

Inequalities in dental caries among Indigenous and non-Indigenous children in Australia: A literature review

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ABSTRACT

Dental caries constitutes one of the most ubiquitous diseases in Australia, with Indigenous children presenting a notably higher prevalence than their non-Indigenous peers. This literature review aims to update the knowledge base developed by Christian and Blinkhorn in 2012, with a particular focus on the contemporary disparities in dental caries between Indigenous and non-Indigenous children. Our research strategy involved a thorough exploration of the Medline, PubMed, and Scopus databases to identify pertinent studies published between 2009 and 2022. Supplementary resources included various government websites and citation searches. We prioritised studies that focused on children aged 5–6 or 12 years—reflecting the World Health Organization’s index ages for oral health—and that reported dental caries prevalence and experience indicators. Our review methodology was guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. The updated search, spanning 2009 to 2023, retrieved studies that reported caries estimates exclusively from 2009 to 2014. Within this period, the prevalence of dental caries in Indigenous children’s primary teeth ranged between 52% and 77%, while the prevalence in permanent teeth varied from 36% to 60%. This updated review indicated that Indigenous children continue to experience caries at an approximately twice higher rate than non-Indigenous children, sustaining the persisting disparity in caries estimates. The findings from this review show that no discernible improvement in dental caries rates among Australian Indigenous children has been observed in comparison to the previous review; and that Indigenous children continue to experience both higher prevalence and severity of dental caries compared to non-Indigenous children.

Keywords: children, dental caries, disparity, indigenous, inequality.

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CLINICAL RELEVANCE

Dental caries among Indigenous children remains a significant health concern in Australia. Prior to this study, there was an established inequality in dental caries estimates between Indigenous and non-Indigenous children. Our updated review shows that this inequality continues to be persistent, with Indigenous children still being twice as likely to experience dental caries. Clinical risk assessment tools should consider indigenous status as an indicator of higher risk. Similarly, clinicians should be cognisant that Indigenous children continue have a higher risk for dental caries, and will require targeted and tailored clinical intervention for effective oral healthcare.

INTRODUCTION

Dental caries is a highly prevalent oral disease that can seriously impact children’s health. According to a 2018 study investigating common paediatric diseases from infancy to 14–15 years, dental caries peaks in severity among children aged 8–9 years.¹ These findings underscore that the issue of dental caries in children warrants significant attention from a health perspective. Moreover, dental caries can also impede children’s growth and development. A study by Van Gerner-Schriks et al. (2011) found an inverse relationship between body proportions (height, weight, and body mass index) and dental caries prevalence, thus suggesting that dental caries can negatively affect children’s physical growth and development.² In addition to physical problems, early caries in preschool children may also lead to

mental and social problems.³ In Australia, paediatricians report that many families overlook their children's oral health, with conditions like dental caries potentially inhibiting children's ability to eat, speak, sleep, and interact socially.⁴

In Australia, Indigenous children are deemed to be at a higher risk for oral diseases such as dental caries. A 2021 study found that 61% of Indigenous children ages 5–10 years had experienced dental caries in their deciduous teeth.⁵

Based on data from the Australian national child oral health survey for two periods (2000–2002 and 2007–2010), the dental caries experience among Indigenous children was more severe, than their non-Indigenous counterparts.⁶ The most recent 2012–2014 national survey on the oral health of Australian children once again highlighted the high prevalence of untreated dental caries among Indigenous children, and it appears that the gap in caries estimates between Indigenous and non-Aboriginal children continues to persist.⁷ In addition, Indigenous children residing in remote areas had a higher prevalence of dental caries.⁷ Several factors potentially contribute to the oral health disparity between Indigenous and non-Indigenous children. Established factors contributing to the oral health disparity between Indigenous and non-Indigenous children include: socioeconomic status, geographic dispersion, oral health related habits and diet. Among Indigenous Australians, additional cultural-specific factors and the ill-effects of colonization have exacerbated the situation, and these include: access to cultural appropriate services, transport issues, sorry business or ceremony obligations, mistrust in mainstream services- due to generational trauma (stolen generation), language barriers and fear of judgement.^{8,9} Thus, the promotion of oral health, along with prevention and management of dental caries, is an urgent priority for the health of Indigenous children.¹⁰

Current research on dental caries among Indigenous children in Australia is limited. There is a scarcity of research that systematically reviews and summarises the disparity in dental caries between Indigenous and non-Indigenous children to determine whether current programs and policies are having an impact on closing the gap. This review aims to update the information presented in Christian and Blinkhorn 2012,¹¹ by compiling and comparing information on dental caries estimates among Indigenous and non-Indigenous Australian children published between 2009 and 2022. The importance of this review lies in its potential to gauge the success of current programs and policies aimed at improving Indigenous oral health, and to inform appropriate intervention strategies and policy guidance for oral health promotion in Australia.

As such, the aim of this review was to investigate the inequality in dental caries between Indigenous and non-Indigenous children in Australia.

The specific study objectives were:

- (1) To describe the caries prevalence and experience.
- (2) To investigate the inequality in caries estimates between Indigenous and non-Indigenous children.

METHODS

The methodology for this review of the literature was informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The term 'Indigenous' is utilised to represent both Aboriginal and Torres Strait Islander peoples of Australia.

Search strategy

The databases searched in this review were Medline, PubMed, Web of Science, Scopus (Appendix A). Official Australian Government reports and information were also examined, including resources from the Australian Institute of Health and Welfare, National Health and Medical Research Council, Australian Indigenous HealthInfoNet, Register of Australian Primary Health Care Research, and Australian Policy Online. Experts in the field were also consulted.

In line with the research objectives and theme, keywords encompassed the following four concepts (Appendix B): Caries, Children, Australia and Indigenous.

Study selection

The study selection was primarily guided by the inclusion and exclusion criteria shown in Table 1. Where comparative estimates for non-Indigenous were not available within a selected paper/report, these were matched (where available) with caries estimates from other studies/reports matched by age, location and time.

Following the literature search, EndNote and Covidence were used for the reference management and screening processes.¹² In the initial stage, one author (Xinhao Wang) independently reviewed the title and abstract of each article according to the inclusion and exclusion criteria. As a quality assurance measure,

Table 1. Studies inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Population	Age: 5–6 and 12-year-old Indigenous Australians	Age: children of other ages Area: other regions around the world
Comparators	Non-Indigenous Australian children	General Australian children with other oral conditions
Outcomes	Caries prevalence and experience	Other oral disease measures
Language	English	Non-English

10% of identified titles and abstracts were independently reviewed by another reviewer (Bradley Christian), with consensus achieved through discussion or consultation with a third reviewer. A similar process was followed for the full text screening. The specific process of article selection for this research is illustrated in the PRISMA flow diagram (Fig. 1).

Data extraction

An evidence table was created to summarise the information from the selected articles and included: the prevalence of dental caries among Indigenous and non-Indigenous children, and the caries experience.¹³ Besides the primary research outcomes, the table also included information such as location, time period, study design, and dental caries diagnostic criteria. Data extraction was performed by one author (Xinhao Wang) and 10% verified for accuracy by a 2nd author (Bradley Christian) with discrepancies resolved by discussion.

Data analysis

The analysis section of this review is narrative, providing a structured summary and discussion of the characteristics and findings of the included studies. This review primarily compares caries outcomes among Indigenous and non-Indigenous Australian

children. Data analysis and discussion focuses on the direction of the disparity in caries estimates, and a discussion from a health inequity perspective.

RESULTS

The characteristics of individual studies are shown in Table 2.^{14–25} Almost all articles adopted a cross-sectional study design and used WHO diagnostic criteria. A key finding was that the review did not identify primary data collection on this topic after 2014 in any of the published studies.

Primary dentition

Table 3 presents the dental caries prevalence (%cp) and experience (dmft/dmfs) in the primary dentition of Indigenous Australian children age 2–10 years. The data spans from 2009 to 2014 across different States. Notably, the dental caries prevalence in Indigenous children's deciduous teeth ranged from 52% to 77%. For example, children aged 2–4 years in Western Australia exhibited a dental caries prevalence of 70%. In contrast, the prevalence in children aged 5–6 years in Queensland was 73%, while the overall prevalence for children in the same age bracket from Queensland, South Australia, Western Australia, Tasmania, Northern Territory, and the Australian Capital Territory was 74%.

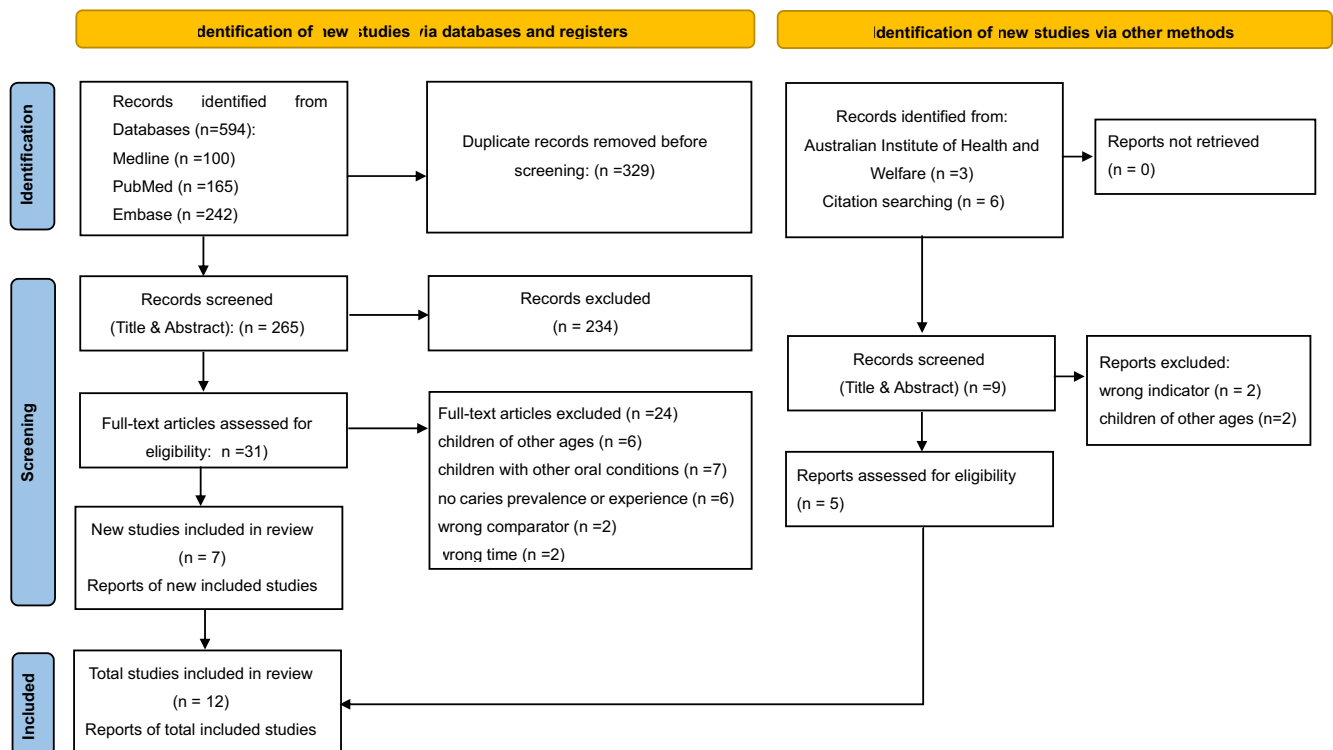


Fig. 1 PRISMA flow diagram showing the study selection process.

Table 2. Study characteristics in this review

Year of caries data collection	Author, year	Study design	Caries index	Diagnostic criteria
2009	Jamieson, 2010	Retrospective study	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1998
2011	Dogar, 2011	Cross-sectional	Deciduous teeth – dmft index	WHO 1997
2010	Ha, Crocombe, & C Mejia, 2014	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1998
2012	Johnson, 2014	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1997
2009	Ha, 2014	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1998
2010–2012	Do & Spencer, 2014	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1998
2014	Smith, 2015	Cross-sectional	Deciduous teeth – dmft index	WHO 2009
2014	Arrow, 2016	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1997
2010	Laloo, 2016	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 1998
2012–2014	Do & Spencer, 2016	Cross-sectional	Deciduous teeth – dmfs index Permanent teeth – DMFS index	Similar to WHO
2012–2014	Martin-Kerry <i>et al.</i> , 2019	Cross-sectional	Deciduous teeth – dmft index Permanent teeth – DMFT index	WHO 2012
2012–2014	Haag, 2021	Cross-sectional	Deciduous teeth – dmfs index	WHO 1997

Table 3. Dental caries prevalence (%cp) and experience (dmft/dmfs) in the primary dentition among Indigenous Australian children

Year	Place	Age (years)	Location [†]	n	%cp	dmft/dmfs	SD	References
2009	NT	6–8	State	4467	54	2.00	nr	Jamieson, 2010
2009	QLD; SA; WA; Tas; NT; ACT	5–10	National	nr	nr	3.42	nr	Ha <i>et al.</i> , 2014
2010	QLD; SA; WA; Tas; NT; ACT	5–6	National	nr	74	4.22	nr	Ha, 2014
2010	QLD; SA; WA; Tas; NT; ACT	5–10	Poor	4471	77	4.12	nr	Laloo, 2016
			Intermediate		76	3.81	nr	
			Affluent		72	3.32	nr	
2010–2012	QLD	5–6	State	nr	73	3.50	nr	Do & Spencer, 2014
2011	WA	2–4	rural and remote	79	70	3.40	3.70	Dogar, 2011
2012	QLD	6	(NPA)-F	nr	nr	4.07	nr	Johnson, 2014
			(NPA)-NF	nr	nr	6.37	nr	
2012–2014	VIC	5–6	Major city	147	nr	2.60	nr	Martin-Kerry <i>et al.</i> , 2019
			Inner regional	283	nr	3.10	nr	
			Outer regional	90	nr	4.40	nr	
2012–2014	Vic; NSW; QLD; SA; WA; Tas; ACT; NT	5–10	National	485	nr	6.40 [‡]	nr	Haag, 2021
2012–2014	Vic; NSW; QLD; SA; WA; Tas; ACT; NT	5–6	National	nr	52	5.90 [‡]	nr	Do & Spencer, 2016
2014	WA	5–10	State	268	nr	2.54	nr	Arrow, 2016
2014	NSW	4	State	173	nr	2.40	2.57	Smith, 2015

Northern Peninsula Area of Far North Queensland (NPA); nr=not reported. SD=Standard deviation; cp=caries prevalence.

[†]Location includes rural or urban location, poor or affluent place, and also fluoride status of drinking water (F=fluoridated; NF=non-fluoridated).

[‡]Caries index: dmfs.

Two studies in New South Wales in 2014²⁰ and Victoria from 2012 to 2014²⁴ outlined differences in dental caries experience between urban and rural areas. For instance, in Victoria, the mean dmft score in the outer region was nearly double that in major cities (4.40 and 2.60, respectively).

Permanent dentition

Table 4 displays the dental caries prevalence (%cp) and experience (DMFT/DMFS) in permanent dentition

among Indigenous Australian children aged 6–15 years. Between 2009 and 2014, the dental caries prevalence rates fluctuated between 36% and 60%. The mean DMFT score generally stayed around 2, except for a marginally smaller mean DMFT score of 0.96 observed in Western Australia in 2014. In 2010, the overall DMFT score for children in Queensland, South Australia, Western Australia, Tasmania, Northern Territory, and the Australian Capital Territory was 2.42. This score significantly exceeded the DMFT scores in Queensland from 2010 to 2012 and Victoria

Table 4. Dental caries prevalence (%cp) and experience (DMFT/DMFS) in the permanent dentition among Indigenous Australian children

Year	Place	Age (years)	Location [†]	n	%cp	DMFT/DMFS	SD	References
2009	NT	11–13	State	2666	36	0.80	nr	Jamieson, 2010
2009	QLD; SA; WA; Tas; NT; ACT	8–12	National	nr	nr	1.20	nr	Ha et al., 2014
2010	QLD; SA; WA; Tas; NT; ACT	6–15	Poor	6138	58	2.27	nr	Lalloo, 2016
			Intermediate		51	1.81	nr	
			Affluent		49	1.70	nr	
2010	QLD; SA; WA; Tas; NT; ACT	12–13	National	nr	60	2.42	nr	Ha, 2014
2010–2012	QLD	12–14	State	nr	53	1.70	nr	Do & Spencer, 2014
2012	QLD	12	(NPA)-F	nr	nr	2.80	nr	Johnson, 2014
			(NPA)-NF	nr	nr	3.50	nr	
2012–2014	Victoria	12	Major city	45	nr	1.90	nr	Martin-Kerry et al., 2019
			Inner regional	93	nr	1.60	nr	
			Location					
			Outer regional	28	nr	1.70	nr	
2012–2014	Vic; NSW; QLD; SA; WA; Tas; ACT; NT	12–14	National	nr	54	2.40 [‡]	nr	Do & Spencer, 2016
2014	WA	6–15	State	349	nr	0.96	nr	Arrow, 2016

Northern Peninsula Area of Far North Queensland (NPA); nr=not reported. SD=Standard deviation; cp=caries prevalence.
[†]Location includes rural or urban location, poor or affluent place, and also fluoride status of drinking water (F=fluoridated; NF=non-fluoridated).
[‡]Caries index: DMFS.

from 2012 to 2014, which were 1.70 and 1.73 (mean values across different locations), respectively.

Much like the primary dentition, a disparity in dental caries experience was observed between urban and rural areas. However, in Victoria, the mean DMFT score for 12-year-old children in major cities was higher at 1.90, while a lower score of 1.70 was reported in outer regions.

Dental caries disparities

Tables 5 and 6 compare caries prevalence and experience estimates in primary and permanent dentition among Indigenous and non-Indigenous children. It was observed that Indigenous children had consistently

higher estimates for dental caries, both in the primary and permanent dentition, compared to non-Indigenous children.

The National Child Oral Health Study from 2012 to 2014 revealed that dental caries prevalence among Indigenous children aged 5–6 years was 55%, compared to a 33% prevalence among non-Indigenous children, a difference of 19%. Regarding caries experience, Indigenous children had a mean dmft score of 3.54 in primary dentition, nearly twice as high as that of non-Indigenous children (mean dmft = 1.77). The relative difference between Indigenous and non-Indigenous children’s deciduous teeth in dmft/dmfs remained mostly unchanged between 2009 and 2014. In other words, the caries experience of Indigenous

Table 5. Comparison of caries prevalence and experience in the primary dentition

Year	State	Caries prevalence (%)			Caries experience (dmft/dmfs)			References
		Ind	non-Ind	Difference	Ind	non-Ind	Difference	
2009	NT	74	54	-	3.40	2.00	1.40	Jamieson, 2010*
2009	QLD; SA; WA; Tas; NT; ACT	nr	nr	-	3.42	1.77	1.93	Ha et al., 2014
2010	QLD; SA; WA; Tas; NT; ACT	74	49	25	4.22	2.22	1.90	Ha, 2014
2010	QLD; SA; WA; Tas; NT; ACT	75 [†]	56 [†]	19	3.75 [†]	2.30 [†]	1.63	Lalloo, 2016
2010–2012	QLD	73	38	35	3.50	1.70	2.06	Do & Spencer, 2014
2011	WA	70	25	45	3.40	0.8	4.25	Dogar, 2011
2012	QLD	nr	nr	-	4.07	1.70	2.37	Johnson, 2014*
2012–2014	VIC	nr	nr	-	3.37 [†]	2.23 [†]	1.51	Martin-Kerry et al., 2019
2012–2014	Vic; NSW; QLD; SA; WA; Tas; ACT; NT	nr	nr	-	6.40 [‡]	2.90 [‡]	2.21	Haag, 2021
2012–2014	Vic; NSW; QLD; SA; WA; Tas; ACT; NT	52	33	19	5.90 [‡]	2.50 [‡]	2.36	Do & Spencer, 2016
2014	WA	nr	nr	-	2.54	1.37	1.85	Arrow, 2016
2014	NSW	nr	nr	-	2.40	1.10	1.30	Smith, 2015*

[†]The mean value of difference location (Poor&Affluent).

[‡]Caries index: dmfs; nr=not reported; Ind=Indigenous.

*Matched from National Child Dental Survey 2012–2014.²³

[Correction added on 25 January 2024, after first online publication: In Table 5, the sub-heading, ‘AB’ has been changed to ‘Ind’ and its footnote has been added in this version].

Table 6. Comparison of caries prevalence and experience in the permanent dentition

Year	State	Caries prevalence (%)			Caries experience (DMFT/DMFS)			References
		Ind	non-Ind	Difference	Ind	non-Ind	Difference	
2009	NT	44	36	-	1.00	0.80*	0.20	Jamieson, 2010
2009	QLD; SA; WA; Tas; NT; ACT	nr	nr	-	1.20	0.51	2.35	Ha, Crocombe, & C Mejia, 2014
2010	QLD; SA; WA; Tas; NT; ACT	53 [†]	38 [†]	15	1.93 [†]	1.13 [†]	1.71	Laloo, 2016
2010	QLD; SA; WA; Tas; NT; ACT	60	49	11	2.42	1.45	1.67	Ha, 2014
2010–2012	QLD	53	46	7	1.70	1.30	1.31	Do & Spencer, 2014
2012	QLD	nr	nr	-	2.80	1.30*	1.50	Johnson, 2014
2012–2014	Victoria	nr	nr	-	1.73 [†]	1.76 [†]	0.98	Martin-Kerry <i>et al.</i> , 2019
2012–2014	Vic; NSW; QLD; SA; WA; Tas; ACT; NT	54.00	37	17	2.40 [‡]	1.30 [‡]	1.85	Do & Spencer, 2016
2014	WA	nr	nr	-	0.96	0.49	1.96	Arrow, 2016

[†]The mean value of difference location (Poor&Affluent).

[‡]Caries index: DMFS; Ind=Indigenous.

*Matched from National Child Dental Survey 2012–2014.²³

[Correction added on 25 January 2024, after first online publication: In Table 6, the sub-heading, 'AB' has been changed to 'Ind' and its footnote has been added in this version].

children in the primary dentition was approximately twice that of non-Indigenous children.

From 2010 to 2014, the prevalence of caries in the permanent dentition of Indigenous and non-Indigenous children did not significantly change over time (Table 6). A similar trend was observed in caries experience (DMFT) among Indigenous and non-Indigenous children. The National Child Oral Health Study from 2012 to 2014 indicated that Indigenous children (54%) aged 12–14 years had a 17% higher prevalence of dental caries than non-Indigenous children (37%). In 2010, Indigenous children (DMFT = 2.42) demonstrated a caries experience that was 1.67 times higher than that of non-Indigenous children (DMFT = 1.45) across Queensland, South Australia, Western Australia, Tasmania, Northern Territory, and the Australian Capital Territory. Similarly, in 2012–2014, the national study reported that the DMFS score for Indigenous children aged 12–14 years was 2.40, 1.85 times higher than the DMFS score of 1.30 for their non-Indigenous counterparts. This gap has mostly persisted between Indigenous and non-Indigenous children in permanent dentition caries prevalence and experience.

DISCUSSION

This literature review provides an update to the information on the Indigenous and non-Indigenous Australian children's dental caries, presented in Christian and Blinkhorn 2012.¹¹ The results of the current review highlight the fact that Indigenous children continue to have higher rates of dental caries compared with non-Indigenous children, with no evidence that the gap is being closed. This in turn could mean that current programs and policies aimed at reducing the gap are not having any impact. However, this result needs to be considered in the important context of the lack of contemporary data. A key finding of this

review is that although the years from 2009 to 2022 were searched, the review data came from only 2009–2014. As a result, the dental caries status of Indigenous Australian children after 2014 could not be determined, which is almost 10 years ago at the time of this review. There is clearly a lack of contemporary evidence on caries estimates to not only inform program planning and policy making, but to also demonstrate impact. This is a major issue.

Indigenous people in Australia have experienced unfair treatment, such as colonisation, racism, and cultural genocide, which has profoundly impacted their physical, mental and emotional health.²⁶ These political and historical factors, have exacerbated the more commonly investigated influences on dental caries, such as: increased consumption of sugar-sweetened beverages²⁷; lack knowledge and awareness of oral health; poor oral health behaviours and access to care.²⁸

In recent years, the government and states have taken various measures to narrow the gap between Indigenous and non-Indigenous children with dental caries. For example, in regional, rural and remote communities in New South Wales where the majority (approximately 56%) Indigenous people live, the communities and the school jointly developed an oral health promotion plan, including brushing teeth at school under the supervision of teachers, distributing fluoride toothpaste at school, publicising oral knowledge, and providing drinking water to reduce the consumption of sugary drinks.²⁹ The previous paragraph mentioned that consuming sugary beverages and lacking oral health knowledge and awareness could lead to caries problems in children. In addition, using fluoride toothpaste twice daily can effectively prevent dental caries.³⁰ Therefore, these specific measures in NSW Indigenous communities play the role of oral health promotion in three directions: prevention of dental caries aetiology,

oral knowledge and awareness, and reduction of bad habits that lead to dental caries. A research project in NSW called 'Smiles not Tears', focused on preschool-age children, promoted brushing twice a day with fluoride toothpaste and reducing sugary foods and drinks intake as much as possible.³¹ A more direct way to prevent dental caries in children is with fluoride varnish. The results of a trial in remote Indigenous communities of Australia's Northern Territory once again confirmed that fluoride varnish could effectively prevent dental caries in children.^{27,32} So while, programs exist to prioritise and provide timely care for Indigenous children, it appears that on a broader level they are not having much of an impact and this could be due to the limited reach as well as the lack of continuity of programs.

From the theoretical and small-scale short-term experimental results, the above dental caries prevention program and specific intervention measures can reduce the severity of dental caries in children. However, the results of this review clearly show that the prevalence of dental caries and the experience of Indigenous Australian children and the gap with non-Indigenous children have not obviously improved. There are several potential reasons for this persistent gap. First of all, most of the reductions have been demonstrated in small scale research and programs, without follow-on scale-up, as such there are problems with sustainability. Second, the target population of these dental caries prevention programs is Indigenous children, so offering a respectful and cultural safe service environment is essential. In other words, the cultural appropriateness is crucial in any intervention program. Third, the majority of current programs and policies are based on Western principles of medicine and as such will have limited impact. Finally, a potential issue with all current programs and policies is that they fail to address the broader drivers of ill-health associated behaviours, that is, they do not address the causes of the causes.

Globally, health disparities between Indigenous and non-Indigenous populations continue to be markedly evident, a pattern that is especially pronounced in affluent nations such as Australia (specifically among Indigenous and Torres Strait Islanders), New Zealand (particularly among the Maori), and Canada (notably among First Nation, Inuit, and Metis peoples).³³ Within the confines of these economically thriving countries, there lies a significant divergence in the prevalence of dental caries between Indigenous children and their non-Indigenous counterparts.³³ Similar to Australia, New Zealand continues to grapple with disparities in dental caries that mirror those observed among Indigenous children in Australia. The Maori people, who constitute the Indigenous community of New Zealand, display evidently higher rates of dental

caries compared with their non-Maori peers.³³ An analysis spanning from 1995 to 2000 showed that Early Childhood Caries (ECC) affected over half of the 5-year-old Maori children, and the incidence rate among Maori youth was found to be 2.2 times greater than that amongst non-Maori children.³³ The inequality in dental caries among Indigenous children in Canada is similar to the patterns seen in New Zealand and Australia. Despite a general decline in dental caries prevalence within the non-Indigenous populace, young First Nations children exhibit a disconcerting escalation in both the severity and prevalence of dental caries. Numerous studies conducted across various First Nations communities in Canada consistently report elevated prevalence rates for dental caries in young children, ranging between 50% and 54%.³⁴ Furthermore, a 2008–2009 Survey Report on Inuit Oral Health showed caries prevalence rates ranging from 44.7% to 80% among individuals aged three years and above. Alarming, 93.4% of school-aged children between 6 and 11 years were found to have at least one instance of dental caries in either their primary or permanent teeth.³⁵

Indigenous groups in all three nations face parallel challenges tied primarily to the negative impacts of colonisation that has led to socioeconomic disadvantages, restricted access to healthcare, cultural disruption and dietary patterns that influence caries rates.³⁶ Additionally, the geographic spread of Indigenous populations within these countries might impinge upon the accessibility of dental care services. This can obstruct the establishment of preventive programs, especially in remote and underprivileged areas, thereby exacerbating the disparities in oral health.³⁶

The strength of this review is that the majority of data reported in these studies comes from official sources (national survey), and these sources of information are all publicly available.²⁴ In addition, the diagnostic criteria used for dental caries are generally consistent across all studies, with eleven studies using WHO standards, and one using diagnostic criteria similar to the WHO guideline.

The 12 studies in this review also have some limitations. First, whether children come from fluoridated areas cannot be accurately accounted,²¹ and children from fluoridated areas may be considered from non-fluoridated regions. Second, dental caries data of some populations were collected when they participated in public oral health services, which may not represent the current caries status in the general population.²⁴ Third, although each study has a uniform diagnostic standard for dental caries, different judgments by each dentist may lead to different diagnosis.^{18,22}

A limitation of the review process was that grey literature was not searched, so that some unpublished local reports may have been missed. The search may

also have missed some sub-official and non-governmental statistical information, and incomplete data may affect the conclusions.

CONCLUSION

This updated review indicated that Indigenous children continue to experience dental caries at an approximately twice higher rate than non-Indigenous children, sustaining the persisting disparity in caries estimates. A more alarming discovery was the absence of contemporary caries data on this topic. There is clearly an urgent need for more timely evidence generation to inform policy/program planning, implementation and evaluation; which will be a key strategy towards better oral health outcomes for Indigenous Australian children.

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AUTHOR CONTRIBUTIONS

X Wang: Conceptualisation; methodology; data curation; software; writing – review and editing; writing – original draft. **A Ghanbarzadegan:** Writing – review and editing; supervision; methodology; formal analysis; data curation. **W Sohn:** Methodology; supervision; writing – review and editing; formal analysis; conceptualization. **E Taylor:** Writing – review and editing. **J Gao:** Writing – review and editing. **B Christian:** Conceptualisation; methodology; data curation; writing – review and editing; formal analysis; methodology; supervision; conceptualization; writing – original draft; software.

REFERENCES

- Liu T, Lingam R, Lycett K, *et al.* Parent-reported prevalence and persistence of 19 common child health conditions. *Arch Dis Child* 2018;103(6):548–556.
- van Gemert-Schriks MC, van Amerongen EW, Aartman IH, Wennink JM, Ten Cate JM, de Soet JJ. The influence of dental caries on body growth in prepubertal children. *Clin Oral Investig* 2011;15:141–149.
- Angelhoff C, Faresjö T, Sundell AL. Measuring hair cortisol concentration, insomnia symptoms and quality of life in pre-school children with severe early childhood caries—a case-control pilot study. *Acta Odontol Scand* 2023;1-9:508–516.
- Koirala A, O'Connor E, Widmer R, Kilpatrick N, Goldfeld S. Oral health care: the experience of Australian paediatricians. *J Paediatr Child Health* 2019;55(11):1374–1380.
- Amarasena N, Chrisopoulos S, Jamieson LM, Luzzi L. Oral health of Australian adults: distribution and time trends of dental caries, periodontal disease and tooth loss. *Int J Environ Res Public Health* 2021;18(21):11539.
- Ha DH, Do LG, Luzzi L, Mejia GC, Jamieson L. Changes in area-level socioeconomic status and oral health of indigenous Australian children. *J Health Care Poor Underserved* 2016;27(1):110–124.
- Ha DH, Do LG, Roberts-Thomson K, Jamieson L. Risk indicators for untreated dental decay among Indigenous Australian children. *Community Dent Oral Epidemiol* 2019;47(4):316–323.
- Saggers S, Gray D. Defining what we mean. In: Carson B, Dunbar T, Chenhall RD, Bailie R, eds. *Social determinants of Indigenous health*. Milton Park UK: Routledge, 2020:1–20.
- Ganesharajah C. *Indigenous health and wellbeing: the importance of country*. 2009. Canberra: Australian Institute of Aboriginal and Torres Strait Islander Studies.
- Dimitropoulos Y, Gunasekera H, Blinkhorn A, *et al.* A collaboration with local Aboriginal communities in rural New South Wales, Australia to determine the oral health needs of their children and develop a community-owned oral health promotion program. *Rural Remote Health* 2018;18(2):1–11.
- Christian B, Blinkhorn AS. A review of dental caries in Australian Aboriginal children: the health inequalities perspective. *Rural Remote Health*. 2012;12(4):2032.
- Babineau J. Product review: Covidence (systematic review software). *J Can Health Libr Assoc* 2014;35(2):68–71.
- Chattopadhyay A. *Periodontal diseases. Chattopadhyay A oral health epidemiology principles and practice* Sudbury, Massachusetts: Jones and Bartlett Publishers, 2011:257–271.
- Jamieson L, Armfield J, Roberts-Thomson K, Sayers S. A retrospective longitudinal study of caries development in an Australian Aboriginal birth cohort. *Caries Res* 2010;44(4):415–420.
- Dogar F, Kruger E, Dyson K, Tennant M. Oral health of preschool children in rural and remote Western Australia. *Rural Remote Health* 2011;11(4):124–130.
- Australian Research Centre for Population Oral Health. Oral health of Australian Indigenous children compared to non-Indigenous children enrolled in school dental services. *Aust Dent J* 2014;59(3):395–400.
- Johnson N, Lalloo R, Kroon J, Fernando S, Tut O. Effectiveness of water fluoridation in caries reduction in a remote Indigenous community in Far North Queensland. *Aust Dent J* 2014;59(3):366–371.
- Ha DH, Crocombe LA, C Mejia G. Clinical oral health of Australia's rural children in a sample attending school dental services. *Aust J Rural Health* 2014;22(6):316–322.
- Do LG, Spencer AJ. The beginning of change: Queensland Child Oral Health Survey 2010–2012: Australian Research Centre for Population Oral Health, The University of ... 2014.
- Smith L, Blinkhorn A, Moir R, Brown N, Blinkhorn F. An assessment of dental caries among young Aboriginal children in New South Wales, Australia: a cross-sectional study. *BMC Public Health* 2015;15:1–6.
- Arrow P. Oral health of schoolchildren in Western Australia. *Aust Dent J* 2016;61(3):333–341.
- Lalloo R, Jamieson LM, Ha D, Luzzi L. Inequalities in tooth decay in Australian children by neighbourhood characteristics and indigenous status. *J Health Care Poor Underserved* 2016;27(1):161–177.
- Do LG, Spencer AJ. *Oral health of Australian children: the National child oral health study 2012–14*. Adelaide: University of Adelaide Press, 2016.
- Martin-Kerry JM, Whelan M, Rogers J, Raichur A, Cole D, de Silva AM. Addressing disparities in oral disease in Aboriginal people in Victoria: where to focus preventive programs. *Aust J Prim Health* 2019;25(4):317–324.
- Haag D, Schuch H, Ha D, Do LG, Jamieson L. Oral health inequalities among indigenous and non-indigenous children. *JDR Clin Trans Res* 2021;6(3):317–323.
- Poirier BF, Hedges J, Smithers LG, Moskos M, Jamieson LM. Aspirations and worries: the role of parental intrinsic

motivation in establishing oral health practices for indigenous children. *Int J Environ Res Public Health* 2021;18(21):11695.

27. Thurber KA, Long J, Salmon M, Cuevas AG, Lovett R. Sugar-sweetened beverage consumption among Indigenous Australian children aged 0–3 years and association with sociodemographic, life circumstances and health factors. *Public Health Nutr* 2020;23(2):295–308.
28. George A, Villarosa AR, Ingram S, *et al.* Oral health status, behaviours, food and beverage consumption of aboriginal children in Australia. *Health Promot J Austr* 2021;32(2):208–215.
29. Dimitropoulos Y, Holden A, Gwynne K, Irving M, Binge N, Blinkhorn A. An assessment of strategies to control dental caries in Aboriginal children living in rural and remote communities in New South Wales, Australia. *BMC Oral Health* 2018;18:1–8.
30. Cunha-Cruz J, Huebner CE, Ludwig S, *et al.* Everybody brush! Consumer satisfaction with a tooth decay prevention program. *Front Public Health* 2017;5:264.
31. Smith L, Blinkhorn A, Moir R, Brown N, Blinkhorn F. Evaluation of an oral health education program for young aboriginal children: feedback from parents, aboriginal health workers and managerial staff. *Int J Health Promot Educ* 2020;58(2):92–103.
32. Slade GD, Bailie RS, Roberts-Thomson K, *et al.* Effect of health promotion and fluoride varnish on dental caries among Australian Aboriginal children: results from a community-randomized controlled trial. *Community Dent Oral Epidemiol* 2011;39(1):29–43.
33. Chang AB, Singleton R. Health issues in Indigenous children: an evidence-based approach for the general pediatrician. *Pediatr Clin North Am* 2009;56(6):1239–1592.
34. Eni R. Health disparities in Canada: A focus on First Nations children. *The State Of The World's Children* 2009;2008:10.
35. Kanatami IT. Inuit oral health survey report. National Equine Health Survey report. 2011.
36. Gracey M, King M. Indigenous health part 1: determinants and disease patterns. *Lancet* 2009;374(9683):65–75.

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APPENDIX A

MEDLINE SEARCH STRATEGY

Ovid MEDLINE(R) ALL <1946 to March 20, 2023>

- 1 dental caries.mp. or Dental Caries/ 56383
- 2 oral caries.mp. 24
- 3 dental decay.mp. 851
- 4 oral decay.mp. 2
- 5 tooth decay.mp. 1617
- 6 1 or 2 or 3 or 4 or 5 57203
- 7 child*.mp. 2728320
- 8 kid*.mp. 974761
- 9 young.mp. 1474238
- 10 preschool.mp. 992700
- 11 school.mp. or Schools/ 294593
- 12 7 or 8 or 9 or 10 or 11 4842344
- 13 Australia*.mp. 215925
- 14 'Australian Aboriginal and Torres Strait Islander Peoples'/ 101
- 15 Aboriginal.mp. 10143
- 16 Indigenous Peoples/ 1194
- 17 Indigenous.mp. 43820
- 18 first nation.mp. 523
- 19 14 or 15 or 16 or 17 or 18 50672
- 20 19 and 6 and 12 and 13 129
- 21 limit 20 to yr='2009–2022' 100

APPENDIX B

KEYWORDS USED TO SEARCH FOR STUDIES IN THE DATABASE

Concept 1:	Concept 2:	Concept 3:	Concept 4:
Caries	Children	Australia	Indigenous
Dental/oral/ tooth decay	Child* Kids Children	Australia*	Indigenous Indigenous
Dental/ oral caries	Young Preschool School		Indigenous and Torres Strait Islander First nation

Note: Within concepts we used 'Or' and across concepts we used 'And'.