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ORIGINAL ARTICLE

Is childhood oral health the 'canary in the coal mine' for poor adult general health? Findings from two New Zealand birth cohort studies

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Abstract

Objectives: This study aimed to investigate whether childhood dental caries was associated with self-reported general health in midlife.

Methods: We used data on childhood oral health (caries experience) and adult self-reported general health from two New Zealand longitudinal birth cohorts, the Dunedin Multidisciplinary Health and Development Study (n = 922 and n = 931 at ages 5 and 45 years, respectively), and the Christchurch Health and Development Study (n = 1048 and n = 904 at ages 5 and 40 years, respectively). We used generalized estimating equations to examine associations between age-5 dental caries and self-rated general health and the number of self-reported physical health conditions at ages 45/40 (diagnosed by a doctor or health professional, n = 14 conditions among both cohorts). Covariates included known risk factors for poor health (SES, IQ, perinatal complications), and personality style, which is known to affect subjective health ratings.

Results: Incidence rate ratios for 'Excellent' self-rated health were lower among those who had high experience of dental caries as children than those who had not in both, the Dunedin (IRR, 0.76; 95% CI, 0.50, 1.14) and Christchurch studies (IRR, 0.69; 95% CI, 0.47, 1.00). Childhood dental caries was not associated with the number of self-reported physical health conditions in midlife, in either cohort. Dunedin Study members who at age 5 were not caries-free or whose parents rated their own or their child's oral health as poor were less likely to report 'Excellent' self-rated general health at age 45 than those who were caries-free and whose parents did not give a 'poor' rating (IRR, 0.69; 95% CI, 0.49, 0.97).

Conclusions: Five-year-olds with greater caries experience were more likely to have poorer self-rated general health by midlife. Beyond this longitudinal association, future research should examine whether childhood dental caries is associated with objective/biological markers of physical health and whether it may have utility as an early indicator for poor general health in adulthood.

KEYWORDS
adult, child, epidemiology, general health, lifecourse, risk

1 | INTRODUCTION

Children can be affected by dental caries soon after their teeth erupt. Those affected are at greater risk of experiencing oral disease later in life.[1,2] Consequences of untreated caries in young children include chronic pain, infection, disrupted sleep, learning difficulties, school absenteeism and poor oral-health-related quality of life.[3] Treating it involves high costs for health systems, with a considerable amount of care being provided under general anaesthesia.[4] Dental caries follows social gradients[5] and is observable in early life, before the onset of general health problems. It shares common social determinants with the four most prevalent non-communicable diseases (NCDs), cardiovascular disease, cancer, diabetes and chronic respiratory disease.[6] For example, socio-ecological factors including socioeconomic deprivation,[1] employment and housing[7] contribute to the inequitable rates of early childhood caries (ECC). Accordingly, NCDs are also clustered among low socioeconomic (SES) groups in high-income countries (although among high SES groups in low/middle-income countries). Disease rates—including diabetes—increase at a faster rate among low SES groups in low/middle-income countries, where there are also higher chances of dying from NCDs.[8,9] Although morbidity and mortality from such chronic diseases occur mainly in adulthood, exposure to risk factors begins in early life.[10]

Caries experience at the age of five years is associated with adult caries experience,[11] yet it remains unclear whether poor child oral health is associated with future adult general health. The lifecourse approach is useful to study early exposures and their associations with chronic diseases,[12,13] and should be taken into account when designing strategies to prevent and control NCDs.[10]

Self-rated health is a simple and useful way to measure general health. Assessment of self-rated health requires a person to integrate their understanding of the 'elements of health' and to rate their health status against a preset descriptor (commonly using a five-response scale). Self-reported health synthesizes perceptions, experiences, emotions and concerns, as a human experience of health[14] and is associated with experience of pain,[15] functional limitation[16] and disabilities, as well as occurrence of various health conditions such as depression,[17] stroke[18] and type 2 diabetes.[19] Poor self-rated general health predicts greater risk of morbidity and mortality.[20,21]

Good oral health is required for good overall health, but as already noted, it is not known whether childhood oral health is associated with general health in later life. Accordingly, we utilized two New Zealand longitudinal birth cohorts to investigate whether poor childhood oral health (a time-specific measure) is associated with (1) poor self-reported general health or (2) multiple chronic self-reported physical health conditions in midlife (time-specific measure in the same individuals four decades later). The use of two cohorts with similar data allowed for replication of findings across different samples and in different locations. This is desirable because reproducibility remains a challenging issue in contemporary science[22] and, here, we aim to address this directly.

2 | METHODS

Participants were members of two New Zealand (NZ) birth cohort studies: the Dunedin Multidisciplinary Health and Development Study; and the Christchurch Health and Development Study (hereafter the Dunedin and Christchurch studies, respectively). Each uses a prospective-longitudinal correlational design in which the same participants have been assessed repeatedly since birth. Both studies document the natural history of health and disease.[23]

The Dunedin Study is a population-representative birth cohort of 1037 individuals (91% of eligible births; 52% boys) born from 1 April 1972 to 31 March 1973 in Dunedin, NZ.[24] Cohort families represent the full SES range of NZ's South Island, and study participants are primarily of NZ European ethnicity (7.5% self-identify as Māori and 1.5% as Pacific people). Perinatal data were collected at birth, and the cohort for the longitudinal study was defined at age 3 years. The cohort has been assessed again at ages 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, 38 and (most recently) at age 45 years, when 938 (94%) of the 997 living cohort members took part. Written informed consent was obtained, and the NZ Health and Disability Ethics Committee approved each assessment phase.

The Christchurch Study, birth cohort comprises 1265 children born in the Christchurch urban region from 15 April to 5 August 1977 (97% of all children born in all local maternity units during that period).[25] Cohort families represent the full SES range of NZ's South Island. Most participants self-identify as being of European origin, but about 13% report Māori or Pacific ethnicity. Participants were studied at birth, four months, annually from age 1 to 16 years, and again at 18, 21, 25, 30, 35 and age 40 years, when 904 (74%) of the 1222 living cohort members participated. Written informed consent was obtained, and each assessment was approved by the Regional Health and Disabilities Ethics Committee.

Both studies use data from several sources (psychometric assessments, interviews, hospital and police records) on a wide range of domains such as mental health, social circumstances, development and wellbeing. Additionally, the Dunedin Study participants have been physically examined using a wide variety of physiological health measures. This study focuses on self-reported health in the fifth decade of life.

2.1 | Oral examinations in childhood

Dental caries experience by age 5 was assessed by four dentists using WHO methods (World Health Organization, 1977) for

participants in the Dunedin Study, and from routinely collected records of the first visit made to a School Dental Service clinic at ages 5 or 6 years for participants in the Christchurch Study. Caries experience was summarized using the dmft index. For analyses presented here, dmft scores were trichotomized: absence of decayed, missing or filled teeth (dmft = 0), moderate caries experience (dmft = 1–4) or high caries experience (dmft ≥ 5). This is consistent with the commonly used service definition for high dental caries experience in NZ and with previous reporting. Methodological characteristics of oral examinations for both studies have been reported elsewhere.[26,27]

In the Dunedin Study, data were also collected on parent's ratings of child's oral health (OH), response options 'Very Good/Moderately good', 'Average' and 'Moderately poor/Very poor/Don't know' and parent's self-rated OH, response options 'Excellent/Fairly good', 'Average' and 'Fairly poor/Very poor/Don't know/Edentulous' (for a detailed description, see Appendix S1). Children's oral health status was categorized as 'not at risk' if they were caries-free at age 5 years and had average or better parent-rated child OH, and average or better parent self-rated OH; and as 'at risk' when they had had any caries experience and/or had poor child/parent ratings of OH.

2.2 | Assessing self-reported physical health in adulthood

In both studies, participants were interviewed face-to-face in mid-adulthood about their physical and mental health, at age 45 years in the Dunedin Study and at age 40 in the Christchurch Study. In the former, interviews were conducted by qualified professionals blind to the participants' previous data.[24]

Self-ratings of general health were made using a single-question format, with a five-point Likert scale, to summarize overall health. The wording of the global questions and ordinal responses differed slightly by study. The Dunedin Study used 'In general, would you say your health is' (response options 'Excellent', 'Very good', 'Good', 'Fair' or 'Poor'). The Christchurch Study used 'Overall, how would you rate your physical health at the present time?' (response options 'Excellent', 'Good', 'Average', 'Poor' or 'Very Poor').

In the Dunedin Study, physical health was also assessed with a general health questionnaire by asking whether each study member had been diagnosed by a doctor or other health professional with any of 36 physical health conditions over the last 12 months. In the Christchurch Study, interviews used a custom-written general health questionnaire. Study members were also asked whether they had been diagnosed by a doctor or other health professional with any of 19 physical health conditions over the last 12 months. Responses to an additional statement: 'Diagnosed with other major chronic long-term problems with your physical health' were also considered. For both studies, responses were coded as yes/no.

Both cohorts obtained information about 14 conditions, specifically heart disease, high blood pressure, stroke, high cholesterol, diabetes and gestational diabetes, asthma, chronic lung disease, arthritis, cancer, epilepsy, chronic eczema, food allergies and sleep disorders. To ensure comparability, analyses were limited to conditions investigated in both cohorts.

Outcome variables for our analyses were as follows: (1) dichotomized self-rated general health (where the excellent health category was compared against all other categories: 'Excellent' = 1, 'Else' = 0, for the Dunedin Study those with excellent health (and available childhood dental data) were 17.7%, n = 148, and for the Christchurch Study were 23.7%, n = 195, of the cohort); and (2) number of chronic self-reported physical health conditions (from 14 conditions that were asked about in both cohorts). These variables were measured at age 40 in the Christchurch Study and at age 45 years in the Dunedin Study.

2.3 | Covariates

Sex, perinatal complications, childhood socio-economic status (SES), childhood IQ and personality style in adulthood were included as covariates. The selection of these variables was guided by previous research.[28,29]

In both studies, family SES was recorded at the child's birth using the Elley–Irving scale of SES for NZ, which places occupations into six categories ranging from 1 = professional to 6 = unskilled labourer. Perinatal complications were recorded shortly after birth, with study members classified as 0 with none, or as 1+ where there were ≥1 perinatal complications. Childhood IQ assessment used the Wechsler Intelligence Scale for Children–Revised (WISC–R) according to standard protocols. The IQ variables were standardized to population norms (mean = 100, SD = 15) in both studies. Personality style in adulthood in the Dunedin Study was assessed by the Multidimensional Personality Questionnaire (MPQ) adapted for NZ, with three superfactors: negative emotionality, positive emotionality and constraint. In the Christchurch Study, personality was assessed using the 'Big-Five' personality dimensions. Neuroticism, extraversion and conscientiousness were used as analogue scales of MPQ superfactors. For the purpose of these analyses, personality scores were standardized into Z scores (mean = 0, SD = 1). For a detailed description of covariates, see Appendix S1.

2.4 | Statistical analysis

Full data were available for n = 837 (Dunedin) and n = 824 (Christchurch) on both childhood dental (time-specific measure) and adult self-reported general health measured four decades later (time-specific outcome). Cross-tabulations were used for categorical dependent variables (self-ratings of health). Generalized Estimating Equations (GEEs) were used to estimate associations between childhood dmft categories at age 5/5-6 and self-rated general health at age 45/40 (Dunedin/Christchurch studies, respectively). Poisson regression using GEEs (with robust variance estimation and unstructured working correlation) estimated incidence rate ratios for dichotomized responses of self-rated health (coded as 'Excellent' = 1 and 'Else' = 0), while negative binomial

regression by GEEs was used for the number of self-reported chronic physical health conditions at middle age. Covariates were sequentially added: Model 1 unadjusted; Model 2 sex; Model 3 sex and childhood SES; Model 4 sex, childhood SES and childhood IQ; Model 5 sex, childhood SES, childhood IQ and personality; and the final Model 6 included sex, childhood SES, childhood IQ, personality and perinatal complications. An additional model was fitted for the Dunedin Study data, using child oral health status ('at risk/not at risk') as independent variable. Analyses used STATA/IC version 16.1 (StataCorp LLC). Reporting of data complied with STROBE guidelines.

3 | RESULTS

Data on self-reported general health in adulthood were available for 837 and 824 participants in the Dunedin and Christchurch Studies, respectively (Table 1). A fifth of Dunedin and nearly a quarter of Christchurch participants rated their general health as 'Excellent'. Consistent gradients in the proportion of participants who rated their general health as 'Excellent' were observed against total and untreated caries experience at age 5 in both studies. Caries-free 5–6-year-olds were more likely to self-rate their general health as 'Excellent' by age 45 and 40 than those with caries.

Table 2 and Appendix S2 report incidence rate ratios for associations between childhood caries experience and 'Excellent' self-rated health in midlife. Relative to those who were caries-free, children who had high caries experience at age 5 were less likely to report 'Excellent' general health ratings at age 40 years in the Christchurch Study (Model 1, dmft 5+: IRR, 0.65; 95% CI, 0.45, 0.95). Dunedin Study estimates for high caries experience were in the same direction, although with a wider confidence interval (Model 1, dmft 5+: IRR, 0.67; 95% CI, 0.44, 1.02.). After accounting for known risk factors for child poor

TABLE 1 Self-rated general health among the Dunedin ($n = 837$) and Christchurch ($n = 824$) study participants at 45 and 40 years of age, respectively, by childhood caries experience

	Self-rated general health, % (*n*)						
	Excellent	**Very good**	**Good**	**Average**	**Fair**	**Poor**	**Very poor**
Dunedin birth cohort							
In general, would you say your health is?	17.7 (148)	42.3 (354)	31.5 (264)	–	7.3 (61)	1.2 (10)	–
Caries experience at age 5 years							
Caries-free (dmft 0)	21.3 (73)	45.8 (157)	26.2 (90)	–	6.1 (21)	0.6 (2) [a]	–
dmft 1–4	15.6 (51)	37.7 (123)	34.7 (113)	–	9.8 (32)	2.2 (7) [a]	–
dmft 5+	14.3 (24)	44.1 (74)	36.3 (61)	–	4.8 (8)	0.6 (1) [a]	–
Presence untreated caries							
0 dt	19.3 (115)	42.4 (253)	29.7 (177)	–	7.2 (43)	1.5 (9)	-
1+ dt	13.8 (33)	42.1 (101)	36.3 (87)	–	7.5 (18)	0.4 (1)	–
Presence missing teeth							
0 mt	17.6 (145)	42.7 (353)	31.1 (257)	–	7.4 (61)	1.2 (10)	–
1+ mt	27.3 (3)	9.1 (1)	63.6 (7)	–	0.0 (0)	0.0 (0)	–
Christchurch birth cohort							
Overall, how would you rate your physical health at the present time?	23.7 (195)	–	48.3 (398)	23.8 (196)	–	3.4 (28)	0.8 (7)
Caries experience at age 5–6 years							
Caries-free (dmft 0)	26.0 (116)	–	48.0 (214)	22.0 (98)	_	3.6 16)	0.5 (2)
dmft 1–4	23.9 (51)	–	45.5 (97)	25.4 (54)	_	4.2 (9)	0.9 (2)
dmft 5+	17.0 (28)	–	52.7 (87)	26.7 (44)	_	1.8 (3)	1.8 (3)
Presence untreated caries							
0 dt	25.1 (128)	–	48.6 (248)	22.4 (114)	_	3.3 (17)	0.6 (3)
1+ dt	21.3 (67)	–	47.8 (150)	26.1 (82)	_	3.5 (11)	1.3 (4)
Presence of missing teeth							
0 mt	24.6 (195)	–	48.0 (381)	23.1 (183)	_	3.5 (28)	0.9 (7) [a]
1+ mt	0.0 (0)	–	56.7 (17)	43.3 (13)	_	0.0 (0)	0.0 (0) [a]

[a]Chi^2 test, $p < .05$.

oral and general health (SES, IQ, perinatal complications), and adult self-reported measures (personality style), incidence rate ratios for 'Excellent' self-rated health were lower among those who had high experience of dental caries as children than for those who had not, both in the Dunedin (IRR, 0.76; 95% CI, 0.50, 1.14) and Christchurch studies (IRR, 0.69; 95% CI, 0.47, 1.00). We conducted additional analyses splitting the response categories of self-rated general health using a different threshold whereby they were 'Excellent/Very good/Good'=1, 'Else'=0 in the Dunedin Study, and 'Excellent/Good'=1, 'Else'=0 in the Christchurch Study. The directionality of findings remained, with significant associations for the moderate caries group (dmft=1-4) in the Dunedin cohort (Appendix S3).

In the Dunedin Study, children who were 'at risk' for dental caries at age 5 (that is, those who were not caries-free, and whose parents rated their own or their child's oral health as poor) were less likely to rate their health as 'Excellent' at age 45 years than children who were not at risk (Table 3 and Appendix S4, IRR, 0.69; 95% CI, 0.49, 0.97). Additional analyses with response categories of self-rated general health dichotomized as 'Good' or above, showed consistency in associations (Appendix S5).

Childhood caries experience, untreated decay and caries-associated tooth loss were not associated with the number of self-reported chronic physical health conditions out of 14 comparable outcomes in adulthood, in either cohort (Table 4, Appendices S6–S8 Similar findings were observed when examining data for the total number of physical health conditions in each study (Appendix S9).

4 | DISCUSSION

Our analysis of two longitudinal datasets found lower incidence rate ratios for 'Excellent' self-rated health at middle age among those who had moderate or high caries experience as children than those who were caries-free, in both study cohorts, suggesting that our findings are consistent and in the expected direction. In the Dunedin Study, when additional indicators were used to describe child's OH at age 5 years (by including age-5 dmft, child OH parent-ratings and parent's own self-rated OH), the presence of at least one indicator of poor child OH was associated with poorer self-rated general health in midlife.

TABLE 2 Associations between age-5-years caries experience and 'Excellent' self-rated general health among Dunedin Study participants at 45 years of age and Christchurch Study participants at 40 years of age by a modified Poisson regression model using GEEs

	Dunedin Study				Christchurch Study			
Independent variables	***n***	**IRR**	**IRR 95% CI**	***p***	***n***	**IRR**	**IRR 95% CI**	***p***
Final model	823				817			
dmft								
0		Ref.				Ref.		
1–4		0.73	0.53, 1.01	.056		0.99	0.75, 1.30	.918
5+		0.76	0.50, 1.15	.196		0.69	0.47, 1.00	.050
Sex								
Female		Ref.				Ref.		
Male		0.75	0.54, 1.02	.070		0.78	0.61, 0.10	.053
Childhood SES								
High		Ref.				Ref.		
Medium		0.77	0.54, 1.11	.160		0.82	0.62, 1.10	.196
Low		0.63	0.37, 1.08	.092		0.89	0.63, 1.27	.560
Childhood IQ		1.01	0.10, 1.02	.106		1.00	1.00, 1.02	.311
Personality								
Negative emotionality		0.70	0.58, 0.84	<.001		–	–	–
Positive emotionality		1.17	1.00, 1.37	.054		–	–	–
Constraint		1.17	0.99, 1.37	.060		–	–	–
Neuroticism		–	–	–		0.81	0.71, 0.93	.004
Extraversion		–	–	–		1.21	1.07, 1.37	.003
Conscientiousness		–	–	–		1.27	1.11, 1.46	.001
Perinatal complications								
0		Ref.				Ref.		
1+		1.29	096, 1.72	.092		0.99	0.76, 1.29	.948

Abbreviations: CI, confidence interval; GEE, generalized estimating equation; IRR, incidence rate ratio.

TABLE 3 Associations between child oral health status[a] at age 5 years and 'Excellent' self-rated general health among Dunedin Study participants at 45 years of age by a modified Poisson regression model using GEEs

Independent variables	*n*	IRR	IRR 95% CI	*p*
Final model	823			
Child oral health status				
Not at risk		Ref.		
At risk		0.69	0.49, 0.97	.031
Sex				
Female		Ref.		
Male		0.75	0.55, 1.03	.075
Childhood SES				
High		Ref.		
Medium		0.77	0.54, 1.09	.139
Low		0.63	0.37, 1.07	.087
Childhood IQ		1.01	1.00, 1.02	.123
Personality				
Negative emotionality		0.70	0.58, 0.83	<.001
Positive emotionality		1.17	1.00, 1.37	.053
Constraint		1.17	0.99, 1.38	.060
Perinatal complications				
0		Ref.		
1+		1.30	0.97, 1.73	.082

Abbreviations: CI, confidence interval; GEE, generalized estimating equation; IRR, incidence rate ratio; OH, oral health.

[a]Not at risk = caries-free, average or better parent self-rated OH, and average or better parent-rated child OH at age 5 years. At risk = yes to at least one of the following: dmft>0 at age 5, poor parent self-rated OH, or poor parent-rated child OH.

Before discussing the implication of the findings, it is important to consider some limitations and strengths of this research. The wording and response options of the health rating scales differed slightly between the studies, preventing exact matching of the variable; nevertheless, we compared outcomes at the 'Excellent' category level but also checked for consistency in findings using a less strict definition of 'Good or above' self-rated health. Some variables did not match exactly between the two study cohorts due to differences in assessment ages; however, they represent comparable childhood measures based on the same scales. The main analyses reported here refer to the 14 comparable physical health conditions; however, supplementary analyses for the total number of conditions queried in each study indicated consistency in findings. The findings derive from two cohorts characterized by a predominance of participants with European ancestry; that is, the number of Māori and Pacific participants in both cohorts was relatively small. Future studies may address this issue with larger and more diverse samples.

With respect to research strengths, both studies are population-based and longitudinal, with high participation rates even after many decades of follow-up.[23] In this study, subjective health ratings in midlife were used as outcome measure. Influenced by personal, socio-cultural and environmental factors,[20] they represent individual perceptions of health and wellbeing and could arguably be considered 'more important' to a person than a professional's clinical diagnosis of disease or disability.[30] Subjective ratings add to the 'sensory' and 'physical' health information a perception of a 'human experience' of health, providing complementary information and informing of a different dimension of health. Another strength is that despite some methodological differences in dental data collection, the tendency in findings was replicated in both birth cohorts. Also, despite slight differences in the assessment ages (for example, age 5-dmft data and age 7-9 years for IQ data), we utilized these set of covariates because they have an influence in such developmental epoch. Another strength was the inclusion of important covariates known to affect oral health. A final strength is that we accounted for personality which is also an important factor affecting subjective ratings of health.[31–33]

Turning to the findings, we observed lower incidence rate ratios for 'Excellent' self-reported health some four decades later among children who had high caries experience than among those who were caries-free at 5 years old. This was despite some differences between the cohorts in terms of the numbers represented in the moderate and high caries groups, and differences in the wording of the self-rated general health questions used; however, findings were not significant in either cohort.

Childhood caries was not associated with number of self-reported chronic health conditions in the 40s, in either cohort. This null finding might be due to the relatively young age of participants, as their experience of chronic conditions was limited. In support, the majority (approximately 60%) of study members reported having none of the 14 health problems. A quarter reported one diagnosed ongoing chronic condition (over the last 12 months) and only one in eight reported two or more. Thus, it may simply be too early in life to detect associations between childhood oral health and later physical health conditions. Prevalence, coincidence and comorbidity of a range of mental and physical health outcomes were previously reported in the two cohorts at age 26 years. Associations were found, but it was suggested that, as study participants continue to age, morbidity would increase.[34] Findings from the Dunedin Study have shown that individuals who are ageing more rapidly are less physically able, show cognitive decline and faster brain ageing, have poorer self-reported health and look older.[35] As participants get older and sicker, the associations between childhood oral health and adult health may well strengthen.

In the Dunedin Study, having one or more indicator of poor childhood oral health (high caries experience, poor parental oral health or poor parent-rated child oral health) was associated with poorer self-ratings of general health in adulthood. In this respect, parental ratings act as relevant adjunct information to objective clinical data because they integrate important personal, family and social-circumstances

TABLE 4 Associations between age-5-years caries experience and chronic physical health conditions among Dunedin Study participants at 45 years of age and Christchurch participants at 40 years of age by a negative binomial regression model using GEEs

	Dunedin Study				Christchurch Study			
Independent variables	***n***	**IRR**	**IRR 95% CI**	***p***	***n***	**IRR**	**IRR 95% CI**	***p***
Final model	823				817			
dmft								
0		Ref.				Ref.		
1–4		1.01	0.88, 1.15	.930		0.90	0.75, 1.07	.229
5+		0.98	0.83, 1.14	.771		0.99	0.84, 1.18	.938
Sex								
Female		Ref.				Ref.		
Male		0.98	0.86, 1.12	.756		1.03	0.89, 1.18	.721
Childhood SES								
High		Ref.				Ref.		
Medium		1.08	0.90, 1.30	.399		1.13	0.92, 1.38	.236
Low		0.95	0.77, 1.19	.676		1.14	0.91, 1.42	.248
Childhood IQ		1.00	0.99, 1.00	.484		0.99	0.99, 1.00	.013
Personality								
Negative emotionality		1.13	1.07, 1.19	<.001		–	–	–
Positive emotionality		0.98	0.93, 1.04	.572		–	–	–
Constraint		1.04	0.97, 1.12	.236		–	–	–
Neuroticism		–	–	–		1.12	1.05, 1.20	<.001
Extraversion		–	–	–		0.94	0.87, 1.01	.083
Conscientiousness		–	–	–		0.96	0.90, 1.02	.183
Perinatal complications								
0		Ref.				Ref.		
1+		1.10	0.98, 1.25	.112		1.00	0.82, 1.25	.977

Abbreviations: CI, confidence interval; GEE, generalized estimating equation; IRR, incidence rate ratio.

information to describe people's perception of health.[30,36] Our findings provide some evidence of the validity of parental ratings when judged against independent clinical data. Not only they were associated with age-5 caries experience cross-sectionally (data not shown), but longitudinally associated with ratings of general health. This gives support to the multilevel model of influences (child, family and community) on children's oral health,[37] whereby alongside individual factors, the wider issues of family composition/function, parental health and socioeconomic position, physical and social environments and healthcare systems also play a role.

Self-reported health has been previously associated with functional decline, survival and the use of health services.[36,38] Dental caries, poor subjective ratings of health and the major NCDs are all examples of compromised health and are driven by the same common structural, psychosocial and behavioural risk factors. Refraining from any causal explanations, we hypothesize that the association between early childhood caries and adult self-reported general health observed might be due to the convergence of early-life exposures and living environments that shape health and disease risk factors in later life.[39] This suggests that some 'connections' between oral diseases and general diseases might be due to common exposure to certain environments and habits,[40,41] or accumulation of unhealthy circumstances,[42] rather than any direct causal effects.[43]

Research examining associations between childhood oral health and subsequent age-related conditions through more objective clinical/physiological measures of physical disease could complement our findings and provide a stronger test of whether the people with poor oral health as children grow up to be the adults with a high burden of disease.

In conclusion, five-year-olds with greater caries experience were more likely to have poorer self-rated general health by midlife. Beyond this longitudinal association, it may be that oral health in the earliest years can act as the 'canary in the coal mine', foreshadowing risk for future poor general health. Whether or not this is ultimately the case, the notion that poor childhood oral health can serve as an early lifecourse signal for compromised physical health decades later deserves more research attention. Appropriate data-analytic approaches for prediction or causal inference should be applied when pursuing such data tasks.[44,45]

AUTHOR CONTRIBUTIONS

BR analysed the data and drafted the paper. JMB, WMT, JB, LJH, SR and RP provided critical intellectual input in data interpretation and revising

the paper. All authors have read and approved the final version of this manuscript and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors report no conflicts of interest related to this study.

DATA AVAILABILITY STATEMENT

The Dunedin Study datasets reported in the current article are not publicly available due to a lack of informed consent and ethical approval for public data sharing. The Dunedin Study datasets are available on request by qualified scientists. Requests involve a concept paper describing the purpose of the data access, ethical approval at the applicant's university and provision for secure data access. We offer secure access on the Duke, Otago and King's College campuses. The Christchurch Study datasets are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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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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