CSIRO PUBLISHING

Australian Health Review, 2021, 45, 584–590
https://doi.org/10.1071/AH20318

Cross-sectional analysis of dental treatment under general anaesthesia in hospitalised Western Australian children in 2018–19

Yosef Faraj Amer Alshehri[1,2,6] MDP&PH(Dist), Dental Public Health Resident

Wendy Nicholls[3] PhD, Clinical Research Associate

Nhu Quynh Mai[1] MDP&PH, Lecturer in Paediatric Dentistry

Joon Soo Park[4,5] DMD, PGCertHighE, Research Fellow in Dental Public Health

Estie Kruger[4] MChD, PhD, Associate Professor in Dental Public Health

[1]School of Human Sciences, The University of Western Australia, Nedlands, WA 6009, Australia. Email: quynhmai0808@gmail.com
[2]Ministry of Health, Riyadh, Kingdom of Saudi Arabia.
[3]Department of Dental Medicine, Perth Children's Hospital, Nedlands, WA 6009, Australia. Email: wendy.nicholls@health.wa.gov.au
[4]International Research Collaborative, Oral Health and Equity, School of Human Sciences, The University of Western Australia, Crawley, WA 6009, Australia. Email: estie.kruger@uwa.edu.au
[5]UWA Dental School, The University of Western Australia, Nedlands, WA 6009, Australia. Email: alex.park@uwa.edu.au
[6]Corresponding author. Email: yfa.030@gmail.com

Abstract.

Objective. To date, there has been little research that has comprehensively analysed dental treatment under general anaesthesia (DGA) at Perth Children's Hospital (PCH) for dental emergencies (dental pain and sepsis). This cross-sectional descriptive analysis of the PCH dental department analysed the demographic of children admitted and the type of treatment used, and assessed the cost.

Methods. This was a retrospective descriptive study analysing the dental records of patients ranging from 2 to 16 years of age at PCH in Western Australia. Of the 310 cases randomly selected from the 2018–19 study period, 202 were admitted for DGA. Two outcome measures were derived: cumulative count of treatment mix and cost analysis.

Results. The mean (±s.d.) age at the time of admission was 6.2 ± 2.6 years and the mean (±s.d.) decayed (d/D), missing, (m/M) and filled (f/F) teeth (dmft/DMFT) was 2.1 ± 0.8. Of the 429 teeth affected, 282 were molars. Treatments were grouped therapeutically; of the 856 treatments performed, 465 were extractions (54%). The total cost, consisting of direct and indirect costs, was A$313 823, and equated to an approximate mean (±s.d.) of A$1554 ± 109 per case.

Conclusion. Untreated dental caries was the most common cause for hospital admission. Most cases presenting at the emergency department were young children (<7 years old) who underwent extractions under DGA.

What is known about the topic? The Child Dental Benefits Schedule (CDBS) was introduced to improve access and affordability to oral health care for children without private dental insurance. However, a significant number of children are still being admitted to hospital for emergency dental treatment.

What does this paper add? Despite the availability of the CDBS, untreated dental caries remains one of the most common reasons for dental emergency in the PCH.

What are the implications for practitioners? Not only are direct costs a burden on the health budget, but indirect and intangible costs also affect children and their families.

Keywords: cost, dental emergency, general anaesthesia, utilisation, Western Australia.

Received 5 November 2020, accepted 9 March 2021, published online 23 June 2021

Introduction

Australia is geographically large, with a population of approximately 25 million people. Children <15 years of age account for 19–20% of the total Western Australian (WA) population.[1] Of all dental treatments, 85% are provided in the private sector and paid for by insurance or out of pocket.[2] However, only 50% of Australians over 5 years of age have private dental insurance.[3]

To target children without private dental insurance, the Child Dental Benefits Schedule (CDBS) was introduced in 2014. The CDBS is a Commonwealth (federally) funded program that helps improve access and affordability to oral health care for priority (socially disadvantaged and low-income) populations. The CDBS is provided under Australia's universal Medicare system, to offer subsidised dental treatment of A$1000 paid over a 2-year period for eligible children (aged 2–17 years), who are recipients of selected government benefit payments.[4] Dental treatments provided are limited to a range of basic dental services, including examinations, X-rays, cleaning, fissure sealing, fillings, root canal treatments and extractions.[4] However, the current utilisation of the CDBS has been low in WA, where only 10% of those who were eligible accessed the scheme, compared with the national rate of 30%.[5]

According to a previously published retrospective analysis, 210 000–280 000 WA children aged between 2 and 17 years were eligible for the CDBS in 2014–15.[6] From CDBS only 30% of the total expenditure accounted for preventive services. One of the reasons may be because children in WA had higher utilisation of the School Dental Service (SDS) compared with children in the other states. Another reason may be a lack of promotion to increase uptake of the CDBS.[7]

In WA, children can attend the SDS at the commencement of primary school, usually at the age of 5 years, and receive intermittent dental care until the age of 16 years. This service is available to all children attending a school recognised by the WA Department of Education.[8,9] Statistics for WA from the National Child Oral Health Study 2012–14 concluded that the prevalence of untreated dental decay in children aged between 5 and 10 years was 22.4%, which was less than the national average of 27.1%.[10] Although less than the national average, the rate of hospitalisation due to oral diseases for children under 15 years of age was 1074 cases per 100 000 population on an annual basis.[11,12] Perth Children's Hospital (PCH), formally Princess Margaret Hospital (PMH), is the only tertiary children's hospital in WA and provides comprehensive and palliative treatment for eligible children. This is the main centre for dental treatment under general anaesthesia (DGA) for children, with some treatment also being performed in private hospitals. The most common reasons for dental emergencies in the PMH were infections and trauma.[13] However, children can receive ongoing comprehensive dental treatment if they meet the necessary eligibility criteria outlined by the PCH.[14] DGA is an alternative and viable option for children who are unable to cope with dental treatment being performed in the dental chair because of age, anxiety and the severity of the dental treatments required.[15] Children below 5 years of age make up the majority of the dental emergency presentations at the PCH (and PMH).[5]

It has been established that early childhood caries (ECC) negatively affects a child's quality of life (QoL).[16] Untreated caries is a global burden and, in the deciduous dentition, it is the 10th most prevalent condition worldwide, affecting 621 million children in 2010.[17] There has also been evidence suggesting strong links between poor oral health, socioeconomic disadvantage and rural or remote residence.[18,19] In WA, it was reported that over 40% of young children in rural and remote areas or those living in high socioeconomic disadvantage had one or more decayed teeth, and 19% and 15% experienced severe ECC caries and toothache respectively.[20]

In WA, dental diseases are the third most common cause of general anaesthesia (GA) given to preschool children.[21] In addition, the age-standardised rate of hospital admissions requiring GA for treatments related to dental conditions in WA from 2016 to 2017 was 7.5 cases per 1000, which was higher than the national average (5.7 cases per 1000).[22] 'Direct costs' (DC) are defined as the opportunity costs of formal services provided by healthcare practitioners.[23] 'Indirect costs' (IC) may be defined as patients' absence from school, parents' and guardians' absence from work, loss of productivity in society, accommodation costs and transportation costs.[11,23] The DC of child hospitalisation for all oral-related conditions in WA from 2000 to 2009 was A$92 million.[11] In addition, the IC, or cost not directly related to the treatment involved, of children's hospitalisation was estimated to be approximately A$138 million in 10 years.[11] However, to date, little research has been done to comprehensively analyse dental emergency cases treated under GA at the PCH.

The aim of the present descriptive analysis of retrospective data (2018–19) of a random sample of PCH dental department patients was to: (1) analyse the treatment utilisation of DGA in children presenting with dental-related emergencies; and (2) assess the DC and estimated IC of DGA in children presenting with dental-related emergencies.

Methods

Subject selection and sample acquisition

This study was approved by the human research ethics committees at the University of Western Australia (Approval no. RA/4/20/5497) and the PCH (Clinical Governance Number 32788). A retrospective descriptive study analysed dental records of patients ranging from 2 to 16 years of age at the PCH.

From 1500 patients who attended the PCH for dental emergencies over a 6-month period (October 2018–March 2019), 310 patient cases were randomly selected from the unique patient identifying number generated by the PCH digital dental software database (Titanium Solutions, Auckland, New Zealand) cross-referenced with the Qualtrics random number generator and assignment function (Qualtrics XM, Provo, UT, USA). This was to assess the cross-sectional nature of the emergency presentation on a sample level instead of at the population level.[24] To achieve an ideal representative sample size with a 95% confidence interval (CI), a minimum of 306 responses was required (Qualtrics XM). From the 310 cases selected, 202 (65%) were admitted for DGA.

Clinical analysis

Patient variables collected included sex, age at the time of treatment, suburb, postcode, patient finance, tooth-by-tooth dental diagnosis presented in an odontogram as per the decayed (D), missing (M) and filled (F) teeth index (dmft (primary dentition)/DMFT (permanent dentition)) and treatment performed in

accordance with the Australian Dental Association (ADA) item codes.[25] To ensure patient confidentially, patients with rare medical conditions that could potentially be re-identified were excluded from the study.

Children who present to the PCH normally present with high dmft/DMFT, so the Significant Caries Index (SiC) was used to highlight individuals with the highest caries experience.[26,27]

The SiC is calculated based on the mean dmft/DMFT of the 30% of children with the highest caries experience. The caries experience was also calculated for children <6 years of age as well as those >7 years of age.

Outcome measure

Three outcome measures were used, namely the cumulative count of treatment mix (ADA treatment codes), cost analysis and geographic analysis. The Socio-Economic Indexes for Areas (SEIFA) is derived from the Australian Bureau of Statistics (ABS), which assigns a score in different areas in Australia in accordance with the relative associated socioeconomic advantage and disadvantage. This is based on 5-yearly Census data. Different suburbs have designated SEIFA scores, as well as Index of Relative Socioeconomic Disadvantage (IRSD) quintiles, also provided by the ABS.[28] SEIFA IRSD quintiles range from 1 (low socioeconomic status) to 5 (high socioeconomic status).

Cumulative count of treatment mix

Dental treatment in the PCH is assigned a three-digit ADA item code[25] for each dental treatment that is considered to be part of current dental practice. The cumulative treatment count was calculated. Treatments were itemised individually as ADA item codes and then grouped in accordance with different therapeutic categories listed in the Appendix of The Australian Schedule of Dental Services and Glossary.[25]

DC analysis

The DC (in Australian dollars) of treatment provided during the study period was calculated for each case, using the recommended costings as supplied by the Department of Health.[29] The DC was itemised individually as per ADA item codes[25] and grouped according to therapeutic category, but did not include anaesthetic agents used, cost or the services provided by the anaesthetist.

IC analysis

The information on IC for each individual was not available, but was estimated based on previously used methodology.[30] To account for travelling days and taking time off from paid employment to care for the child, 2.5, 3.5 and 4.5 days were allocated for patients living in major city suburbs, regional suburbs and remote suburbs respectively. The average cost to the economy per day was estimated at approximately 20% of the average weekly earnings.[30] In the 12 months to May 2019, the full-time average weekly earnings for average Australian adults were A$1634.[31] In terms of ICs, these were estimated because the data were not available at the time of data acquisition at the PCH. It is important to note that the national unemployment rate was 5.3%.[32] An estimated cost for transport was allocated to each of the geographic groups (major city to remote). Travel cost was estimated on three levels (low, medium and high) to account for different methods of transport.[30]

Statistical analysis

Unless indicated otherwise, data are presented as the mean ± s.d. SPSS version 25.0 (IBM Corp., Chicago, IL, USA) was used to undertake the descriptive statistical analysis. This study computed one-way analysis of variance (ANOVA) between the independent variables. Statistical significance was set at two-tailed $P < 0.05$. The linear regression was formulated using GraphPad Prism version 8.00 for Windows (GraphPad Software, San Diego, CA, USA). Furthermore, Pearson's r (range –1 to 1) and 95% CIs were generated to assess the correlation.[33]

Results

Demographics

Of the 202 cases admitted for DGA, 91 were males (45%) and 111 were females (55%). There was no significant difference between the number of boys and girls. Children aged 2–5, 6–9 and 10–18 years accounted for 47% ($n = 95$), 40% ($n = 80$) and 13% ($n = 27$) of the study cohort respective. The mean age of children at the time of admission was 6.2 ± 2.9 years (Table 1). All cases were publicly funded.

Caries experience (DMFT)

The mean d/D, m/M and f/F per patient was 2.0 ± 3.8, 0.01 ± 0.10 and 0.1 ± 0.7 respectively. The mean dmft/DMFT was 2.1 ± 3.8. The SiC for d/D, m/M and f/F per patient was 6.5 ± 4.1, 0.02 ± 0.13 and 0.3 ± 1.3 respectively. The mean SiC dmft/DMFT was 6.9 ± 4.0. Of the 429 teeth affected, significantly more teeth were affected by D ($n = 406$) than M ($n = 2$) and F ($n = 21$; $P < 0.05$ for both). D accounted for 95% of the total affected teeth (d/D : dmft/DMFT ratio = 0.95). However, there was no difference between the m/M : dmft/DMFT and f/F : dmft/DMFT ratios ($P > 0.05$).

Of the 429 teeth affected, 282 were posterior teeth (66%) and 147 were anterior teeth (34%; Table 2). There was a significant difference between the number of teeth affected by D and F ($P < 0.05$). However there was no significant difference between M anterior and posterior teeth ($P > 0.05$). There were no anterior teeth with fillings, and no posterior teeth missing. There was a significant difference between anterior and posterior dmft/DMFT (0.7 ± 1.8 vs 1.4 ± 2.5 respectively; $P < 0.05$). There was also a significant difference between anterior and posterior SiC dmft/DMFT (2.4 ± 2.6 vs 4.5 ± 2.7; $P < 0.05$). For children <6 years of age, the dmft/DMFT (count) for total, anterior and posterior teeth was 324, 130 (40%) and 194 (60%) respectively. For children >7 years of age, the dmft/DMFT (count) for total, anterior and posterior teeth was 105, 17 (16%) and 88 (84%) respectively.

Table 1. Sex and the mean (±s.d.) age of patients undergoing DGA ($n = 202$)

	No. patients (%)	Age (years)
Sex		
Male	91 (45)	5.9 ± 2.4
Female	111 (55)[A]	6.5 ± 3.2
Total	202 (100)	6.2 ± 2.6

[A]Although the number of female patients was greater than that of male patients, the difference was not significant ($P > 0.05$).

Table 2. Count and caries experience categorised to anterior and posterior teeth of patients undergoing DGA ($n = 202$)
A, anterior; D, decay; M, missing; F, filling; P, posterior; T, teeth; SiC, Significant Caries Index

	d/D	m/M	f/F	dmft/DMFT (count)	Mean (±s.d.) dmft/DMFT
A	145	2[B]	0	147	0.7 ± 1.8
P	261[A]	0	21[C]	282	1.4 ± 2.5[G]
Total	406	2	21	429	2.1 ± 3.8
SiC A	143	1[E]	0	144	2.4 ± 2.6
SiC P	255[D]	0	20[F]	275	4.5 ± 2.7[H]
SiC total	398	1	20	419	6.9 ± 4.0
Age (years)					
<6	311	2	11	324	2.6 ± 4.2
A	128	2	0	130 (40%)	1.0 ± 2.2
P	183	0	11	194 (60%)	1.6 ± 2.6
>7	95	0	10	105	1.4 ± 2.9
A	17	0	0	17 (16%)	0.2 ± 0.8
P	78	0	10	88 (84%)	1.1 ± 2.4

[A]P D > A D ($P = 0.05$).
[B]A M > P M ($P > 0.05$).
[C]P F > A F ($P < 0.05$).
[D]SiC P D > SiC A D ($P = 0.05$).
[E]SiC A M > SiC P M ($P > 0.05$).
[F]SiC P F > SiC A F ($P < 0.05$).
[G]P DMFT > A DMFT ($P < 0.05$).
[H]SiC P DMFT > SiC A DMFT ($P < 0.05$).

Treatment count and cost (direct)

Of 856 treatments performed, more than half ($n = 465$; 54%) were extractions. Two treatments that had more than 40 counts were intraoral periapical or bitewing radiograph ($n = 46$; 5.4%) and fissure and/or tooth surface sealing ($n = 44$; 5.1%). Of the total DC of A$120 489, the cost of extractions was A$79 538 (66%) and averaged A$171 per treatment. Treatment under GA or sedation had a DC of A$14 357 (11.9%) and averaged A$147 per treatment.

After the treatments were grouped, extractions and treatment under GA had the highest frequency ($n = 465$ and 99 respectively) as well as the highest DC (A$79 538 and A$14 424 respectively; Table 3). The clinical dental examination had the next highest count ($n = 78$; A$8394) and restorations had the next highest DC ($n = 42$; A$8674). Pulpotomy had the lowest count and the lowest DC ($n = 2$; A$185). The mean DC for each case was A$596.

Indirect and total costs

The estimated mean low, medium and high ICs per case were estimated to be A$882, A$1235 and A$1588 respectively. The total IC was A$193 334 (A$957 per case). The total cost (DC + IC) was A$313 823 (mean A$1554 ± 109 per case).

Suburb analysis

Major city suburbs accounted for 82% of the total admission counts ($n = 165$), inner regional suburbs accounted for 10% ($n = 20$), outer regional suburbs accounted for 5% ($n = 11$), remote suburbs accounted for 2% ($n = 4$) and very remote suburbs accounted for 1% ($n = 2$). Thirty-seven of 202 cases were residing in remote to regional WA (18%).

Table 3. Count and DC of grouped procedures of cases undergoing DGA ($n = 202$)

Treatment type	Count	DC (A$)
Examinations	78	8394
Radiographs	84	5002
Photographs	18	614
Preventative	65	3248
Extractions	465	79 538
Oral surgery	3	410
Pulpotomy	2	185
Restorations	42	8674
Treatment under general anaesthesia	99	14 424

Socioeconomic status

According to the SEIFA IRSD quintile categories, Quintile 1 (lowest) had the highest count ($n = 57$; 28%) and quintile 4 had the lowest count ($n = 27$; 13%). Of all cases, 69% were in the SEIFA quintiles 1–3 ($n = 140$). Furthermore, an increase in quintile had a non-significant inverse correlation with DGA case admission count (slope = –4.50; 95% CI –19.3, 10.3; $P = 0.4046$; $r = –0.488$).

Discussion

This is the first study to date to analyse this range of variables associated with cases of DGA at the PCH. Regardless of financial status, all patients were eligible for publicly funded dental emergency treatment. However, after the necessary treatments and postoperative reviews were completed following emergency DGA, patients were discharged for follow-up and definitive treatment from external service providers, such as private dental clinicians.[34] Most cases presenting at the PCH in this study were females (55%), which contradicts previously published findings.[12,35–38] Of the emergency cases presenting at the PCH, 10 had pre-existing medical conditions and were eligible for ongoing care.[34] The rationale for this eligibility is that children who were medically compromised are more susceptible to developing fatal systemic complications as a result of untreated dental infections.[39]

The mean DMFT was 2.1 ± 3.8 (and the SiC dmft/DMFT was 6.9 ± 4.0), based on patients with a mean age of 6.2 ± 2.9 years. This DMFT is higher than the mean DMFT in WA children aged 5–10 years (DMFT = 1.4).[22] Dental caries in the present study accounted for 94.6% of the total affected teeth; this is higher than in previous studies,[11,35–38,40] where dental caries was the primary indication for oral health-related hospital admission in preschool and primary school children.[11,37] It is important to note that the majority (87%) of the children admitted to the PCH were <10 years of age and 36% of the total teeth affected by caries were the anterior teeth. Therefore, it is highly likely that the problem leading to admission had started well before the school years. As a result, the CDBS (although it covers children from 2 years of age) and SDS would not have had the opportunity to address the issues (i.e. ECC), which may start before 2 years of age. This may be a major contributing factor to the high number of posterior teeth affected by caries (64%).

Upon stratification, for children >7 years old, there was a higher number of dmft/DMFT (count) in the posterior compared with anterior teeth and a high likelihood of molar–incisor hypomineralisation (MIH) in those patients. MIH may affect

one in five Australian children[41] or one in six children globally.[42] MIH can affect the first permanent molars that erupt at ~6 years of age, and a significant association between MIH and dental caries has been reported.[43] A positive relationship between the extent of hypomineralised second primary molars and carious lesion severity has also been reported.[44]

Of the 310 cases collected, 202 underwent DGA (65%). This is consistent with previous findings, where 66% of patients presented with dental infections and underwent DGA.[13] The predominant procedure performed under DGA was tooth extraction, accounting for 54% of total treatments. In addition, extractions had the highest DC (66% of the total DC). For Australian children undergoing DGA from 1993 to 2004, there was a 4.9-fold rise in extractions.[45] Cost-wise, restorations had the third-highest DC (7.2%). However, restorations and endodontic treatment could potentially minimise space loss that may result from early extraction of deciduous molar teeth.[46] For Australian children undergoing DGA from 1993 to 2004, there was a 3.3-fold rise in restorations.[45] In the present study, there were two teeth (0.2% of total treatments) that underwent a pulpotomy and a stainless steel crown due to extensive caries.[47] Premature space loss due to untreated dental caries can negatively affect QoL because it can impact overall function and emotional well being, as well as giving rise to detrimental oral symptoms.[48]

DGA services can be resource intensive, both to the taxpayer and/or to the parents/guardians of the child undergoing the procedure.[45] Of the 202 cases in the PCH, total associated DCs were calculated to be A$120 490, or A$596 per case. According to the National Independent Hospital Pricing Authority, the mean DC of the common DGA (comprehensive treatment including extractions and restorative work) was A$3029 in 2012–13.[49] Our findings are below the average cost. This may be due to the primary focus of this study being on children presenting with dental emergencies who received emergency treatment only. Comprehensive care was not provided but anticipated for completion and on-going care by the on-referral practitioner.

Of the 202 cases, 37 resided in regional to remote WA. People living in regional to remote areas will have increased ICs because of travelling further to reach the PCH, which is located 5 km from the main city centre of Perth (WA). Parents/guardians may be financially affected as a result of their child being admitted to hospital, including loss of work time and earnings, and the costs of accommodation and travel.[45] The total IC in this study was A$193 334 (mean A$957 per case). Based on previously published data, the ICs in the present study were initially proposed to be 1.5-fold those of DCs.[50] However, the present study showed that the IC was 1.6-fold those of DC which is higher than the previously published data.[50]

There was no significant association between socioeconomic area-based background and DGA admissions. In contrast with previously published studies, possession of dental insurance was dependent on SES, remoteness and Indigenous status.[51] This indicates that patients requiring similar services would likely have higher DCs and ICs as a result of potential increased out-of-pocket costs. However, in this study there were higher numbers of children living in the major city areas with ease of access to the PCH. Other published studies indicated that children residing in remote to regional areas were at an increased risk of hospital admissions.[11,35–38,40] It is possible that, in the present study, children residing in remote and regionals areas were either untreated or potentially palliatively managed (e.g. antibiotic therapy and analgesics) without surgical intervention.

There are several limitations to the present study. Data were limited to the most current as at the time of study. The cases presented were only those related to pain and sepsis. This study did not consider the DCs of hospital admissions and anaesthetics administered by the anaesthetist, because the data were not available, but this could provide an avenue for a future studies.

Admission to a tertiary hospital can be seen as an indicator for a deficiency in the healthcare system. It is important to highlight the association between avoidable hospitalisation and primary health care.[52] The results in this study highlight the high costs associated with DGA at a publicly funded tertiary centre and the need for a stronger focus on preventive dental care for children to decrease the prevalence and incidence of dental infections.[13] One way to achieve this could be to reintroduce family-friendly public service announcements emphasising the importance of brushing.[53] In addition, it may be recommended for clinicians to raise parents' awareness of the negative effects of ECCs and to emphasise the availability of the CDBS, which may be accessed from the age of 2 years for early detection and prevention. By minimising untreated dental diseases with preventive care, beneficial cost-reduction outcomes on a hospital level would include a reduction in emergency staff resources, pressure, services and waiting times. This would also lower the cost at state and national levels for dental-related government spending on tertiary hospital care.

This study provides a foundation for a more significant research project. Undertaking further prospective research with a larger sample size, as well as a longer duration, has the potential to provide a better understanding of the overall treatments administered, as well as the cost-effectiveness of dental services at PCH. Because the PCH data span broad treatments provided in WA's only tertiary hospital for children, other studies may investigate the emergency treatments provided to children other than DGA and the associated costs. Further investigations are required to determine the cost to provide the same dental treatments at private dental clinics with potentially both public- and private-based funding to be able to offer cost comparisons for future planning.

Conclusion

Untreated dental caries in children was the most common cause for hospital admission. Predominant cases to present at the emergency department were young children (<7 years old) and those receiving extractions under GA. Not only do DCs remain a burden on the health budget and the Australian economy, but ICs and intangible costs also affect children and their families. As a result, having a better understanding of barriers to accessing preventive dental care will be critical to potentially reducing the financial burden on the Australian health system.

Competing interests

The authors declare no competing interests.

Acknowledgements

The authors acknowledge the Department of Dental Medicine staff at the Perth Children's Hospital. The authors also acknowledge Winthrop

Professor Marc Tennant at the School of Human Sciences and Clinical Associate Professor John Winters from Perth Children's Hospital for their kind support and assistance.

References

1 Australia Bureau of Statistics (ABS). Regional population by age and sex; 2019. Available at: https://www.abs.gov.au/statistics/people/population/regional-population-age-and-sex/latest-release [Verified 22 September 2020]
2 Tennant M, Kruger E. Turning Australia into a 'flat-land': what are the implications for workforce supply of addressing the disparity in rural-city dentist distribution? *Int Dent J* 2014; 64: 29–33. doi:10.1111/idj.12059
3 Australian Institute of Health and Welfare (AIHW). Oral health and dental care in Australia: key facts and figures 2015. 2016.
4 Australian Government - Department of Health. Guide to the Child Dental Benefits Schedule. 2018.
5 WA Department of Health. State Oral Health Plan 2016–2020. Perth: Office of the Chief Dental Officer, Clinical Services and Research, Department of Health; 2016.
6 Putri DE, Kruger E, Tennant M. Retrospective analysis of utilisation of the Australian Child Dental Benefit Scheme. *Aust Health Rev* 2020; 44: 304–9. doi:10.1071/AH19011
7 Arrow P. Oral health of schoolchildren in Western Australia. *Aust Dent J* 2016; 61: 333–41. doi:10.1111/adj.12368
8 Hallett KB, O'Rourke PK. Social and behavioural determinants of early childhood caries. *Aust Dent J* 2003; 48: 27–33. doi:10.1111/j.1834-7819.2003.tb00005.x
9 Government of Western Australia. School Dental Service; Available at: https://www.dental.wa.gov.au/dental-services/school-dental-service [Verified 22 September 2020]
10 Ha DH, Roberts-Thomson KF, Arrow P, Peres KG, Do LG. Children's oral health status in Australia, 2012–14. Adelaide: University of Adelaide Press; 2016.
11 Alsharif AT, Kruger E, Tennant M. A population-based cost description study of oral treatment of hospitalized Western Australian children aged younger than 15 years. *J Public Health Dent* 2015; 75: 202–9. doi:10.1111/jphd.12088
12 Alsharif AT, Kruger E, Tennant M. Dental hospitalization trends in Western Australian children under the age of 15 years: a decade of population-based study. *Int J Paediatr Dent* 2015; 25: 35–42. doi:10.1111/ipd.12095
13 Aminian P, Kruger E, Winters J, Nicholls W, Tennant M. Dental emergency attendance at an Australia tertiary children's hospital. *Asia Pac J Health Manag* 2018; 13: i35. doi:10.24083/apjhm.v13i2.1
14 Yawary R, Anthonappa RP, Ekambaram M, McGrath C, King NM. Changes in the oral health-related quality of life in children following comprehensive oral rehabilitation under general anaesthesia. *Int J Paediatr Dent* 2016; 26: 322–9. doi:10.1111/ipd.12200
15 Jamjoom MM, al-Malik MI, Holt RD, el-Nassry A. Dental treatment under general anaesthesia at a hospital in Jeddah, Saudi Arabia. *Int J Paediatr Dent* 2001; 11: 110–6. doi:10.1046/j.1365-263x.2001.00252.x
16 Abanto J, Carvalho TS, Mendes FM, Wanderley MT, Bonecker M, Raggio DP. Impact of oral diseases and disorders on oral health-related quality of life of preschool children. *Community Dent Oral Epidemiol* 2011; 39: 105–14. doi:10.1111/j.1600-0528.2010.00580.x
17 Kassebaum NJ, Bernabe E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of untreated caries: a systematic review and metaregression. *J Dent Res* 2015; 94: 650–8. doi:10.1177/0022034515573272
18 Kruger E, Dyson K, Tennant M. Pre-school child oral health in rural Western Australia. *Aust Dent J* 2005; 50: 258–62. doi:10.1111/j.1834-7819.2005.tb00370.x
19 Smith K, Kruger E, Dyson K, Tennant M. Oral health in rural and remote Western Australian indigenous communities: a two-year retrospective analysis of 999 people. *Int Dent J* 2007; 57: 93–9. doi:10.1111/j.1875-595X.2007.tb00444.x
20 Dogar F, Kruger E, Dyson K, Tennant M. Oral health of pre-school children in rural and remote Western Australia. *Rural Remote Health* 2011; 11: 1869.
21 Sims C, Stanley B, Milnes E. The frequency of and indications for general anaesthesia in children in Western Australia 2002–2003. *Anaesth Intensive Care* 2005; 33: 623–8. doi:10.1177/0310057X0503300512
22 Australian Institute of Health and Welfare (AIHW). Oral health and dental care in Australia; 2019. Available at: https://www.aihw.gov.au/reports/dental-oral-health/oral-health-and-dental-care-in-australia]
23 Ernst R. Indirect costs and cost-effectiveness analysis. *Value Health* 2006; 9: 253–61. doi:10.1111/j.1524-4733.2006.00114.x
24 Carlisle K, Larkins S, Croker F. Disparities in dental health of rural Australians: hospitalisation rates and utilisation of public dental services in three communities in North Queensland. *Rural Remote Health* 2017; 17: 3807. doi:10.22605/RRH3807
25 Australian Dental Association (ADA). The Australian Schedule of Dental Services and Glossary 12th Edition. 2017.
26 Armfield JM. High caries children in Australia: a 'tail' of caries distribution. *Aust Dent J* 2005; 50: 204–6. doi:10.1111/j.1834-7819.2005.tb00362.x
27 Bratthall D. Introducing the Significant Caries Index together with a proposal for a new global oral health goal for 12-year-olds. *Int Dent J* 2000; 50: 378–84. doi:10.1111/j.1875-595X.2000.tb00572.x
28 Australia Bureau of Statistics (ABS). SEIFA by State Suburb Code (SSC). 2016.
29 Australian Government - The Department of Health. The Child Dental Benefits Schedule; 2018. Available at: https://www1.health.gov.au/internet/main/publishing.nsf/Content/childdental [Verified 22 August 2019]
30 Anjrini AA, Kruger E, Tennant M. Cost effectiveness modelling of a 'watchful monitoring strategy' for impacted third molars vs prophylactic removal under GA: an Australian perspective. *Br Dent J* 2015; 219: 19–23. doi:10.1038/sj.bdj.2015.529
31 Australia Bureau of Statistics (ABS). Average Weekly Earnings, Australia, May 2019. 2019.
32 Australia Bureau of Statistics (ABS). Labour Force, Australia, Sep 2019. 2019.
33 Schober P, Boer C, Schwarte LA. Correlation coefficients: Appropriate use and interpretation. *Anesth Analg* 2018; 126: 1763–8. doi:10.1213/ANE.0000000000002864
34 Perth Children's Hospital. Dental department; 2019. Available at: https://pch.health.wa.gov.au/Our-services/Dental [Verified 1 August 2019.]
35 Slack-Smith L, Colvin L, Leonard H, Kilpatrick N, Read A, Messer LB. Dental admissions in children under two years–a total-population investigation. *Child Care Health Dev* 2013; 39: 253–9. doi:10.1111/j.1365-2214.2011.01360.x
36 Slack-Smith L, Colvin L, Leonard H, Kilpatrick N, Bower C, Brearley Messer L. Factors associated with dental admissions for children aged under 5 years in Western Australia. *Arch Dis Child* 2009; 94: 517–23. doi:10.1136/adc.2008.145672
37 Tennant M, Namjoshi D, Silva D, Codde J. Oral health and hospitalization in Western Australian children. *Aust Dent J* 2000; 45: 204–7. doi:10.1111/j.1834-7819.2000.tb00558.x
38 Kruger E, Dyson K, Tennant M. Hospitalization of Western Australian children for oral health related conditions: a 5–8 year follow-up. *Aust Dent J* 2006; 51: 231–6. doi:10.1111/j.1834-7819.2006.tb00434.x
39 Foster H, Fitzgerald J. Dental disease in children with chronic illness. *Arch Dis Child* 2005; 90: 703–8. doi:10.1136/adc.2004.058065

40 Slack-Smith LM, Read AW, Colvin LJ, *et al*. Total population investigation of dental hospitalizations in indigenous children under five years in Western Australia using linked data. *Aust Dent J* 2011; 56: 358–64. doi:10.1111/j.1834-7819.2011.01366.x

41 Arrow P. Prevalence of developmental enamel defects of the first permanent molars among school children in Western Australia. *Aust Dent J* 2008; 53: 250–9. doi:10.1111/j.1834-7819.2008.00057.x

42 Hubbard MJ. Molar hypomineralization: What is the US experience? *J Am Dent Assoc* 2018; 149: 329–30. doi:10.1016/j.adaj.2018.03.013

43 Americano GC, Jacobsen PE, Soviero VM, Haubek D. A systematic review on the association between molar incisor hypomineralization and dental caries. *Int J Paediatr Dent* 2017; 27: 11–21. doi:10.1111/ipd.12233

44 Owen ML, Ghanim A, Elsby D, Manton DJ. Hypomineralized second primary molars: prevalence, defect characteristics and relationship with dental caries in Melbourne preschool children. *Aust Dent J* 2018; 63: 72–80. doi:10.1111/adj.12567

45 Jamieson LM, Roberts-Thomson KF. Dental general anaesthetic trends among Australian children. *BMC Oral Health* 2006; 6: 16. doi:10.1186/1472-6831-6-16

46 Pedersen J, Stensgaard K, Melsen B. Prevalence of malocclusion in relation to premature loss of primary teeth. *Community Dent Oral Epidemiol* 1978; 6: 204–9. doi:10.1111/j.1600-0528.1978.tb01151.x

47 American Academy Of Pediatric Dentistry (AAPD). Pulp Therapy for Primary and Immature Permanent Teeth. *Pediatr Dent* 2017; 39: 325–33.

48 Monte-Santo AS, Viana SVC, Moreira KMS, Imparato JCP, Mendes FM, Bonini GAVC. Prevalence of early loss of primary molar and its impact in schoolchildren's quality of life. *Int J Paediatr Dent* 2018; 28: 595–601. doi:10.1111/ipd.12416

49 Independent Hospital Pricing Authority. National Hospital Cost Data Collection Australian Public Hospitals Cost Report 2012–2013, Round 17. Darlinghurst, NSW: Independent Hospital Pricing Authority: 2015.

50 Drummond MF, Sculpher MJ, Claxton K, Stoddart GL, Torrance GW. Methods for the economic evaluation of health care programmes. Oxford: Oxford University Press; 1997.

51 Alsharif AT, Kruger E, Tennant M. Disparities in dental insurance coverage among hospitalised Western Australian children. *Int Dent J* 2014; 64: 252–9. doi:10.1111/idj.12116

52 Kruger E, Tennant M. Potentially preventable hospital separations related to oral health: a 10-year analysis. *Aust Dent J* 2015; 60: 205–11. doi:10.1111/adj.12322

53 hit92.9. It's time: Perth wants those community service ads back on TV! 2017. Available at: https://www.hit.com.au/story/its-time-perth-wants-those-community-service-ads-back-on-tv-15415 [Verified 10 September 2020]