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ORIGINAL ARTICLE

Trends in social inequalities in early childhood caries using population-based clinical data

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Abstract

Objective: To assess the longitudinal trends in social inequalities in early childhood caries (ECC) using collected population-based data.

Methods: Clinical data on children were routinely collected from 2008 to 2019 in Victoria, Australia. ECC prevalence and severity (dmft) were quantified according to Indigenous status, culturally and linguistically diverse (CALD) status, concession cardholder status, geographic remoteness and area deprivation. The inverse probability weighting was used to quantify social inequalities in ECC. The weighted prevalence differences, and the ratio between the weighted prevalence of ECC and mean dmft and their 95% confidence interval, were then plotted.

Results: Absolute inequalities in ECC prevalence increased for children by 7% for CALD status and cardholder status between 2008 and 2019. Likewise, absolute inequalities in ECC severity in this time period increased by 0.6 for CALD status and by 0.4 for cardholder status. Relative inequalities in ECC increased by CALD (ratio: 1.3 to 2.0), cardholder status (1.3 to 2.0) and area deprivation (1.1 to 1.3). Relative inequalities in severity increased by CALD (1.5 to 2.8), cardholder (1.4 to 2.5) or area deprivation (1.3 to 1.5). Although children with Indigenous status experienced inequalities in ECC prevalence and severity, these did not increase on the absolute (ECC: 0.1–0.1 Severity: 1.0–0.1) or relative scale (ECC ratio: 1.3–1.3 Severity ratio: 1.6–1.1).

Conclusions: Trends in inequalities in ECC were different according to sociodemographic measures. Oral health policies and interventions must be evaluated on the basis of reducing the prevalence of oral diseases and oral health inequalities between population sub-groups.

KEYWORDS
disparities, early childhood caries, inequalities, paediatric dentistry

1 | BACKGROUND

Globally, over 600 million children aged fourteen and under suffer with dental caries of deciduous teeth, also ranked first for prevalence among all 297 diseases studied for this age-group in the 2019 Global Burden of Disease study.[1,2] Early childhood caries (ECC) has a multifactorial aetiology and negatively impacts quality of life of children.[3,4] Depending on its severity, ECC can lead to difficulty in chewing, malnutrition, gastrointestinal disorders, negatively affecting children's educational achievement and socialization.[5,6] Severe ECC may require children to undergo invasive procedures under general anaesthesia leading to dental related preventable hospitalizations, particularly among children with social disadvantage.[7]

ECC is becoming more common in socially disadvantaged subpopulations across many high income and lower income countries,[2,8] despite the overall decline in dental caries prevalence over the years.[3] Associations between social disadvantage (captured through household income, parental education, remoteness) and ECC have been reported across many countries including Australia, Kuwait, Colombia, China, Thailand and the United States.[9–14] Young children are a vulnerable subgroup 'within' a vulnerable population because of their inability to communicate oral health needs and their dependence on carers.[15] For that reason, social inequalities in oral health outcomes in young children are a major public health challenge and reflect societal failure.[16,17] Considering that dental caries is the most common chronic disease of childhood,[15] inequalities in ECC are a major public health problem.

Three critical gaps exist in studies on social disadvantage and ECC. First, studies have mainly examined the associations between social disadvantage and ECC at one time point.[18] Quantifying the trends in inequalities over time in ECC is critical, as inequalities can still increase even if the prevalence of ECC may decrease over time. Second, inequalities at the population level are largely unquantified by important sociodemographic characteristics such as Indigenous status or migration status in Australia. Finally, social inequalities in ECC are mainly reported only on the relative scale. However, reductions in inequalities on the relative scale over time may not translate into reductions in inequalities on an absolute scale,[19] which may result in completely different conclusions about inequality over time. Reporting of inequality in absolute scale is also important as it drives policy decisions due to direct relevance for public health impact.[19]

The present study quantifies the trends in social inequalities in ECC on both relative and absolute scales using routinely collected state-wide population-based clinical data of children from Victoria, Australia. An additional aim was to compare the estimated trends in inequalities according to different types of social disadvantage.

Article Summary

By assessing population-based data, this study provides evidence on the inequalities in early childhood caries by different social disadvantage markers.

What's Known on This Subject

Dental caries is the most common chronic disease of childhood and can lead to other comorbidities. Early childhood caries is becoming more common in socially disadvantaged sub-populations across many high income and lower income countries. However, longitudinal evidence is lacking.

What This Study Adds

Social inequalities in early childhood caries and its severity increased by culturally and linguistically diverse or concession cardholder status both in the absolute and relative scales. Dental health system services should be evaluated based on reducing the oral health inequalities.

2 | METHODS

2.1 | Study population

The public dental system in Australia primarily provides dental care to the population experiencing socioeconomic disadvantage. Dental Health Services Victoria (DHSV), the lead oral health agency in Victoria, Australia, routinely collects oral health and demographic data annually through the Titanium® patient management system to inform planning of dental health services. The time series cross sectional data include treatment history, clinical diagnoses and demographic characteristics of patients across the state of Victoria. For this analysis, data from children aged six and under who came in for a dental visit at a Victorian public dental clinic in the period 2008 to 2019 were included.

Ethical approval was granted by the University of Melbourne Human Office of Research Ethics and Integrity ID 1953877 Committee and Dental Health Services Victoria.

2.2 | Social exposure variables

There were five separate exposure variables. First, Indigenous status at the time of registration was considered. Participant's parents or guardians filled a form where they self-identified as Aboriginal and Torres Strait Islander or non-Indigenous. Second, the main language spoken at home was dichotomized, English versus others, as a proxy for the background of children belonging to culturally and linguistically diverse (CALD) households. Third, children from households experiencing substantial economic disadvantage were identified; these households are provided with benefits and a concession card. Children who were dependents of concession cardholders (henceforth, cardholders for brevity) were recorded as cardholders and those without were non-cardholders. Fourth, geographic remoteness was assessed and classified children depending on where they lived: in major cities or inner regional. The final exposure was area deprivation, and we matched participant's postcodes to area Index for Relative Socioeconomic Disadvantage

(IRSD) provided by the Australian Bureau of Statistics. IRSD scores are part of the Australian Socio-Economic Indexes for Areas (SEIFA) that are composite scores for area level deprivation generated at a small area level. Then, participant's IRSD scores were classified into tertiles. Data on each of these variables were collected at the first contact with the public dental health services, and information on cardholder status was updated if the parents' or guardians' status changed in subsequent visits.

2.3 | Outcome measures

As part of the clinical examination of children, dental professionals record missing teeth, treated and untreated cavitated or filled carious lesions on a tooth map in the Titanium® system. A decayed, missing, filled tooth (dmft) score was then automatically computed by the software and recorded for each patient. A score of 1 or more indicates experience of cavitation while a score of 0 indicates no carious lesions experience. Children may attend public dental services without cavitated carious lesions, but they may also attend because they have developed cavitated carious lesions and experience pain. There were two outcomes of interest: (1) presence of ECC when children came in for a dental visit at the public dental services and (2) severity of the carious experience measured by dmft score.

2.4 | Covariates

As confounding factors, age at their clinic visit and child's sex (male, female) were included. When Indigenous status and CALD status were considered exposures, age, sex, geographic remoteness and SEIFA were adjusted. When SEIFA or geographic remoteness was the exposure, Indigenous status, CALD status, cardholder status and either SEIFA or geographic remoteness were also included as confounders. When cardholder status was the exposure, Indigenous status, CALD status, SEIFA and geographic remoteness were adjusted. The theoretical relationships are presented in the Directed Acyclic Graphs (Supplementary file S1).

2.5 | Statistical analysis

The characteristics of the included sample using number (%) and means (standard deviations) as appropriate in 2008 and 2019 were summarized. Inverse probability weighting (IPW) was performed to calculate the weighted average effect of each social exposure variable on the potential-outcome means (i.e. ECC and dmft) and the potential-outcome means in those advantaged and non- advantaged population according to the social exposure variables. IPW maximizes exchangeability on the measured covariates, a desirable property for causal inference, between the exposed (Indigenous, CALD, cardholders, remoteness and SEIFA) and unexposed groups.[20] As such, the time trends in inequalities rather than changes in caries status were evaluated. The standardized prevalence differences and standardized prevalence ratios of ECC were estimated to quantify inequalities on absolute and relative scales, respectively, for each exposure. The outcomes of the presence of ECC and dmft score were predicted had those with Indigenous status, CALD status, concession cardholder status, geographic remoteness and by area deprivation, the same distribution of covariates (age, year of the clinic visit, child sex, geographic remoteness) as those with non-Indigenous status, non-CALD status, non-cardholder status, living in major cities or living in areas other than deprived areas, respectively. The absolute inequality was quantified as the standardized prevalence differences the 95% confidence interval (CI) for the prevalence of ECC and dmft scores between those socially advantaged (non-Indigenous status, non-CALD status, non-cardholder status, living in major cities or living in areas other than deprived areas) and disadvantaged were plotted. Additionally, the ratio and 95% CI between the population means of those at an advantage and those at a disadvantage (relative effect) were calculated. Indigenous status data from 2008 to 2014 were excluded because there were low counts. Changes in absolute inequalities and relative inequalities over time as well as the associated uncertainty were examined. To quantify uncertainty around these estimates, 1000 samples for each of these equation by year were bootstrapped. All statistical analyses were conducted on Stata v16.1.

3 | RESULTS

Overall, 132 109 children aged below 6 years attended the public dental service and had their clinic visit in 2008–2019 (Supplementary file S2). In both 2008 and 2019, approximately half of the children who attended the clinics were females (Table 1). There was a small percentage of children with Indigenous status (1.6% and 2.8%), respectively). In 2008, more than half were cardholders and in 2019 only a quarter were cardholders. On average, more children had ECC on their dental visit in 2008 than in 2019 and the mean dmft score was higher (2.3 vs. 1.1).

3.1 | Presence of early childhood caries at dental visit

The standardized prevalence differences of ECC varied from 2008 to 2019 (Figure 1). Overall, children with Indigenous status had higher prevalence of ECC than non-Indigenous children, but this difference was slightly reduced over time (11% to 7%), although the estimates had high uncertainty. The inequality by CALD status has increased on the absolute scale between 2008 and 2019 (15% to 22%). In 2008, the standardized prevalence difference between CALD and non-CALD children was 15% (95% CI:10–20%) and increased to 22% (95% CI: 18%–27%) in 2019. Likewise, cardholders had a higher prevalence of ECC and the difference steadily

TABLE 1 Characteristics of the study sample in 2008 and 2019

	2008 (*N* = 3242)	2019 (*N* = 7446)
Characteristic	%. (*n*/*N*)	%. (*n*/*N*)
Female	50.6% (1642/3246)	49.5% (6430/13009)
Age[a]	4.6 (1.2; 1–6)	4.2 (1.1; 1–6)
Indigenous status	1.6% (52/3246)	2.8% (268/9743)
CALD status	12.6% (407/3246)	9.7% (939/9743)
Card holder status	63.1% (2047/3246)	28.4% (2771/9743)
Other areas	40.3% (1309/3246)	30.9% (3014/9743)
SEIFA tertiles		
1	32.0% (1038/3246)	38.1% (3715/9743)
2	23.5% (763/3246)	27.5% (2679/9743)
3	44.5% (1445/3246)	34.4% (3349/9743)
ECC	47.3% (1535/3246)	25.1% (2447/9743)
dmft count[a]	2.3 (3.5; 0–20)	1.1 (2.5; 0–19)

Abbreviations: CALD, culturally and linguistically diverse; ECC, early childhood caries dmft: decayed, missing, filled tooth; N, sample total number n: sample number; SEIFA, Socio-Economic Indexes for Areas.
[a]Mean; min-max.

increased from 11% [95%CI: 8%–15%] to 18% [95%CI: 16%–20%]. Conversely, children living in remote areas had similar prevalence of ECC. Finally, children in the lower tertile of SEIFA had higher prevalence of ECC than those at the higher tertile, the difference increased in the period of 2008–2011 and then decreased over time (11% to 6%).

On the relative scale (Figure 2), Indigenous status inequalities increased between 2012 and 2016 and then decreased. Over the whole period, the ratio stayed constant from 1.31 (95%CI: 1.11–1.54) in 2012 to 1.30 (95% CI: 1.01–1.66) in 2019. A steep increase in inequalities on the relative scale was observed for CALD status from 1.33 (95%CI: 1.21–1.46) to 1.96 (95%CI: 1.77–2.17). Likewise, the inequalities on the relative scale for cardholder status increased from 1.28 (95%CI: 1.18–1.39) to 1.91 (95%CI: 1.78–2.04). There were minor increases in the relative inequalities for remoteness status (1.01 [95%CI: 0.94–1.09] to 1.14 [95%CI: 1.04–1.26]) and SEIFA (1.13 [95%CI: 1.03–1.23] to 1.30 [95%CI: 1.18–1.44]) over the study period. Trends were unclear for SEIFA as there was variations in annual changes in relative inequality. Point estimates are available in Supplementary file S3.

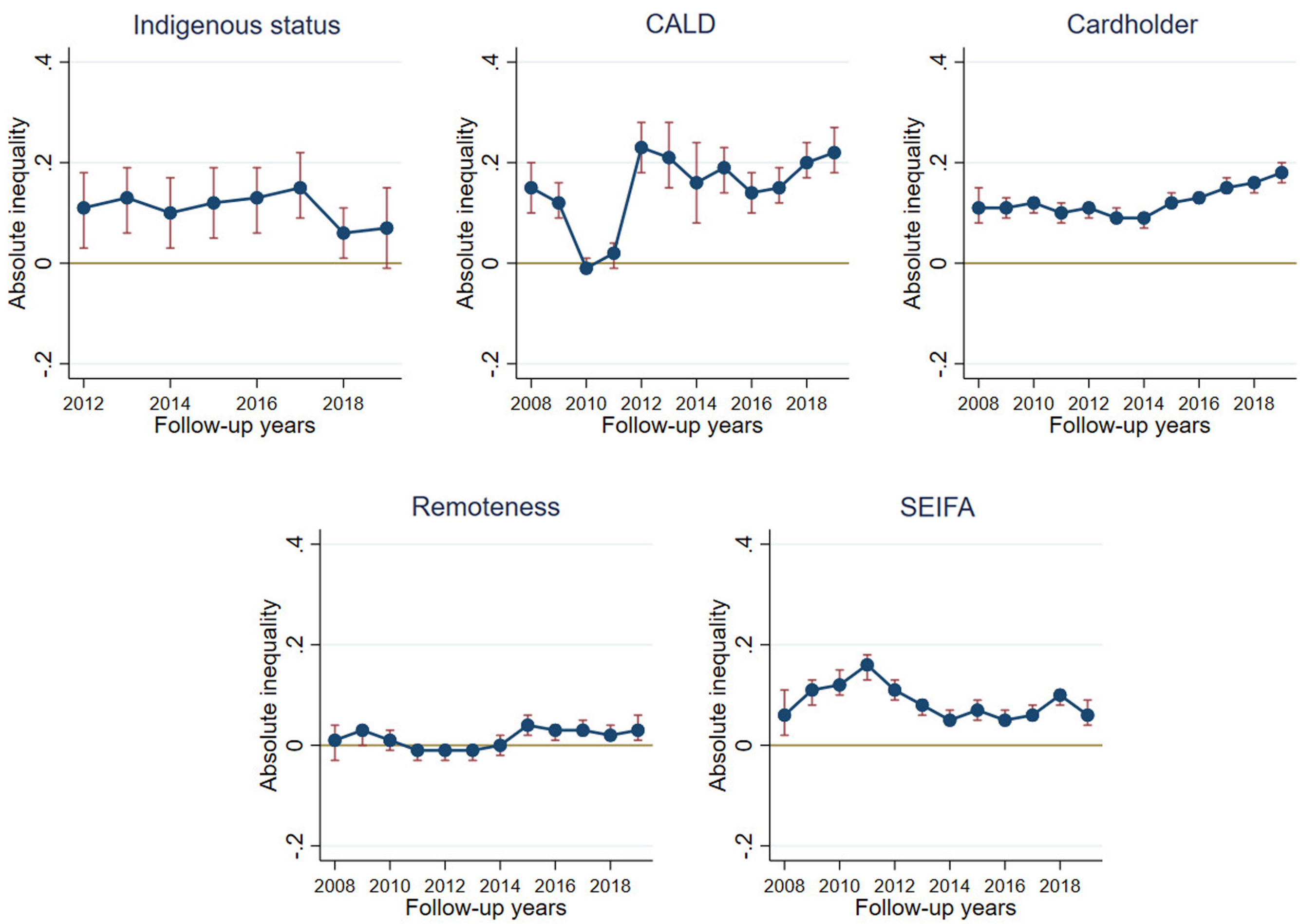

FIGURE 1 Standardized prevalence differences of ECC over study period

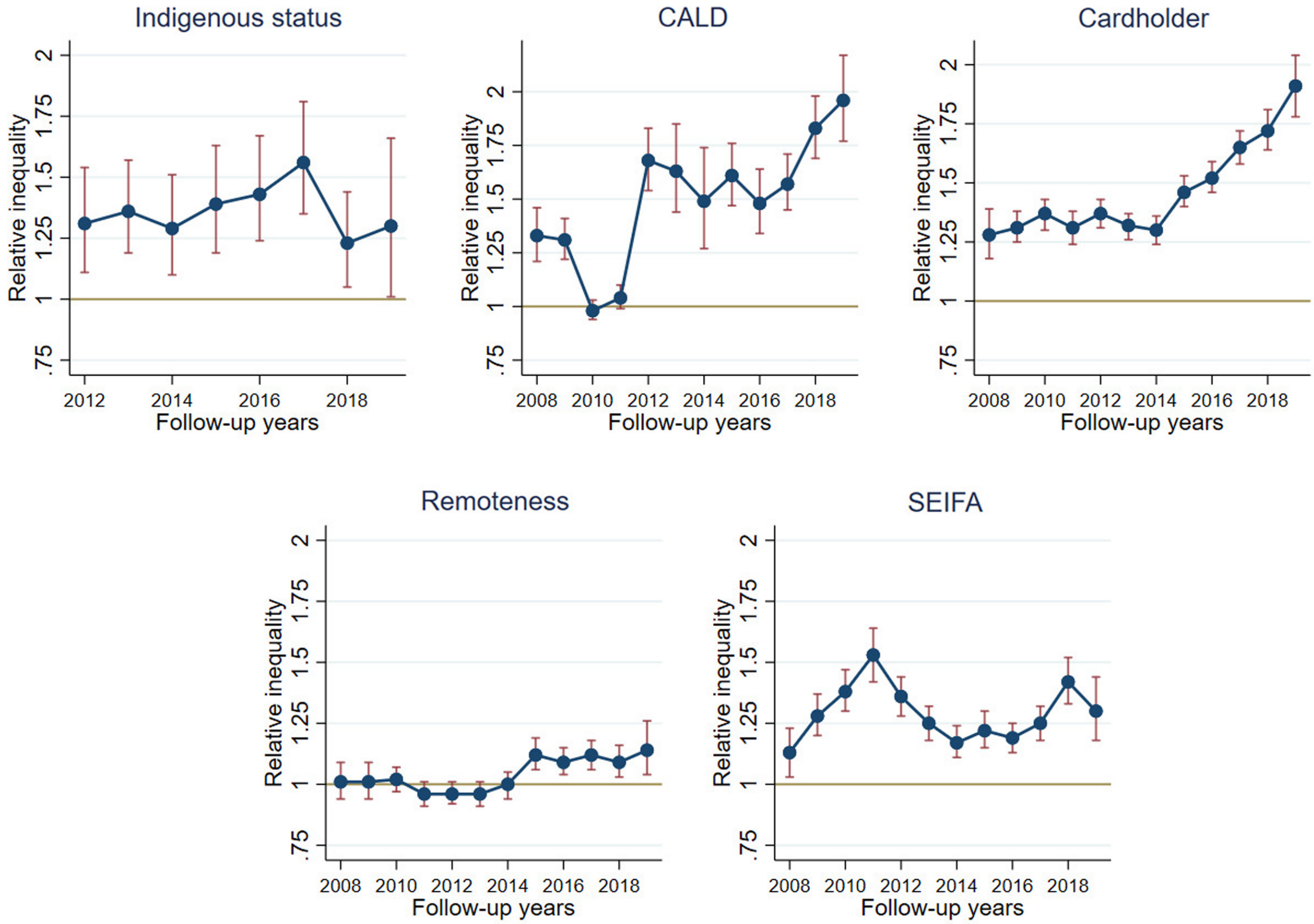

FIGURE 2 Ratio between the population prevalence of ECC means over the study period

3.2 | Severity of carious experience

The absolute inequalities (Figure 3) in dmft scores decreased for Indigenous status from 0.98 (95% CI: 0.36–1.60) in 2012–0.07 (95% CI: −0.30–0.45) in 2019. On the contrary, children with CALD status had higher dmft counts in 2008 (1.16; 95%CI: 0.74–1.59); this difference decreased to 0.27 (95%CI: 0.13–0.42) in 2011 and then sharply increased in 2012 and remained high until 2019 (1.72; 95%CI: 1.27–2.17). Likewise, cardholders had higher dmft; the difference increased steadily from 0.77 (95%CI: 0.53–1.01) in 2008 to 1.14 (95%CI: 1.00–1.28) in 2019. Children living in other areas had no notable differences in dmft. Finally, children in the lowest tertile of SEIFA had higher mean dmft compared to those in the highest tertile, and the difference was maintained during the whole period; from 0.57 (95%CI: 0.24–0.90) in 2008 to 0.40 (95%CI: 0.26–0.53) in 2019.

Overall, the relative inequality (Figure 4) by Indigenous status decreased over time from 1.64 (95%CI: 1.28–2.09) in 2008 to 1.07 (95%CI: 0.77–1.48) in 2019. Conversely, children with CALD status had a higher dmft population mean, the relative inequality decreased from 1.54 (95%CI: 1.35–1.76) in 2008 to 1.03 (95%CI: 0.97–1.10) in 2010 and then it sharply increased to 2.8 (95%CI: 2.35–3.34) in 2019. Similarly, cardholders had higher dmft population means, and the relative difference increased gradually from 1.43 (95%CI:1.27–1.60) in 2008 to 2.54 (95%CI: 2.31–2.80). The relative difference regarding children living in remote areas was negligible. Children in the lower tertile of SEIFA had higher dmft population means that those at the higher tertile of SEIFA, the relative difference increased from 1.26 (95%CI: 1.10–1.44) in 2008 to 1.46 (95%CI:1.28–1.67) in 2019. Point estimates and estimates from the comparison between first and second tertiles of SEIFA are available in Supplementary file S3.

4 | DISCUSSION

This study assessed the trends in social inequalities in prevalence of ECC and its severity in children in the state of Victoria, Australia. Trends in inequalities differ according to the type of sociodemographic measure under examination, highlighting a complex and mixed situation. Inequalities in ECC prevalence and severity showed an increasing trend on both absolute and relative scale for cardholder status, and a substantial increase by CALD status, over the study period. Absolute and relative inequalities by area deprivation

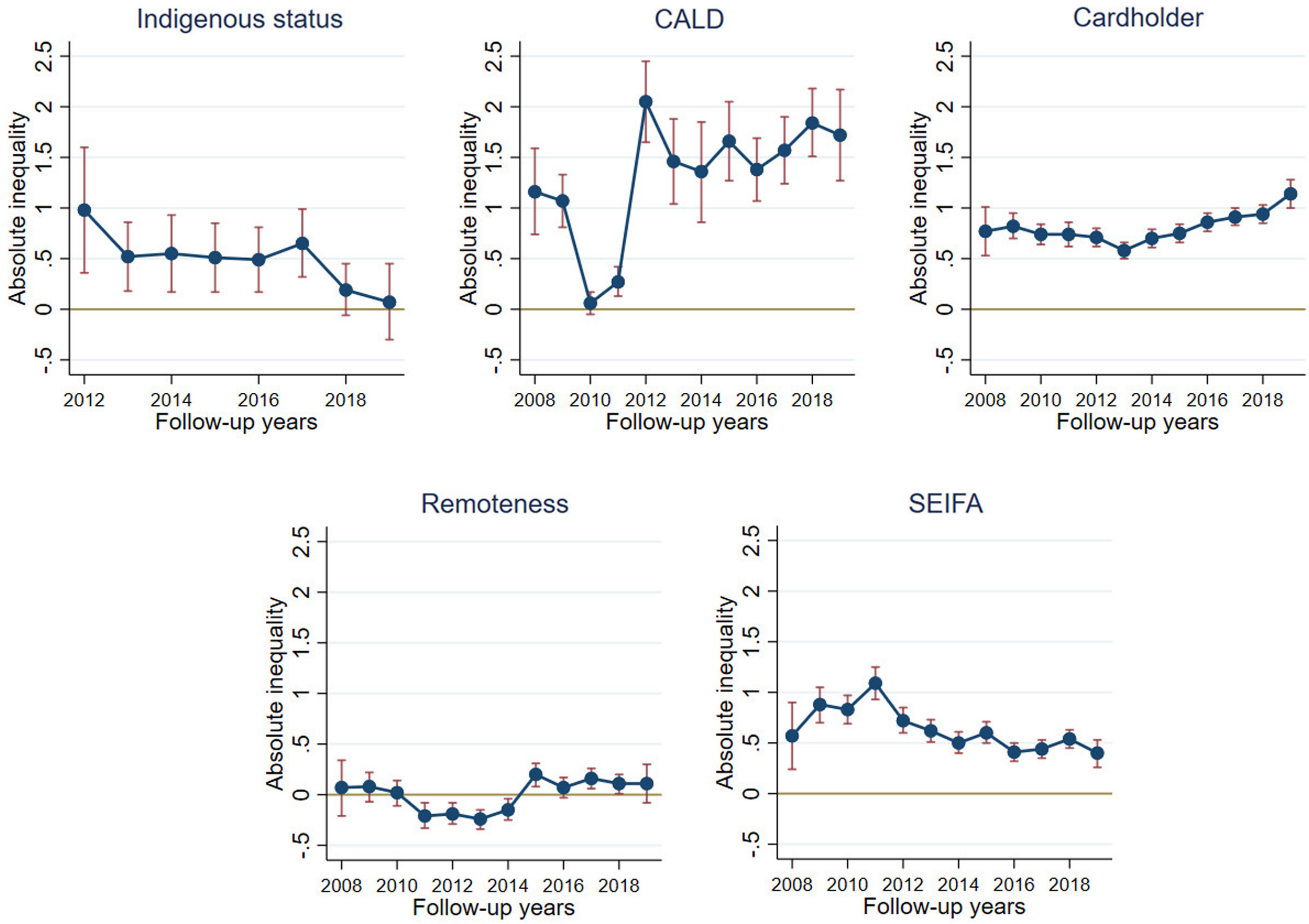

FIGURE 3 Standardized differences of dmft score over study period

showed some variations but were generally stable over time. There was a reduction in inequality by Indigenous status over time on both absolute and relative scales. Minimal inequality was observed across the years by remoteness status.

It has been reported that Indigenous children in Australia (those identifying as Aboriginal and/or Torres Strait Islander) experience poorer oral health when compared with their non-Indigenous counterparts.[21–23] Moreover, the 2012–2014 Australian National Child Oral Health Study (NCOHS) identified that Indigenous children that were aged 5–10 years had a higher prevalence of untreated dental caries (40% vs. 26%) in their primary dentition when compared to non-Indigenous children.[24] The present findings indicated a trend in which the health inequalities between Indigenous and non-Indigenous in ECC changed slightly and there was a stable gap during 2012–2019. While this was a promising result, only the inequalities in children who accessed the public dental services were estimated in this study, as such, there may be more severe cases on the general population. To assess the generalizability of this finding, it will be crucial in the future to compare the characteristics of Indigenous children attending the public dental services to those who do not attend dental services.

A high proportion of the Australian population comes from migrant or refugee backgrounds with an estimated 26.3% in 2016 being born overseas.[25] ECC can be a potential risk for children from refugee and migrant backgrounds as, in most cases, their family may be more socioeconomically disadvantaged compared to the general population.[26] In most high-income countries, including Australia, children with different CALD backgrounds go through several barriers such as language and financial, while accessing appropriate oral health information and services.[27–29] The findings showed a reduction in oral health inequalities by CALD status in 2010 which increased thereafter. The reduction may be explained partly by the variation of cultural impacts and barriers which depend on the cultural background of each child that accessed the dental service[26] and to the inclusion of refugee and asylum seekers families as priority groups for dental services which reduces costs and wait times.[30] Afterwards, there was a sharp increase in oral health inequalities by CALD status, which highlights the need of inclusion of long-term interventions and dental services to provide treatment and preventative services for this diverse population.[31]

Socioeconomic disadvantage has been described as an important marker of health inequalities in ECC.[32,33] The results suggested longitudinal trends of inequalities at both individual level (card holders) and aggregated level (SEIFA) on both absolute and relative scales. The negative effects of early socioeconomic inequalities can

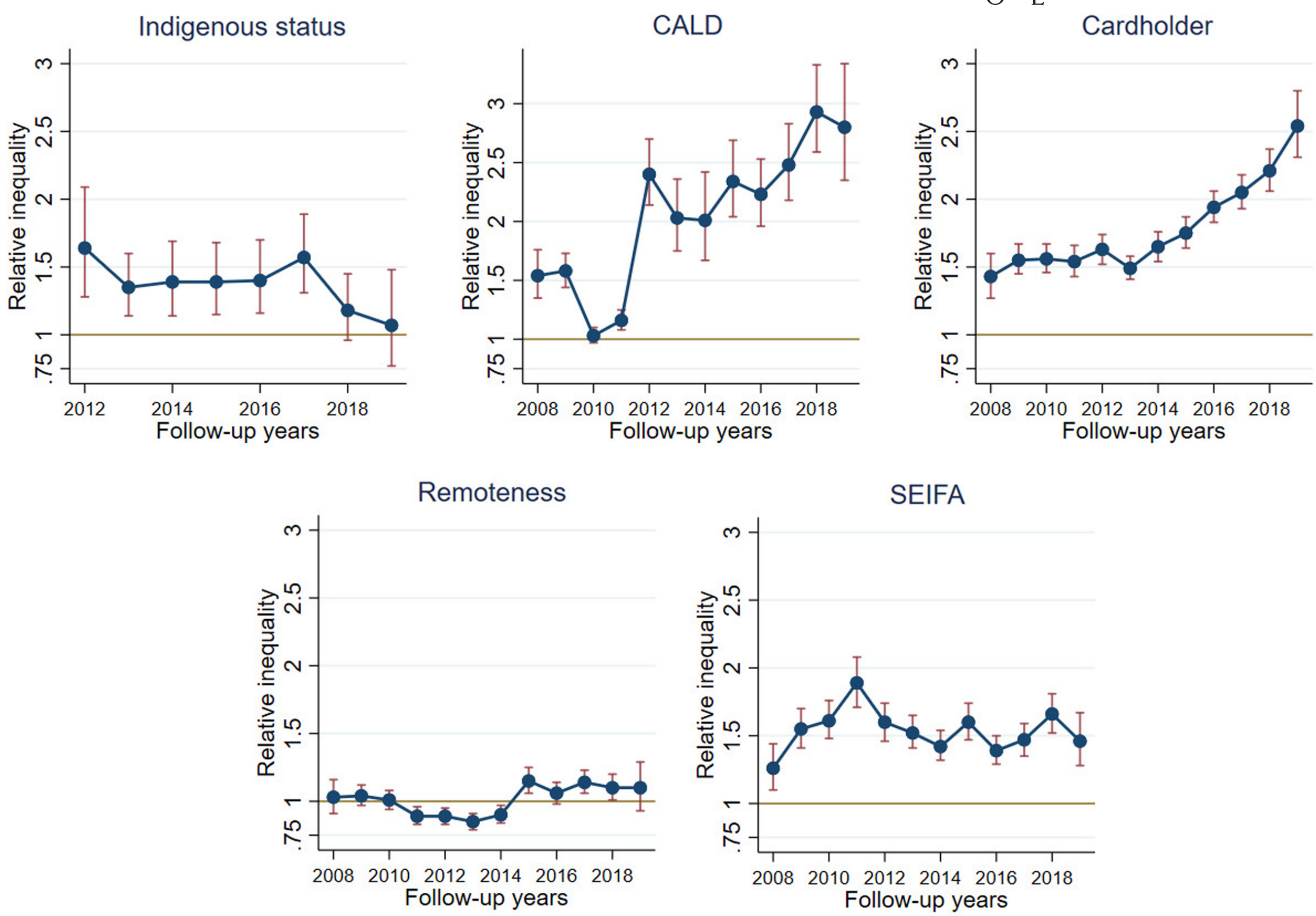

FIGURE 4 Ratio between the population dmft score means over the study period

have long-term consequences on oral and systemic health, which can persist into the third decade of life and even if there is an upward change in socioeconomic status.[34,35] Reduction of financial barriers to oral health will have an important impact on reducing health inequalities in ECC.

The finding of no inequalities in ECC by geographic remoteness, and the presence of inequalities by SEIFA across the time-period, is important given that geographic remoteness is often prioritized as a marker of social disadvantage in planning of dental healthcare needs. Similarly, remoteness of residence was not associated with decayed surfaces in children.[36] The findings highlight that at the area level, inequalities in ECC were present using a multidimensional and composite measure of deprivation rather than a single measure of geographic remoteness.[37] Therefore, area-level targeting of oral health and dental healthcare resources must consider deprivation comprehensively rather than just from a remoteness perspective.

The present study has both strengths and limitations. Strengths include access to a well-characterized time series data from children that accessed the public dental service in Victoria. The study capitalized on administrative clinical data to examine inequalities as population-based surveys and studies that examined inequalities over time were largely underrepresented by Indigenous people and people from CALD backgrounds. Second, inequality on both absolute and relative scales were determined as consistent with best practices in health inequality assessment. Finally, objective dental clinician diagnosed ECC and severity data were used. One of the limitations of the study was that the analysis represents inequalities in only those children that accessed the public dental service, which was usually provided to people that are eligible because of their socioeconomic characteristics (usually socially disadvantaged) and involves significant wait times. Families with higher income may prefer to attend private practice, and therefore, the described oral health inequalities were likely to be underestimated. Due to the nature of routinely collected clinical data, there were no estimates of inter or intra examiner variation. However, the guidelines were provided by the Dental Health Services Victoria to standardize the data collection process among oral health professionals. Also, the estimates in inequalities by Indigenous status could not be examined for the whole study period due to small number of Indigenous children aged less than 6 years that accessed the public service, and inequalities with wide uncertainty where data were available were estimated. Finally, the present study was based in Victoria; the findings should be interpreted with caution when considering different settings.

In conclusion, the present findings provide robust evidence of oral health inequalities over time in children under 6 years old in Victoria, Australia. Children of culturally diverse backgrounds and those living in families with low socioeconomic status require targeted interventions as both relative and absolute inequalities in ECC increased over time. The study shows the need of evaluating dental health services not just on the basis of reducing the prevalence of oral diseases but also reducing inequalities between population subgroups. A more responsive and planned policy targeted to reduce specific inequalities in dental health services is required. Further research should focus on evaluating the same inequalities longitudinally at a national level to assess differences in oral health outcomes between sub-groups in the population.

AUTHOR CONTRIBUTIONS

Prof Dashper and Dr Tsakos conceptualized and designed the study and critically reviewed the manuscript for important intellectual content. Dr Hegde and Dr Whelan collected data, conceptualized and designed the study and critically reviewed the manuscript for important intellectual content. Mr Lopez and Dr Singh conceptualized and designed the study, carried out the initial analyses, drafted the initial manuscript and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

D.J. Lopez, A. Singh, S. Hedge, M. Whelan, G. Tsakos and S. Dashper have nothing to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Dental Health Services Victoria. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from https://www.dhsv.org.au/ with the permission of Dental Health Services Victoria.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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