COHORT STUDY 0

Family-Level Predictors of Australian Children's Dental Caries and Injuries

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Abstract: ***Purpose:*** *Fisher-Owens et al. described the diverse family-level factors influencing children's oral health, but few studies have investigated these relationships using longitudinal data. This study investigated the association between family and child oral health using the Longitudinal Study of Australian Children (LSAC), a cross-sequential dual cohort study.* ***Methods:*** *A total of 10,090 children were recruited at baseline, and seven waves of data are available. Children's parents or guardians reported experiences of dental caries and injury. Data were used to model family-level predictors with generalized estimating equations.* ***Results:*** *In the final model, predictors of dental caries over time were younger mothers (odds ratio [OR] equals 1.37, 95 percent confidence interval [95% CI] equals 1.01 to 1.87) and lower parental education (OR equals 1.24, 95% CI equals 1.10 to 1.39). Other significant factors were poor parental health, parents smoking, English as the main language, and Indigenous parents. Parents with consistent parenting styles protected against caries. Predictors of dental injury included socioeconomic status and parental age.* ***Conclusions:*** *This study highlighted a number of significant family-level constructs that predict dental caries and injury. Understanding the influence of family provides evidence to warrant investigation into tailored interventions targeting young mothers, common health risk factors, and parenting styles. (Pediatr Dent 2020;42(1):28-35.E1-E5) Received August 18, 2019 / Last Revision November 18, 2019 Accepted November 21, 2019*

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A child's development, well-being, and health can be greatly influenced by their family context.[1] The people living in a child's immediate environment "provide support and role modeling to children, influencing children's oral health both directly and indirectly," according to Fisher-Owens et al.[2] It is well established that poor health behaviors related to diet, toothbrushing, fluoridated toothpaste use, and fluoridated tap water consumption can result in poorer oral health outcomes in children.[3] Moreover, parental knowledge and practices can directly influence these oral health behaviors for their children.[4] A number of randomized controlled trials and intervention studies have successfully sought to increase parental oral health literacy to improve oral health outcomes for children.[5,6]

To understand the broad influences on children's oral health, Fisher-Owens et al. produced a conceptual model.[2] The broad family-level constructs in the conceptual model are socioeconomic status, social support, family composition, family function, health behaviors, practices and coping skills of the family, the health status of parents, culture, and physical safety.[2] Some of the family constructs, such as socioeconomic status, have been investigated frequently.[7] A review of the Australian literature, however, found that many of the other family-level influences were not well investigated and should be the focus of future research.[8]

Family composition and function are defined by the relationships and quality of the interactions between the child and parent.[2] Poorer indicators of family function and parental psychological distress have been associated with poorer child oral health.[9] Frequency of oral hygiene behaviors are influenced by the parent's confidence in undertaking brushing and lack of time.[10] Exploratory qualitative evidence has been produced to show that uncooperativeness in children is a barrier to parents undertaking toothbrushing or preventing sugary food and drink consumption.[11,12]

In addition to the limited quantity of studies investigating family influences on Australian children's oral health, methodologies employed tended to be qualitative, cross-sectional, or focused on singular factors, often failing to account for confounding factors.[8] These studies have limited predictive use and generalizability to other populations. This may be attributed to the challenges and costs associated with large longitudinal studies necessary to build multivariate models. The Longitudinal Study of Australian Children (**LSAC**) is a government-led investigation into the environment in which Australian children grow up and its impact on development and well-being.[13] Established in 2002, with data collection commencing in 2004, the LSAC is a cross-sequential dual cohort study.[13,14] Of the approximately 20 million Australian people in 2004, 1.26 million were zero- to four-year-old children. At baseline, the LSAC recruited two geographically and demographically representative cohorts of zero- to four-year-olds. The Figure presents a graphical representation of the distribution of the LSAC cohorts compared to the Australian population at the time of recruitment.[8] As oral health measures were included in the LSAC, this dataset provides an opportunity to build a multivariate model drawing on the Fisher-Owens conceptual model constructs.[8]

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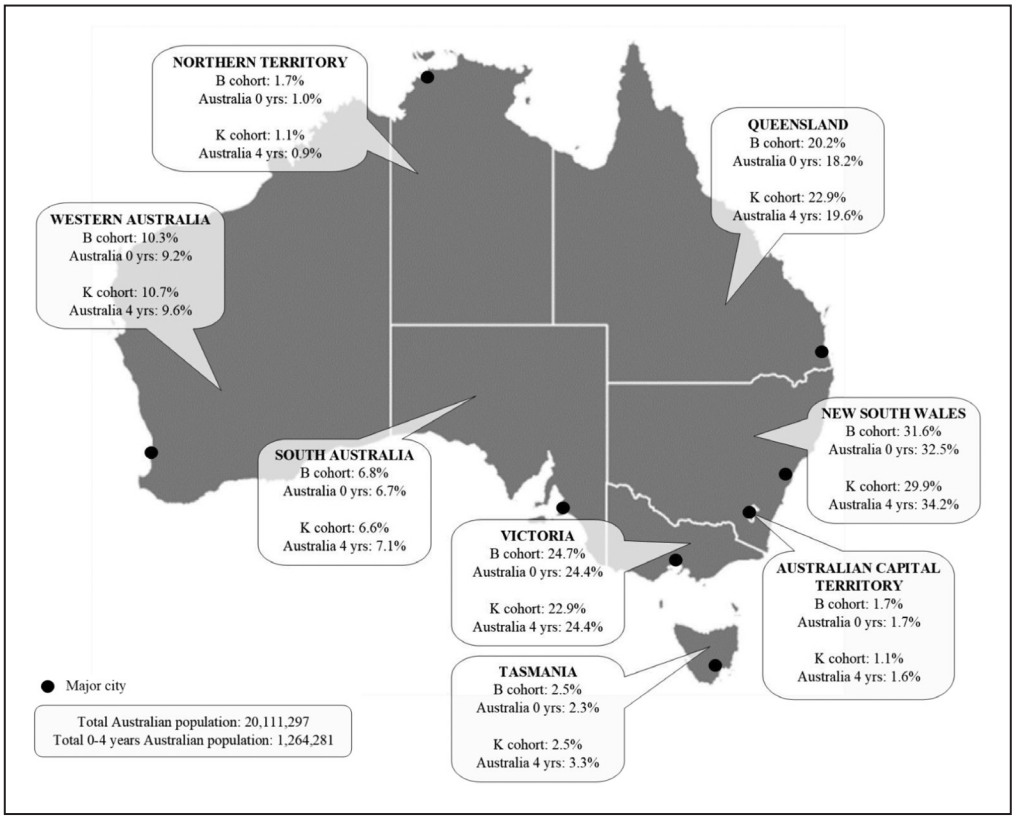

Figure. The geographic distribution of the Longitudinal Study of Australian Children birth (N=5,047) and kindergarten (N= 4,983) cohorts at wave one (2004) compared to the Australian Estimated Resident Population data for 0 (N=243,026) and 4 (N= 253,202) year old's.

* B cohort: Birth cohort (children born 2003-2004, <1 year at recruitment).
K cohort: Kindergarten cohort (children born 1999-2000, 4-5 years at recruitment).
Data extracted from: Soloff C, Lawrence D, Mission S, Johnstone R. LSAC Technical paper No. 3 Wave 1 weighting and non-response. The Australian Government: The Australian Institute of Family Studies; 2006.

The empirical application of conceptual models is difficult, even when adequately large longitudinal datasets are available, as selecting the suitable measures for conceptual constructs can be difficult.[2] When a large number of variables are included in a statistical model, estimation can be difficult, patterns of effects can be hard to interpret, and associations can be over-controlled. To best represent theoretical constructs described in the Fisher-Owens conceptual model, the use of multi-dimensional measures with explicit indications are recommended. With a strong focus on family, the LSAC investigated household characteristics, parental education, culture, finance, health and behaviors, interfamily relationships, and social support using multidimensional validated scales/measures.[13,14] Many of the LSAC measures were factors conceptualized in the Fisher-Owens et al. constructs.[2]

In their study, Gansky and Shafik highlighted the lack of empirical studies using multifactorial and multilevel conceptual frameworks to inform targeted approaches to improving oral health.[15] A broad and rigorous understanding of children's oral health can help identify influences and set an agenda for policy reform and interventions to target.[16] Interventions targeting family often focus on parental knowledge; however, with many other influences identified by Fisher-Owens et al., it is warranted to investigate which of these other constructs could be influencing oral health.

Therefore, the purpose of this study was to investigate the association between family factors and child dental caries and injury over time using the nationally representative cohorts of the Longitudinal Study of Australian Children.

Methods

LSAC. This study used the Strengthening the Reporting of Observational Studies in Epidemiology (**STROBE**) checklist. A total of 10,090 children were recruited at baseline, including a birth (children born 2003-2004) and kindergarten (children born 1999-2000) cohort.[14] Data collection is conducted biennially and seven waves of data were available for use in this study.[14] Baseline data (wave one) was collected in 2004 and the most recent wave available for analysis (wave seven) was collected in 2016.[14] The LSAC cohorts are representative of the general Australian child population (Table 1). Previous analysis of retention of participants found that, while retention remained over 80 percent throughout the waves, dropout was higher for children of Aboriginal and Torres Strait Islander backgrounds (herein respectfully referred to as Indigenous Australians) and mothers whose first language was not English (data reported elsewhere).[14] Most often, the parent reporting was the child's biological mother but may also have been the child's father or guardian (herein referred to as carer; Table 1).[17] Carers reported across the wave's children's experience of dental injuries and caries since the previous wave (two years; full questions found elsewhere).[18] No clinical examination of the children was undertaken as part of the LSAC.

Ethical approval for the LSAC was granted by the Australian Institute of Family Studies Ethics Committee.[13] Further information on the LSAC study design and how to access the dataset can be found in data user guides and technical reports published online.[17]

Family constructs. In this study, the authors refer to a construct as an idea or theory defined by various elements and a factor as an individual measure within a construct. Family-level factors measured throughout waves one to seven in the LSAC were considered for inclusion by the researchers if they were suitable for inclusion under the family-level constructs defined by the Fisher-Owens et al. conceptual model.[2] The wording and variables of the included measures in this study are reported in the **Supplemental Electronic Data – sTable 1** and can also be found online in publicly available documents on the LSAC website.[19]

The factors included in this study were recorded by the child's primary study respondent (parent one) to ensure that children were not excluded if their primary caregiver was not their biological mother. Information specific to the biological parents (i.e., biological mother's age at childbirth) were recorded for some measures (see **Supplemental Electronic Data – sTable 1**). All possible waves of data were included for each measure included. Responses from wave one only were used for time-invariant measures where the outcomes were static.

Socioeconomic status. Socioeconomic status was defined based on how parents' education and income impact their children's oral health status.[2] The finance and education status of families was measured using items from the Australian Bureau of Statistics Household Expenditure Survey.[20] Items included the financial hardship scale, parental weekly income, and parental highest level of education.[20]

Table 1. DEMOGRAPHICS OF CHILDREN AT WAVES ONE AND SEVEN* OF THE LONGITUDINAL STUDY OF AUSTRALIAN CHILDREN

		Wave one	Wave seven
		Total	Total
		N=10,090	N=6,470
		N (%)	N (%)
Gender	Male	5,144 (51.0)	3,310 (51.2)
	Female	4,946 (49.0)	3,160 (48.8)
Australian state	New South Wales	3,188 (31.6)	1,932 (29.9)
	Victoria	2,496 (24.7)	1,481 (22.9)
	Queensland	2,042 (20.2)	1,482 (22.9)
	South Australia	686 (6.8)	427 (6.6)
	Western Australia	1,040 (10.3)	694 (10.7)
	Tasmania	249 (2.5)	211 (3.3)
	Northern Territory	169 (1.7)	70 (1.1)
	Australian Capital Territory	220 (2.2)	173 (2.7)
Indigenous status	No	9,671 (95.9)	6,311 (97.6)
	Yes	417 (4.1)	157 (2.4)
Country of birth	Australia	9,860 (98.6)	6,333 (98.7)
	Other	136 (1.4)	82 (1.3)
Language spoken at home	English	8,914 (88.3)	5,858 (90.5)
	Other	1,176 (11.7)	612 (9.5)
Parent 1 relationship to study child	Biological parent	10,046 (99.6)	6,318 (99.4)
	Grandparent	18 (0.2)	13 (0.2)
	Adopted parent	13 (0.1)	8 (0.1)
	Aunt/uncle	6 (0.1)	4 (0.1)
	Foster parent	4 (0.0)	2 (0.0)
	Step-parent	2 (0.0)	4 (0.1)
	Unrelated adult	1 (0.0)	2 (0.0)
	Full sibling	0 (0.0)	1 (0.0)
	Cousin	0 (0.0)	1 (0.0)

* Data collection is conducted in the Longitudinal Study of Australian children biennially, and seven waves of data were available for use in this study.[14] Baseline data (wave one) was collected in 2004, and the most recent wave data available for analysis (wave seven) was collected in 2016.[14] Dropout between waves one and seven was higher for children of Indigenous backgrounds and mothers whose first language was not English (statistical data reported elsewhere).[14]

Family composition. Family composition was defined by household characteristics, including a single-parent or reconstituted household.[2] Family composition was measured in the LSAC by the total number of people in the household, the study child's order of birth, if the study child was living with a biological parent or two parents, and if there was a change in household composition since the previous wave.

Family function. Family function was defined by family relationships and carers' interest and response to their children's activities.[2] Multiple scales and questions were used as measures of parenting, relationships between the parents/guardians, and the parent/child and family overall in the LSAC. Measures included the parenting efficacy scale, consistent parenting scale, co-parenting scale, argumentative relationship scale, Hendrick relationship quality scale, parental warmth scale, inductive reasoning scale, work-synergy scale, and a rating of the ability for the family to get along.

Parenting efficacy was measured in the LSAC with a modified scale from the Early Childhood Longitudinal Study-Birth Cohort and was defined by a parent's attitudes and beliefs about his/her competence as a parent. Adapted from a Canadian longitudinal study, the consistent parenting scale assesses the consistency of parental discipline.[21] Adapted from the quality of co-parental interaction scale, the co-parenting scale measures a parent's perceived level of support received from his/her partner in raising the study child.[22] Similarly, the argumentative relationship scale and Hendrick relationship quality scale indicates the perceived level of conflict and quality of the relationship between the study child's parents/guardians.[22] The inductive reasoning scale and parental warmth scale were used to determine the relationship between the study child and the parent/guardian.[23] The work-family synergy scale was used to indicate the impact of parental work on parenting and family.[24] A single-item measure was also used for parents/guardians to rate the overall ability for the family to get along.

Parental health status and health behaviors. Two closely related constructs were the health status of parents and the family environments that enable and support healthy choices and lifestyles.[2] The health of the primary parent/guardian (parent one) was measured with the global measure for health and the K-6 depression scale.[25] Other health factors recorded for the child's biological mother and father were age, gestational diabetes or hypertension, and alcohol, smoking, and prescription medicine consumption during the biological mother's pregnancy. Throughout the waves, parent one's alcohol consumption, smoking status, level of physical activity, and daily fruit and vegetable consumption were recorded.

Social support. Social support was defined in the conceptual model as the support received from friends, families, and communities, as social isolation is associated with risk-taking behaviors and less health-promoting activities.[2] The medical outcome study social support scale was used to measure emotional/informational, tangible, affectionate, and positive social interaction social support.[26] An average level of support for raising children from parents, in-laws, other family, friends, and neighbors was also included.

Physical safety. The physical safety construct was defined as an absence of harm or injury and unsafe family environments, such as abuse or trauma, that can result in a dental injury.[2] The definition of the construct by Fisher-Owens was

limited and may be due to the difficulty and variability of this construct in the liter-ature.[2] The angry and hostile parenting scales were used in the LSAC as indicators of aversive or hostile verbal and physical behavior toward children.[27]

Culture. Culture has a myriad of influences at the family level and can vary between countries and local context. Some common factors include language, diet, health care use, and family interactions.[2] For an Australian context, factors included in the LSAC were adapted from the Australian Bureau of Statistics Census measures. Culture was measured by parent one's country of birth, Indigenous status, religion, and primary language spoken at home.

Generalized estimating equations. Data were analyzed using SPSS 25.0 software (IBM Corp., Armonk, N.Y., USA). Generalized estimating equations (**GEE**) were used to estimate the regression coefficients of the longitudinal data using an unstructured correlation structure. All possible cases were included in the analysis, as missing data varied throughout the waves. The final family-level variables were included as independent variables of interest in the GEE analysis. The dependent variables of interest were self-reported dental caries and injury (in the previous two years) measured between two and 16 years old. Child age and period (year of measure) were included in the model to adjust for potential confounding effects.

After restructuring the original data to a time as case configuration, the unadjusted odds ratios and 95 percent confidence intervals were calculated for all independent variables of interest. Multivariate models were built by adding statistically significant independent variables by family-level construct. Factors were considered for inclusion in the final model by assessing the significance level and the corrected quasi-likelihood under independent model criterion (**QICC**; a smaller QICC indicates better fit) and if assumptions (such as no multicollinearity) were met.

Analyses of missing variables were undertaken, and the final model produced from the original data was fit with the imputed dataset. Multiple imputations were performed for all variables included in the models using a fully conditional method with a regression model, with 100 fixed iterations used to generate 40 multiple imputations. Associations throughout child ages were calculated by splitting the data file by child age (years) and running the final GEE model produced for dental caries and injury.

Results

A total of 10,090 children were recruited in the LSAC at baseline. Most children were born in Australia, were non-Indigenous, and lived in a major urban area (Table 1). Prior to adjustment, numerous measures of socioeconomic status, family composition, function, parental health status, health behaviors, social support, culture, and physical safety were significant predictors of dental caries over time (see **Supplemental Electronic Data – sTable 2**). No factors in family composition and social support were significant predictors of dental injury (see **Supplemental Electronic Data – sTable 2**).

After adjusting for the confounding effects of the child's age, the final GEE model produced a model fit QICC equal to 34,977 (Table 2). Predictors of dental caries over time were younger mothers, lower parental education, increasing poor parental global health scores, parents currently smoking, English as the main language at home, and Indigenous parents (Table 2). The results from the model fit with imputed data were comparable to the actual data.

Table 2. FINAL ADJUSTED ASSOCIATIONS BETWEEN CARER-REPORTED DENTAL CARIES AND FAMILY-LEVEL VARIABLES FROM THE LONGITUDINAL STUDY OF AUSTRALIAN CHILDREN *

		Adjusted model		Imputed model	
Number of included subjects		N=8,835		N=10,090	
Goodness of fit †		QICC value=34,977		QICC value=88,180	
		OR (95% CI)	*P*-value ‡	OR (95% CI)	*P*-value ‡
Age (years)	Continuous variable	0.96 (0.94-0.98)	<0.001	1.02 (1.01-1.02)	<0.001
Financial hardship scale	Higher scores, more hardship	1.16 (1.11-1.21)	<0.001	1.17 (1.14-1.20)	<0.001
Highest level of education completed	Year 11 or below	1.24 (1.10-1.39)	<0.001	1.26 (1.18-1.34)	<0.001
	High school (year 12)	1.19 (1.05-1.34)	0.006	1.13 (1.06-1.21)	<0.001
	TAFE/certificate ‡	1.18 (1.09-1.28)	<0.001	1.22 (1.16-1.27)	<0.001
	Bachelor's degree or higher	1		1	
Change in household composition since previous wave	Yes	1.10 (1.03-1.18)	0.003	0.99 (0.95-1.02)	0.448
	No	1		1	
Consistent parenting scale	Higher scores, higher consistency)	0.89 (0.85-0.94)	<0.001	0.91 (0.89-0.94)	<0.001
Mother's age at child's birth (years)	≤18	1.37 (1.00-1.87)	0.051	1.44 (1.24-1.67)	<0.001
	19-28	1.05 (0.90-1.23)	0.512	1.03 (0.94-1.13)	0.486
	29-38	0.88 (0.76-1.02)	0.091	0.88 (0.81-0.96)	0.005
	≥39	1		1	
Global health measure	Higher scores, poorer health	1.05 (1.02-1.09)	0.005	1.05 (1.03-1.07)	<0.001
Current smoking	Yes	1.10 (1.01-1.20)	0.003	1.13 (1.08-1.18)	<0.001
	No	1		1	
Main language spoken at home	English	1.18 (1.06-1.31)	0.040	1.18 (1.11-1.25)	<0.001
	Other	1		1	
Parents Indigenous status	Yes	1.26 (1.01-1.57)	0.033	1.16 (1.04-1.29)	0.008
	No	1		1	

* OR=odds ratio; CI=confidence interval; QICC=corrected quasi-likelihood under independent model criterion; TAFE=technical and further education.

† Factors were considered for inclusion in the final model by assessing the significance level and the corrected quasi-likelihood under independent model criterion (where a smaller QICC score indicates better fit) and if assumptions (such as no multicollinearity) were met.

‡ A *P*-value of <0.05 was considered statistically significant.

When stratified by the child's age (years), factors significantly predicting caries prior to teenage years were financial hardship, change in household composition, younger mothers, parents smoking, and Indigenous parents (see **Supplemental Electronic Data – sTable 3**). Predictors of caries in older childhood and teenage years were lower parental education, poorer parental consistency, poorer parental self-reported health, and speaking English at home (see **Supplemental Electronic Data – sTable 3**).

Few family factors were predictors of dental injury prior to adjustment (see **Supplemental Electronic Data – sTable 2**). The period (year of measurement) was added to the model to control for confounding (Table 3). After an adjustment, increasing financial hardship, lower parental education, and younger mothers remained predictors of dental injury over time (Table 3). The results from the model fit with imputed data were comparable to the actual data. When stratified by child's age, few factors predicted dental injury due to the small proportion of children reporting an injury, creating large confidence intervals (see **Supplemental Electronic Data – sTable 4**).

Discussion

Using empirical evidence, this study built a model of the family using a popular conceptual model and almost all constructs predicted oral health outcomes in Australian children. Family socioeconomic status, composition, function, health status, health behaviors, and culture were predictors of dental caries in children over time. Fewer factors were predictors of dental injury in children, including socioeconomic status and parental age. The differences between models highlight how Fisher-Owens' conceptual model is relevant for describing dental caries, although there is a need for a more refined and specific model for describing dental injury in children. Further investigation of the relationship between family-level constructs and other child and community-level constructs is needed to explain dental injury during childhood. The significance observed between dental injury and financial hardship and younger mothers may be explained by other factors and methods, such as structural equation modeling and multilevel modeling, which can be used to model these hierarchical relationships.[28]

The significance of family on children's caries experience was demonstrated in this study using a nationally representative sample measured over 14 years. These findings are similar to other international examples, such as a large cross-sectional telephone study run in the United States by Bramlett et al.[29] This study was able to model all the Fisher-Owens constructs but was limited in generalizability to populations such as Australia due to demographic and health system differences. Using broadly focused longitudinal data from the country of interest can provide contextualized insight into the local population and provide appropriate policy and intervention recommendations. In Australian literature, there has been an overall lack of focus on the influence of family on oral health. Of the studies investigating family, a higher proportion is focused on family socioeconomic status.[8] Parental education and oral health literacy can directly influence oral health behaviors and dietary choices, while income can indirectly influence dental caries experience through the ability to afford and prioritize dental care and healthy foods.[2]

Measures of education and income were primarily significant predictors of caries before the age of 10 years. It could be reasoned that parental education and income becomes less influential as a child's own autonomy and oral health literacy develop. Child development is also a construct defined in the Fisher-Owens conceptual model; further investigation into the child-family relationship is needed at different stages of childhood.

Understanding predictors of caries at different stages of childhood is important to provide evidence for tailored age-appropriate interventions to reduce dental caries. Many inter-ventions targeting families have used anticipatory guidance with parents of young children to prevent early childhood caries.[5,30] Anticipatory guidance is proactive counseling used to educate and motivate parents on what to expect regarding oral health development in children and behaviors and regimes to prevent caries.[5] Similar to other Australian studies,[5,31] the authors found that children with younger mothers had the highest odds of dental caries, even after controlling for income and education. Further breakdown of maternal age found that this was only significant among children younger than four years old. This association has previously been attributed to lack of life experience indirectly influencing children's oral health[30]; anticipatory guidance could be a useful method to prevent caries in this group.

Table 3. FINAL ADJUSTED ASSOCIATIONS BETWEEN CARER-REPORTED DENTAL INJURY AND FAMILY-LEVEL VARIABLES FROM THE LONGITUDINAL STUDY OF AUSTRALIAN CHILDREN*

		Adjusted model		Imputed model	
Number of included subjects		**N=9,207**		**N=10,090**	
Goodness of fit†		**QICC value=13,337**		**QICC value=22,399**	
		OR (95% CI)	***P*-value‡**	**OR (95% CI)**	***P*-value‡**
Study period	Continuous variable (2004-2016)	0.92 (0.90-0.94)	<0.001	0.97 (0.96-0.97)	<0.001
Highest level of education completed	Year 11 or below	1.19 (0.99-1.44)	0.069	1.28 (1.12-1.46)	<0.001
	High school (year 12)	0.93 (0.76-1.14)	0.469	0.87 (0.75-1.02)	0.080
	TAFE/certificate	1.15 (1.01-1.32)	0.036	1.19 (1.01-1.32)	0.001
	Bachelor's degree or higher	1		1	
Financial hardship scale	Higher scores, more hardship	1.11 (1.04-1.19)	0.003	1.08 (1.03-1.14)	0.002
Mother's age at child's birth (years)	≤18	1.60 (0.97-2.62)	0.064	1.45 (1.01-2.08)	0.047
	19-28	1.35 (1.03-1.77)	0.029	1.54 (1.23-1.91)	<0.001
	29-38	1.12 (0.86-1.46)	0.396	1.22 (0.98-1.51)	0.076
	≥39	1		1	

* OR=odds ratio; CI=confidence interval; QICC=corrected quasi-likelihood under independent model criterion; TAFE=technical and further education.

† Factors were considered for inclusion in the final model by assessing the significance level and the corrected quasilikelihood under independent model criterion (where a smaller QICC score indicates better fit) and if assumptions (such as no multicollinearity) were met.

‡ A *P*-value of <0.05 was considered statistically significant.

Similarly, the authors also found that children with carers who were current smokers had an increased risk of caries at four years of age. This association has previously been attributed to common risk factors in disease and health beliefs.[32] Taking a common risk factor approach to anticipatory guidance by including education more broadly on oral health, diet, and behaviors—including smoking—could be a way to effectively prevent caries in younger children by including another significant predictor of dental caries.[33]

Across all child ages, parents with a consistent parenting style protected against dental caries experience in children. Other evidence on child oral health and family function/parenting styles has been inconsistent.[34] Differences in the literature could be due to the difficulty in measuring family function, with measures often limited by social desirability bias and varying reliability. Measures included in the LSAC were selected for their validity and reliability, and the consistent parenting scale represented discipline and how well children follow instructions.[21] Consistent and authoritative parenting has been associated with more positive oral health behaviors and the prevention of dental caries.[34,35] Interventions targeting parenting styles have proven effective in changing health behaviors in children to reduce obesity and prevent childhood smoking.[36,37] The Triple P Program® is an example of a multilevel parenting support intervention designed to target emotional and behavioral problems in children—one that's supported by international and Australian literature.[38] No evidence on parenting style interventions to reduce caries has been published. The parenting intervention development model suggested by Jackson and Dickinson could be used for oral health interventions, and future studies should investigate the feasibility and efficacy of an oral health parenting program.[36]

Family culture was a significant predictor of dental caries in children over time. Culture on a family level refers to the influence that cultural norms (such as language, traditional diet, and practices) and religious beliefs have on parents in managing children's oral health. In this study, a parent's Indigenous status was the prominent predictor of caries in a child. The broad factors representing culture in this study do not indicate why oral health was poorer; further studies investigating their relationship with community- and child-level factors are needed. Previous research has found that reduced access to fluoridated water, dental service use, oral hygiene behaviors, and poorer diet contribute to poorer oral health in Indigenous parents and children.[39]

Australian literature reports that the oral health information provided to families from culturally diverse backgrounds is often reported as difficult to read and vague.[40] Parental choices regarding child's oral hygiene behaviors, use of dental care, support for fluoride, and diet can be influenced by carers' experiences of oral health and cultural norms (described in community-level influences). Interventions targeting Indigenous children's oral health have also targeted family-level factors but also attribute their success to including culturally appropriate oral health education and information about dental services.[39] The gap in oral health diseases compared to the general population warrants continued investigation into this population's experiences of oral health. A study similar to the LSAC, the Longitudinal Study of Indigenous Children, should be used to highlight the factors influencing oral health to inform interventions and policy for this group.

Conclusions

Based on this study's results, the following conclusions can be made:

1. This study identified a number of family-level constructs from the Fisher-Owens[2] conceptual model, which predicts dental caries and dental injury in children over time:
    a. family socioeconomic status, composition, function, health status, health behaviors, and culture were predictors of dental caries; and
    b. family socioeconomic status and parental age were predictors of dental injury.
2. Understanding the influence of family factors on child oral health should inform the development of interventions focused on supporting young parents with their health behaviors and parenting styles.
3. Future studies should investigate the relationship between family and child-level constructs across varying stages of childhood.

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Supplemental Electronic Data

Supplemental Table 1

s Table 1. FAMILY-LEVEL MEASURES FROM THE LONGITUDINAL STUDY OF AUSTRALIAN CHILDREN

Influence group[1]	Domain	Measure	Item details	Categorization for generalized estimating equations
Socioeconomic status	Finance[2]	Financial hardship scale	6 items Yes/No response Total score is sum of yes responses	High scores indicate higher hardship
		Parent 1 income	1 question Likert scale 1-4	≤$500/week $500-$999/week $1,000-$1,999/week ≥$2,000/week
	Education[2]	Highest level of education completed	2 questions	Year 11 or below High school (year 12) TAFE/certificate Bachelor's degree/postgraduate degree
Family composition	Household characteristics	Total household size	1 question	Number
		Number of older siblings	1 question	Number
		Study child living with two parents	1 question	No Yes
		Change in household composition since previous wave	1 question	Yes No
Family function	Parenting	Parenting efficacy scale[3]	Mean of 4 items Likert scale 1 to 5	High scores indicate higher parenting efficacy
		Consistent parenting scale[4]	Mean of 5 items Likert scale 1 to 5	High scores indicate greater parental consistency
	Parental relationships	Co-parenting scale[5]	Mean of 4 items Likert scale 1 to 5	High scores indicate higher support
		Argumentative relationship scale[5]	Mean of 4 items Likert scale 1 to 5	High scores indicate higher conflict
		Hendrick relationship quality scale[6]	Mean of 6 items Likert scale 1 to 5	High scores indicate higher relationship quality
	Parent/child relationship	Parental warmth scale[7]	Mean of 6 items Likert scale 1 to 5	High scores indicate higher parental warmth
		Inductive reasoning scale[7]	Mean of 3 items Likert scale 1 to 5	High scores indicate higher inductive reasoning
	Family function overall	Ability for family to get along	1 question Likert scale 1 to 5	High scores indicate poorer ability to cooperate
		Work-family synergy scale[8]	Mean of 9 items Likert scale 1 to 5	High scores indicate good work-family synergy

Supplemental Table 1 — continued

s Table 1. CONTINUED

Influence group[1]	Domain	Measure	Item details	Categorization for generalized estimating equations
Health status of parents	Parent 1 health	Global health measure[9]	1 question Likert scale 1 to 5	High scores indicate poorer overall health
		K-6 depression Scale[10]	Mean of 6 items Likert scale 1 to 5 High scores indicate less psychological distress	1.0-2.9: high 3.0-4.9: moderate 5.0: low psychological distress
	Biological parent's health	Mother's age at child's birth (years)	1 question	≤18 19-28 29-38 ≥39
		Father's age at child's birth (years)	1 question	≤18 19-2 29-38 ≥39
		Pregnancy diabetes	1 question	Yes No
		High blood pressure during pregnancy	1 question	Yes No
Health behaviors and practices of family	Behaviors during pregnancy	Alcohol consumption	1 question	Yes No
		Current smoking	1 question	Yes No
		Prescription medicine	1 question	Yes No
	Parent 1 behaviors	Alcohol consumption	1 question Usual monthly consumption	Daily Weekly 1-3x monthly Not in the last year to never
		Smoking	1 question Current smoker	Yes No
		Exercise[11]	1 question Number of days a week physically active	0-2 3-5 6-7
		Vegetable intake	1 question Serves per day	<5 serves ≥5 serves
		Fruit intake	1 question Serves per day	<2 serves ≥2 serves
Social support	Parent 1 social support	Medical Outcomes Survey social support survey[12]	Mean of 15 items Likert scale 1 to 5	High scores indicate more social support available
		Support for raising children from parents, in-laws, other family, friends, neighbors	Mean of 5 items Likert scale 1 to 5	High scores indicate more social support available
Culture	Parent 1 culture[13-15]	Country of birth	1 question	Australia Other
		Indigenous status	1 question	Yes No
		Religion	1 question	Yes No
		Main language spoken at home	1 question	English Other
Physical safety	Parent 1 relationship	Angry parenting scale[16]	Mean of 7 items Likert scale 1 to 4	High scores indicate greater angry parenting
		Hostile parenting scale[3]	Mean of 3 items Likert scale 1 to 10	High scores indicate greater irritable parenting

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Supplemental Table 2.

sTable 2. UNADJUSTED ODDS RATIOS FOR CARIES AND INJURY FROM WAVES ONE TO SEVEN IN THE LONGITUDINAL STUDY OF AUSTRALIAN CHILDREN (N=10,090)*

Construct	Measure	Categorization (scale direction)	Unadjusted OR	
			Caries	Injury
			(95% CI)	(95% CI)
Socioeconomic status	Financial hardship scale	Higher scores, more hardship	1.23 (1.18-1.27)†	1.15 (1.08-1.23)†
	Parent 1 income per week	≤$500	1.27 (1.09-1.48)†	1.43 (1.06-1.92)†
		$500-$999	1.43 (1.23-1.67)†	1.43 (1.06-1.92)†
		$1,000-$1,999	1.29 (1.10-1.51)†	1.04 (0.76-1.41)
		≥$2,000	1	1
	Highest level of education completed	Year 11 or below	1.43 (1.29-1.59)†	1.35 (1.12-1.62)†
		High school (year 12)	1.24 (1.11-1.39)†	1.04 (0.85-1.27)
		Technical training (TAFE/certificate)	1.32 (1.23-1.42)†	1.22 (1.07-1.39)†
		Bachelor's degree or higher	1	1
Family composition	Total household size	Number	1.07 (1.04-1.10)†	1.01 (0.97-1.06)
	Number of older siblings	Number	1.05 (1.01-1.08)†	0.97 (0.91-1.03)
	Study child living with two parents	No	1.26 (1.17-1.37)†	1.02 (0.87-1.18)
		Yes	1	1
	Change in household composition since previous wave	Yes	1.11 (1.04-1.17)	1.13 (1.01-1.27)
		No	1†	1
Family function	Parenting self-efficacy scale	Higher scores, higher efficacy	0.92 (0.88-0.96)†	0.87 (0.81-0.94)†
	Consistent parenting scale	Higher scores, higher consistency	0.87 (0.83-0.91)†	0.97 (0.89-1.06)
	Coparenting scale	Higher scores, higher efficacy	0.87 (0.83-0.92)†	0.93 (0.85-1.03)
	Argumentative relationship scale	Higher scores, higher conflict	1.12 (1.06-1.18)†	1.11 (1.00-1.22)
	Hendrick relationship quality scale	Higher scores, higher quality relationship	0.91 (0.87-0.95)†	0.97 (0.89-1.06)
	Parental warmth scale	Higher scores, higher warmth	0.88 (0.84-0.92)†	1.08 (0.99-1.19)
	Inductive reasoning scale	Higher scores, higher reasoning	1.05 (1.01-1.08)†	1.13 (1.06-1.21)†
	Ability for family to get along	Higher scores, higher cooperation	1.12 (1.09-1.15)†	1.05 (0.99-1.11)
	Work-family synergy scale	Higher scores, higher synergy	0.87 (0.82-0.92)†	0.86 (0.77-0.96)†

sTable 2 continued on next page.

sTable 2. CONTINUED

Construct	Measure	Categorization (scale direction)	Unadjusted OR	
			Caries (95% CI)	Injury (95% CI)
Health status of parents	Global health measure	Higher scores, poorer health	1.13 (1.09-1.17)†	1.02 (0.96-1.09)
	K-6 depression scale	Probable serious mental illness	1.36 (1.17-1.58)†	1.21 (0.88-1.66)
		No probable serious mental illness	1	1
	Mother's age at child's birth (years)	≤18	1.65 (1.26-2.17)†	1.82 (1.12-2.97)†
		19-28	1.09 (0.94-1.26)	1.39 (1.06-1.82)†
		29-38	0.84 (0.73-0.97)†	1.10 (0.85-1.44)
		≥39	1	1
	Father's age at child's birth (years)	≤18	1.64 (0.95-2.83)	1.51 (0.56-4.11)
		19-28	1.14 (1.02-1.27)†	1.30 (1.08-1.58)†
		29-38	0.88 (0.81-0.97)	1.12 (0.95-1.32)
		≥39	1†	1
	Gestational diabetes	Yes	1.08 (0.92-1.25)	0.88 (0.67-1.15)
		No	1	1
	High blood pressure during pregnancy	Yes	0.95 (0.84-1.09)	0.99 (0.78-1.25)
		No	1	1
Health behaviors and practices of family	Alcohol consumption during pregnancy	Yes, occasionally	0.91 (0.81-1.02)	1.15 (0.93-1.43)
		Yes, most days	0.41 (0.20-0.86)†	0.94 (0.23-3.82)
		No	1	1
	Smoking during pregnancy	Yes, occasionally	1.32 (1.12-1.56)†	1.43 (1.04-1.98)
		Yes, most days	1.37 (1.15-1.63)†	1.32 (0.93-1.86)
		No	1	1
	Prescription medicine during pregnancy	Yes	1.12 (1.02-1.24)	1.05 (0.90-1.22)
		No	1†	1
	Alcohol consumption	Daily	0.95 (0.79-1.16)	0.91 (0.62-1.34)
		Weekly	0.93 (0.85-1.01)	1.05 (0.89-1.23)
		1-3x monthly	0.98 (0.91-1.07)	1.11 (0.95-1.30)
		Not in the last year/never	1	1
	Current smoking	Yes	1.34 (1.24-1.45)	1.30 (1.13-1.49)
		No	1†	1†
	Exercise (frequency per week)	0/2	0.93 (0.86-1.01)	0.99 (0.84-1.15)
		3/5	0.91 (0.84-0.99)	1.05 (0.90-1.23)
		6/7	1	1
	Vegetable intake (daily serves)	<5 serves	1.07 (0.96-1.20)	1.11 (0.88-1.38)
		≥5 serves	1	1
	Fruit intake (daily serves)	<2 serves	1.10 (1.04-1.17)	0.99 (0.88-1.12)
		≥2 serves	1†	1
Social support	Medical Outcomes Survey social support survey	Higher scores, higher support	0.91 (0.88-0.94)†	0.96 (0.90-1.03)
	Support for raising children	Higher scores, higher support	1.03 (0.99-1.07)	0.92 (0.86-1.00)
Culture	Country of birth	Australia	1.10 (1.01-1.19)	1.14 (0.98-1.33)
		Other	1	1
	Indigenous status	Yes	1.44 (1.19-1.74)†	1.51 (1.10-2.07)
		No	1	1†
	Religion	Yes	1.00 (0.91-1.10)	0.87 (0.74-1.01)
		None	1	1
	Main language spoken at home	English	1.12 (1.01-1.24)	1.19 (0.99-1.42)
		Other	1†	1
Physical safety	Angry parenting scale	Higher scores, higher angry parenting	1.16 (1.10-1.22)†	1.27 (1.15-1.40)†
	Hostile parenting scale	Higher scores, higher irritable parenting	1.01 (0.98-1.05)	1.03 (0.97-1.10)

* OR=odds ratio; CI=confidence interval. † Statistically significant $P<0.01$.

Supplemental Tables 3 and 4.

sTable 3. ADJUSTED ASSOCIATIONS BETWEEN CARER-REPORTED DENTAL CARIES AND FAMILY-LEVEL VARIABLES STRATIFIED BY CHILD'S AGE (YEARS)*

	Age (years)	4/5	6/7	8/9	10/11	12/13	14/15
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Financial hardship scale	Higher scores, more hardship	1.26 (1.12-1.43)†	1.29 (1.18-1.42)†	1.11 (1.03-1.19)†	1.17 (1.09-1.25)†	1.06 (0.96-1.17)	1.09 (0.96-1.23)
Highest level of education completed	Year 11 or below	1.64 (1.16-2.33)†	1.34 (1.04-1.74)†	1.20 (1.01-1.41)†	1.05 (0.88-1.27)	1.18 (0.94-1.49)	1.33 (0.93-1.89)
	High school (year 12)	1.86 (1.35-2.56)†	1.04 (0.81-1.34)	1.21 (1.03-1.44)†	0.98 (0.81-1.18)	1.33 (1.06-1.67)†	1.31 (0.90-1.90)
	TAFE/certificate	1.49 (1.15-1.92)†	1.12 (0.94-1.34)	1.21 (1.08-1.36)†	1.11 (0.98-1.25)	1.13 (0.98-1.31)	1.36 (1.08-1.73)†
	Bachelor's degree or higher	1	1	1	1	1	1
Change in household composition since previous wave	Yes	0.97 (0.78-1.20)	1.22 (1.03-1.45)†	1.25 (1.11-1.41)†	1.18 (1.04-1.33)†	1.15 (0.99-1.34)	1.16 (0.93-1.43)
	No	1	1	1	1	1	1
Consistent parenting scale	Higher scores, higher consistency)	0.79 (0.67-0.92)†	0.92 (0.82-1.05)	0.87 (0.80-0.94)†	0.87 (0.80-0.94)†	0.94 (0.85-1.04)	0.80 (0.69-0.92)†
Mother's age at child's birth (years)	≤18	2.39 (1.07-5.32)†	1.75 (0.88-3.48)	0.80 (0.47-1.35)	1.31 (0.77-2.22)	1.78 (0.95-3.31)	1.07 (0.31-3.68)
	19-28	1.08 (0.68-1.71)	1.26 (0.89-1.77)	0.89 (0.71-1.11)	1.12 (0.88-1.43)	1.04 (0.79-1.37)	1.10 (0.70-1.73)
	29-38	1.02 (0.66-1.59)	0.95 (0.68-1.31)	0.79 (0.64-0.98)	0.99 (0.78-1.25)	0.79 (0.60-1.03)	0.83 (0.54-1.29)
	≥39	1	1	1	1	1	1
Global health measure	Higher scores, poorer health	1.04 (0.93-1.17)	1.01 (0.93-1.10)	1.02 (0.96-1.08)	1.02 (0.96-1.08)	1.19 (1.11-1.27)†	1.12 (1.00-1.24)
Current smoking	Yes	1.65 (1.30-2.10)†	1.08 (0.89-1.32)	1.01 (0.88-1.16)	1.03 (0.89-1.19)	1.06 (0.88-1.26)	1.27 (0.97-1.65)
	No	1	1	1	1	1	1
Main language spoken at home	English	0.75 (0.56-1.01)	1.04 (0.83-1.31)	1.26 (1.07-1.49)†	1.19 (1.01-1.41)†	1.36 (1.09-1.70)†	1.64 (1.15-2.33)†
	Other	1	1	1	1	1	1
Parents' Indigenous status	Yes	1.40 (0.79-2.47)	1.07 (0.66-1.76)	1.50 (1.06-2.13)†	1.12 (0.77-1.63)	1.30 (0.84-2.02)	0.81 (0.36-1.82)
	No	1	1	1	1	1	1

* OR=odds ratio; CI=confidence interval. † Statistically significant $P<0.01$.

sTable 4. ADJUSTED ASSOCIATIONS BETWEEN CARER-REPORTED DENTAL INJURY AND FAMILY-LEVEL VARIABLES STRATIFIED BY CHILD'S AGE (YEARS)*

	Age (years)	4/5	6/7	8/9	10/11	12/13	14/15	Age (years)
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Highest level of education completed	Year 11 or below	0.87 (0.56-1.34)	1.93 (1.20-3.11)†	1.34 (0.84-2.14)	1.36 (0.96-1.91)	1.24 (0.83-1.85)	0.80 (0.47-1.37)	1.17 (0.52-2.61)
	High school (year 12)	0.61 (0.38-0.97)	0.85 (0.47-1.54)	1.22 (0.78-1.92)	0.87 (0.58-1.30)	1.12 (0.73-1.71)	1.27 (0.78-2.08)	0.31 (0.07-1.34)
	TAFE/certificate	0.95 (0.70-1.29)	1.25 (0.85-1.84)	1.03 (0.74-1.44)	1.25 (0.97-1.62)	1.23 (0.94-1.62)	1.16 (0.84-1.59)	0.99 (0.57-1.71)
	Bachelor's degree or higher	1	1	1	1	1	1	1
Financial hardship scale	Higher scores, more hardship	0.99 (0.81-1.21)	1.15 (0.94-1.40)	1.18 (1.00-1.39)	1.14 (0.99-1.30)	1.02 (0.86-1.21)	1.05 (0.85-1.28)	1.43 (1.15-1.77)†
Mother's age at child's birth (years)	≤18	0.63 (0.14-2.82)	0.76 (0.15-3.74)	1.28 (0.33-4.98)	1.77 (0.71-4.44)	0.75 (0.17-3.41)	7.15 (2.48-20.57)†	2.17 (0.18-26.36)
	19-28	1.13 (0.62-2.07)	1.12 (0.55-2.31)	1.28 (0.65-2.52)	1.28 (0.78-2.11)	1.47 (0.82-2.62)	1.79 (0.86-3.72)	1.48 (0.44-5.03)
	29-38	1.03 (0.57-1.84)	1.07 (0.53-2.16)	1.16 (0.60-2.25)	1.04 (0.64-1.71)	1.18 (0.66-2.10)	1.25 (0.61-2.59)	0.98 (0.29-3.26)
	≥39	1	1	1	1	1	1	1

* OR=odds ratio; CI=confidence interval. † Statistically significant $P<0.01$.