open source, http://www.qgis.org/en/site) with the matching boundary files to map the outcome data to geography. Boundary files for state, statistical regions (SR) and local government areas (LGAs) were used.

Results

A Monte Carlo simulation for all 273 000 Australian 12-year-old children (with 5% being Indigenous (derived from the census data[4]) was completed. This method allocated simulated children to geographic locations based on the known distribution of children derived from the census data[4].

Statistical region level

Australia is divided into 65 non-overlapping/no-gaps statistical regions by the Bureau of Statistics. Each region has between 1300 and 9000 12-year-olds. The estimated DMFT ranges from 0 to 1.2. The state-by-state breakdowns of the estimated DMFT rates are presented in Table 1. However, they are complicated by the high variation in the number of statistical regions per state. The distribution of the values geographically is presented in Figure 1.

Statistical region subset level

Australia is divided into 85 statistical region subsets determined by the Bureau of Statistics. Each region has between 160 and 9000 12-year-olds. At this scale level, the average estimated DMFT ranges from 0 to 1.2. However, approximately 120 000 12-year-olds (45%) are estimated to live in each statistical region subset (SRS) where the average DMFT is between 1 and 1.25 (Table 2). It is important to notice that at this level of geographic clustering no region appears to have a DMFT in excess of 1.25. Clearly, this is in contrast to the existing literature[4] and known levels of decay in some children and is the apparent result of averaging.

Local government area level

Australia is divided into 556 local government areas determined by the Bureau of Statistics. Each area has between 2 and 11 000 12-year-olds. At this smaller level of geographic distribution the range of estimated average DMFT scores extends to just under 2.5 (Table 3). However, this coupled with the wide range in population provides a different analytical risk (low sample size). The geographic distribution of the local government areas find that highest estimated DMFT are not in the major cities but are found in rural, regional and remote Australia (Fig2). Even when low population local government areas (fewer than 50 12-year-olds) are eliminated from the study the high acuity analysis paints a very different picture to that presented at the cumulative level of SR (Fig1).

Result summary

In short, moving from different levels of clustering produced different statistical influences that drive different conclusions. At the high scale (SR or state) the gross averaging of the non-normally distributed disease burden masks the small subset of disease-bearing children. At the much higher acuity of analysis (local government area) the risk of low numbers in the sample becomes a significant issue.

Discussion

The data presented in this study highlights two important points. First, the different levels of analysis, SR, SRS and LGA, highlight the effect of averaging in a grossly skewed (non-normally distributed) distribution of dental decay. This averaging masks the distribution and extent of disease in some groups within the population. Studies of population subsets from previous work clearly find some children suffer significantly higher burdens of dental disease[16]. Second, the study shows at the LGA level (when the risk of small samples is removed) a clear localization of disease burden away from the cores of major cities and towns, and focused on rural, regional and remote Australia. This is not inconsistent with the sample studies from various smaller studies that have highlighted the high disease burdens in these regions[16].

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Table 1: Decayed, missing or filled teeth ranges for statistical regions in each Australian state/territory

State/territory	Number of statistical regions	No. of 12-year-olds	DMFT range†
New South Wales	22	90 178	0–1.18
Victoria	14	66 980	0–1.08
Queensland	13	55 035	0.32–1.05
South Australia	6	19 585	0.02–1.17
Western Australia	7	28 070	0–0.61
Tasmania	1	6790	0.84–0.84
Northern Territory	1	2480	0.55–0.55
Australian Capital Territory	1	4223	0.01–0.01

† Low to high average for each statistical region
DMFT, estimated decayed, missing or filled teeth

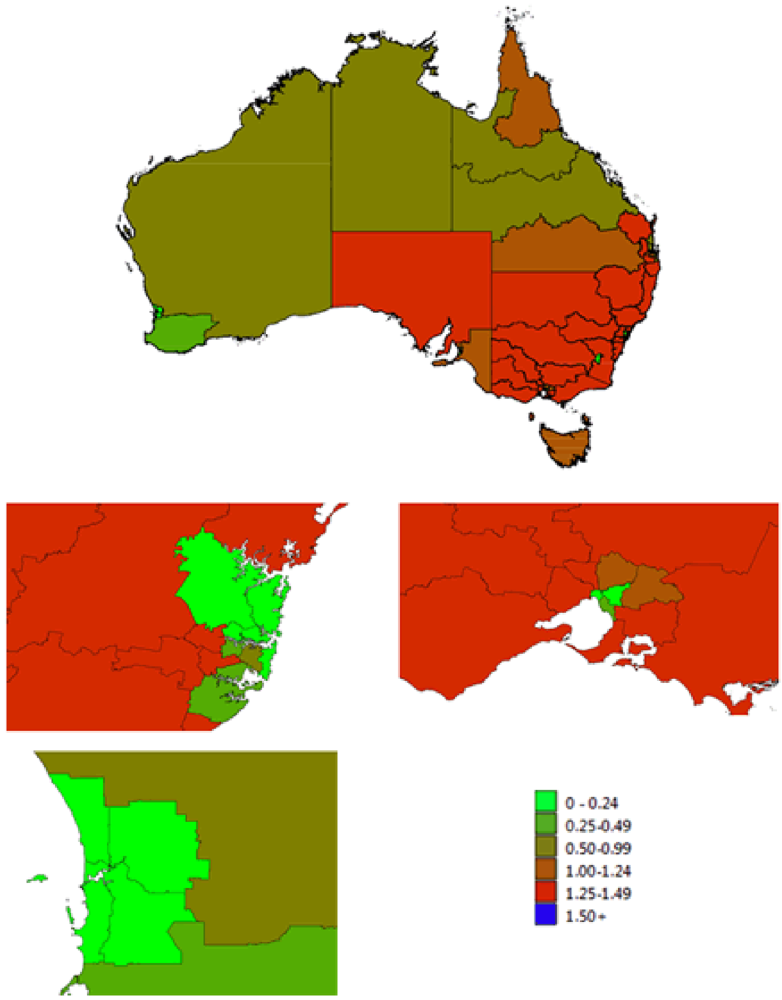

Figure 1: Estimated 12-year-old decayed, missing or filled teeth for each statistical region of Australia. High-magnification views of capital cities (Sydney, top left; Melbourne, top right; Perth, bottom left) are presented below the national map.

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Table 2: Number of 12-year-olds estimated in each statistical region subset (SRS) across Australia and average decayed, missing or filled teeth within each SRS

DMFT range†	Number	Average
0.00–0.24	51 544	0.06
0.25–0.49	28 874	0.35
0.50–0.74	37 581	0.66
0.75–0.99	34 100	0.85
1.00–1.24	121 242	1.08

† Low to high average for each statistical region subset
DMFT, estimated decayed, missing or filled teeth

Table 3: Estimated number of 12-year-olds in each decayed, missing or filled teeth range measured at the level of local government areas

DMFT range†	Number	Average
0–0.24	67 663	0.04
0.25–0.49	18 361	0.41
0.5–0.74	26 592	0.63
0.75–0.99	39 930	0.91
1.00–1.24	113 220	1.11
1.25–1.49	6502	1.35
1.50–1.74	877	1.61
1.75–1.99	162	1.90
2.00–2.24	31	2.00
2.25–2.49	3	2.33

† Low to high average for each local government area
DMFT, estimated decayed, missing or filled teeth

Although removal of low-number LGAs was essential for statistical purity of the analysis, it would not be unsurprising that high levels of decay would exist in these areas as well, based on the neighbouring data. Clearly, this research needs to expand the simulation approach to include a greater number of ages, and it will require greater computing capacity (that is currently in planning). From this the authors expect to be able to simulate the entire child population to produce an even greater fidelity of outcome.

However, the existing data does provide state child dental health systems with high-acuity distribution of disease information and therefore a real approach to becoming more targeted with their limited resources. At the LGA level it is evident that the systems need to move to the periphery of cities and to rural, regional and remote Australia. This redirection of resource allocation will complement the extent of fluoride exposure from the managed water supplies of major metropolitan areas[2] and would address much of the pain and suffering experienced in areas of less service availability[3]. Historically reported data points to a real need to examine the focus of school dental services. In a workforce shortage environment[17] that is facing even greater resource pressures and consequential mal-distributions over the coming years, the sustainability (and fairness) of universal coverage school dental services needs to be examined to ensure they remain highly targeted at disease burden, and not just focused on the children that are easy to reach (and suffer the least disease).

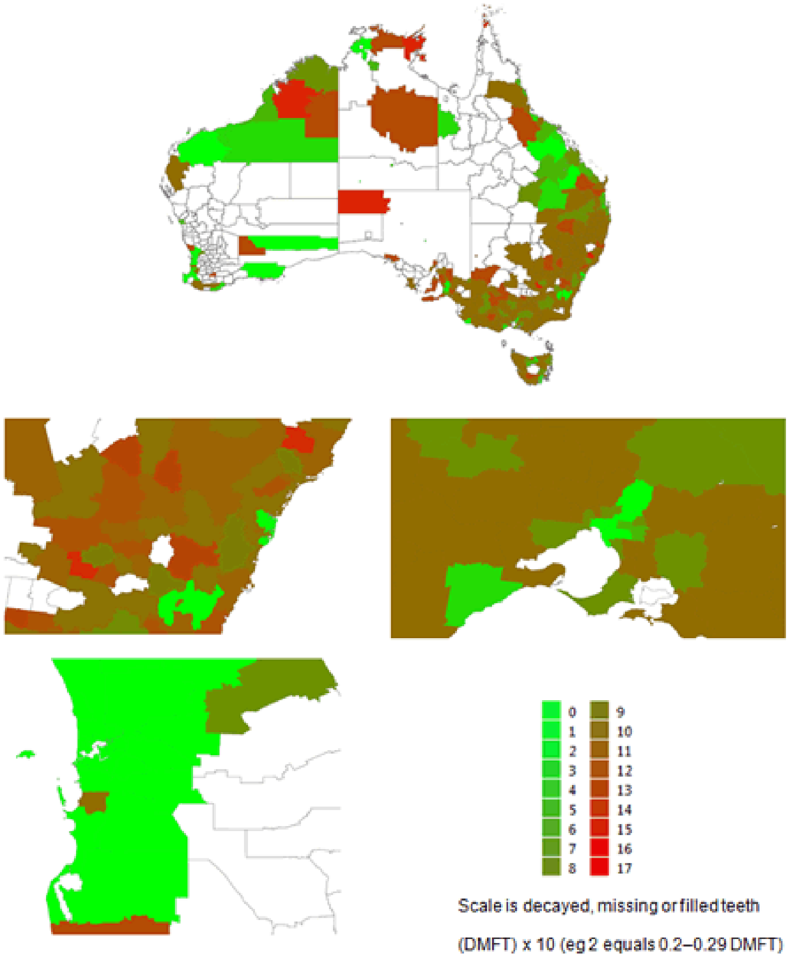

Figure 2: Estimated 12-year-old decayed, missing or filled teeth for each local government region of Australia (all those with a population of fewer than 50 12-year-olds are left blank). High-magnification views of capital cities (Sydney, top left; Melbourne, top right; Perth, bottom left) are presented below the national map.

Conclusions

This study applied a previously accepted system of granular simulation to address shortcomings in data accessibility to examine a real dental public health issue: childhood dental disease. The results clearly highlight the importance of care when examining the existing data and, second, opportunities for far greater levels of targeting of services to children in need.

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