Oral health status and longitudinal cardiometabolic risk in a national sample of young adults

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ABSTRACT

Background. Dental and cardiometabolic diseases are highly prevalent, share many common risk factors, and begin during youth. Despite poor dental health being known to influence dietary behaviors that are in turn linked to cardiometabolic health, the role of oral health on concomitant and future cardiometabolic disease is understudied. We sought to determine the association of oral health with cardiometabolic markers during adolescence and early adulthood.

Methods. Our sample included 11,556 participants with data from waves 1 (when participants were aged 12 to 19 years) and 4 (when they were aged 26 to 32 years) of the National Longitudinal Study of Adolescent to Adult Health. Multivariable linear and logistic regression separately examined associations between different markers of oral health (that is, missing teeth, periodontal disease, and deferred dental care) and markers of cardiometabolic health (that is, lipids, blood pressure, and body mass index), adjusting for sociodemographic characteristics.

Results. Mean age was 29 years at follow-up (wave 4). In adjusted analyses, deferred dental care during both adolescence ($\beta = 1.25$; 95% confidence interval [CI], 0.6 to 2.0; $P = .001$) and early adulthood ($\beta = 0.9$; 95% CI, 0.4 to 1.3; $P < .001$) was associated with an increased body mass index during early adulthood. Deferred dental care in early adulthood was also associated with increased systolic ($\beta = 0.9$; 95% CI, 0.4 to 1.5; $P = .002$) and diastolic ($\beta = 1.0$; 95% CI, 0.5 to 1.5; $P < .001$) blood pressure values and an increased likelihood of being hypertensive (odds ratio = 1.2; 95% CI, 1.0 to 1.3; $P = .03$).

Conclusions. In this nationally representative study deferred dental care during adolescence and concurrently in early adulthood was associated with poorer cardiometabolic disease during early adulthood. Providing better access to dental care may have benefits not only for oral health but also for long-term cardiometabolic health.

Practical Implications. Deferred dental care during adolescence and early adulthood, but not recent tooth loss or periodontal disease, is associated with increased risk of cardiometabolic disease.

Key Words. Dental; adolescent; cardiometabolic; cholesterol; blood pressure.

JADA 2017:148(12):930-935

https://doi.org/10.1016/j.adaj.2017.09.029

Cardiometabolic disease, which includes obesity, type 2 diabetes, hypertension, dyslipidemia, liver enzyme dysregulation, and coronary artery disease, is a significant public health burden among the US population.[1] The origin of cardiometabolic risk and disease (CMRD) is largely in childhood and adolescence. Overweight and obesity, the most common of this group of conditions, affect nearly 1 in 3 children, predict adult obesity, and put affected children at risk of other cardiometabolic diseases in adulthood.[2,3] An increased body mass index (BMI) (in kilograms per square meter) during adolescence, even in the high normal range regardless of adult BMI, is associated with an increased risk of experiencing early cardiovascular mortality.[4] The prevalence of cardiometabolic disease is on the rise and represents an increasingly large portion of the long-term disease burden, with lifestyle factors and especially diet being important risk factors.[5]

Teeth can play a critical role in maintaining overall health and decreasing cardiometabolic risk through a variety of mechanisms, most straightforwardly through dietary choices but potentially via other mechanisms such as oral protection or esthetics.[6-9] The oral cavity is the first organ in the digestive system, and impairments in the oral cavity can have far reaching impact and affect one's overall health.

Missing dentition is thought to affect diet, and thereby overall nutrition, in several ways. People with missing teeth and improperly fitted prostheses may avoid hard foods, resulting in decreased consumption of hard fruits and vegetables; may avoid foods that can get caught in between dentition, including nuts and fiber; and may eat more soft foods, including carbohydrate-rich foods and prepared foods, which often means an accompanying increase in the intake of cholesterol and saturated fatty acids.[10-14] These dietary modifications can all increase the risk of obesity and cardiovascular disease. From 3% through 8% of the population have missing adult dentition, due to a variety of conditions, including congenitally missing teeth, aplasia, ectodermal dysplasia, and other forms of congenital, genetic, or environmental hypodontia.[15,16] In addition to this, youth can also lose teeth as a result of trauma and odontogenic infection. Despite the important physiological role teeth play in nutrition, little is known about how missing teeth affect CMRD.

Studies have also found an association between periodontal disease and cardiovascular disease, although a causal relationship has not been clearly established.[17] Possible mechanisms that have been proposed range from direct biological effects to common social risk factors. Biological causes have largely focused on common bacteria found in both the gingiva and arteries and on common inflammatory pathways. Bacteria present in dental plaque that enters the bloodstream may play a role in the development and progression of atherosclerosis.[18] Other studies have pointed toward the activation of inflammatory cytokines and acute-phase reactants.[19] Given the lack of causal evidence, the observed associations may also be explained by common health behaviors, including poor hygiene and self-care, or by more upstream socioeconomic determinants, leading to both poor dentition and poor cardiometabolic health.[20] Common socioeconomic conditions may be the coincidence of common risk factors or simply unmeasured confounding.

Aside from periodontal disease, dental infections may represent another pathway through which impaired dental health leads to CMRD. Dental caries are a common infection during youth, affecting more than 1 of every 2 adolescents between the ages of 12 and 19 years, with higher rates among Hispanic adolescents and those living in families with lower incomes.[21] Evidence from 2016 found that among children from families with low socioeconomic status, childhood infection involving a variety of organ systems, including the digestive system, can worsen adult cardiometabolic risk.[22] In families with low socioeconomic status, given the high prevalence of dental infections, dental caries may thus be predictive of future adult cardiometabolic disease. Deferred dental care—dental care that is either late or missed—may be associated with increased cardiometabolic risk by neglecting to treat dental infections or to attend to missing dentition. Access to dental care continues to be a considerable problem among certain populations within the United States.[23]

In this study, we sought to test the association between oral health status and markers of cardiometabolic health in adolescents and to track this association into early adulthood. We hypothesized that poorer oral health status, defined as reported tooth loss or periodontal disease, and deferred dental care are associated with poorer cardiometabolic markers, even after adjusting for sociodemographic factors.

METHODS

Sample. We analyzed data from waves 1 and 4 of the National Longitudinal Study of Adolescent to Adult Health (Add Health), a nationally representative school-based cohort of youth who were followed from adolescence into adulthood. Baseline (wave 1) data were collected from 1994 through 1995 when participants were in grades 7 to 12 and were aged 12 to 19 years. Participants were followed over 4 waves of data collection with the most recent data (wave 4) collected in 2008 when participants were aged 24 to 32 years.

Measures. ***Markers of cardiometabolic health.*** We examined 4 cardiometabolic markers that belonged to 3 main groups: BMI, blood pressure, and blood lipids. BMI was calculated from objectively measured height and weight collected in home in wave 4 with the use of standardized procedures. Blood pressure measures were systolic pressure, diastolic pressure, and presence or absence of hypertension. Add Health field interviewers measured blood pressure with the use of an approved automatic device. They took 3 readings, double entering the second and third measurements and averaging these measurements for the final value. Presence of hypertension was defined as having a systolic blood pressure of 140 millimeters of mercury or greater or a diastolic blood pressure of 90 mm Hg or greater, in accordance with current clinical guidelines.[24] Blood lipid measures were total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), and triglycerides (TGs). Participants in wave 4 provided capillary whole blood via a finger stick; 17% of participants were fasting at the time of blood collection. Dried samples were analyzed for TC, HDL, LDL, and

ABBREVIATION KEY. Add Health: National Longitudinal Study of Adolescent to Adult Health. **BMI:** Body mass index. **CMRD:** Cardiometabolic risk and disease. **HDL-c:** High density lipoprotein cholesterol. **LDL-c:** Low density lipoprotein cholesterol. **TC:** Total cholesterol. **TG:** Triglyceride.

TABLE 1

Participant characteristics, oral health status markers, and cardiometabolic disease outcomes in the National Longitudinal Study of Adolescent to Adult Health (N = 11,556).

VARIABLE	SAMPLED FREQUENCY	VALUE*
Sociodemographic Characteristics		
Age (Wave 4)	11,556	28.8 ± 0.12
Female	6,434	51.8 (0.69)
Race		
White	6,355	67.4 (2.8)
Black	2,211	14.1 (1.9)
Hispanic	1,689	10.8 (1.5)
Other	1,301	7.8 (0.9)
Parental education		
Less than high school	1,095	9.3 (1.0)
High school graduate	3,220	29.0 (1.2)
Some college or technical school	3,913	34.2 (1.0)
College graduate or beyond	3,328	27.6 (1.5)
Oral Health Predictors		
Tooth loss or periodontal disease (wave 4)	372	3.4 (0.2)
Deferred dental care (wave 1)	1,300	11.1 (0.6)
Deferred dental care (wave 4)	4,902	43.9 (0.8)
Cardiometabolic Risk (Wave 4)		
BMI†	11,556	28.9 ± 0.13
Total cholesterol decile	11,556	5.6 ± 0.05
Triglycerides decile	11,556	5.4 ± 0.05
LDL-c‡ decile	11,556	5.6 ± 0.05
HDL-c§ decile	11,556	5.5 ± 0.06
Systolic blood pressure (millimeters of mercury)	11,556	124.7 ± 0.21
Diastolic blood pressure (mm Hg)	11,556	79.2 ± 0.16
Hypertension¶	2,063	18.6 (0.6)

* Values are mean ± standard error (SE) or % (SE).
† BMI: Body mass index.
‡ LDL-c: Low-density lipoprotein cholesterol.
§ HDL-c: High-density lipoprotein cholesterol.
¶ Hypertension was defined as blood pressure values of 140/90 mm Hg or more.

TGs. The lipid values (in milligrams per milliliter) were rank ordered and reported in deciles in an effort to avert bias because of assay technologies.

Oral health status. Measures of oral health status were obtained with 3 questions that assessed tooth loss or periodontal disease in wave 4 and deferred dental care in waves 1 and 4. Tooth loss or periodontal disease was assessed with the use of the following question: "Have you had gum disease (gingivitis; periodontal disease) or tooth loss because of cavities in the past 4 weeks?" Deferred dental care was assessed during wave 1 with the following question: "When did you last have a dental examination by a dentist or hygienist?" with answers dichotomized into 2 years ago or less versus more than 2 years ago, and during wave 4 as: "In the past 12 months have you had a dental examination by a dentist or hygienist?"

Covariates. We included the following sociodemographic covariates from wave 1, given their role as potential confounders: age, sex, race/ethnicity, poverty status, and parental education. Race/ethnicity was self-reported and was defined as non-Hispanic white, non-Hispanic black, Hispanic/Latino, or other. Poverty status was defined as the percentage of federal poverty guidelines taking into account parental report of household income and reported household size.

Statistical analysis. Descriptive statistics were used to report the study sample and distribution of baseline oral health status and cardiometabolic markers (Table 1). Bivariate analyses using 2-sample *t* tests assessed for associations between BMI, blood pressure, and lipid deciles and, separately, tooth loss or periodontal disease and deferred dental care in waves 1 and 4. χ^2 tests examined the associations between hypertension and tooth loss or periodontal disease as well as deferred dental care in wave 1 and wave 4. Linear regression models tested for associations between oral health predictors and, separately, blood lipid deciles, systolic and diastolic blood pressure values, and BMI, whereas logistic regression tested for the association between oral health status predictors and presence of hypertension. Models were adjusted for age, sex, race/ethnicity, poverty status, and parental education; models examining lipid decile and hypertension outcomes were further adjusted for BMI. A *P* value less than .05 was used to define statistical significance for all analyses. The Add Health study was approved by the University of North Carolina Institutional Review Board. Use of the data was approved by the Boston Children's Hospital Institutional Review Board.

RESULTS

The final study population included 11,556 participants and was evenly distributed by sex, but had a racial/ethnic makeup that was predominantly non-Hispanic white (67%) (Table 1). Three percent of participants reported having tooth loss or periodontal disease in the past month at wave 4, 11% reported having deferred dental care at wave 1 and 44% at wave 4. At wave 4, the mean BMI was 29; 19% of the participants had measured blood pressure in the hypertensive range.

Unadjusted bivariate associations are presented in Table 2, with adjusted model results presented in Table 3. In unadjusted models, deferred dental care during adolescence was associated with a higher BMI (30.6 versus 28.7; $P < .001$) in early adulthood. This association persisted after adjusting for potential sociodemographic confounders ($\beta = 1.25$; 95% confidence interval [CI], 0.6 to 2.0; $P = .001$). Deferred dental care during adolescence was also associated with higher systolic and

TABLE 2

Unadjusted associations between oral health status during adolescence and early adulthood and cardiometabolic risk during early adulthood.

CARDIOMETABOLIC RISK: WAVE 4	TOOTH LOSS OR PERIODONTAL DISEASE: WAVE 4			DEFERRED DENTAL CARE: WAVE 1			DEFERRED DENTAL CARE: WAVE 4		
	Yes	No	*P**	Yes	No	*P**	Yes	No	*P**
BMI, Kilograms per Square Meter, Mean ± SE†	29.8 ± 0.5	28.9 ± 0.1	.05	30.6 ± 0.3‡	28.7 ± 0.1‡	< .001‡	29.5 ± 0.2‡	28.5 ± 0.2‡	< .001‡
Total Cholesterol Decile, Milligrams per Milligrams per Liter, Mean ± SE	5.31 ± 0.2	5.57 ± 0.1	.2	5.35 ± 0.1‡	5.58 ± 0.1‡	.03‡	5.57 ± 0.1	5.55 ± 0.1	.7
Triglycerides Decile, mg/mL, Mean ± SE	5.69 ± 0.2	5.42 ± 0.1	.2	5.46 ± 0.1	5.42 ± 0.1	.7	5.53 ± 0.1‡	5.34 ± 0.1‡	.005‡
LDL§ Decile, mg/mL, Mean ± SE	5.21 ± 0.2	5.59 ± 0.1	.06	5.38 ± 0.1‡	5.60 ± 0.1‡	.03‡	5.58 ± 0.1	5.58 ± 0.1	1.0
HDL¶ Decile, mg/mL, Mean ± SE	5.03 ± 0.2‡	5.48 ± 0.1‡	.03‡	5.17 ± 0.1‡	5.50 ± 0.1‡	.003‡	5.35 ± 0.1‡	5.56 ± 0.1‡	.002‡
Systolic BP,# Millimeters of Mercury, Mean ± SE	125.7 ± 0.9	124.7 ± 0.2	.3	126.0 ± 0.6‡	124.6 ± 0.2‡	.02‡	126.1 ± 0.3‡	123.7 ± 0.3‡	< .001‡
Diastolic BP, mm Hg, Mean ± SE	79.7 ± 0.7	79.2 ± 0.2	.5	80.3 ± 0.4‡	79.1 ± 0.2‡	.006‡	80.2 ± 0.2‡	78.5 ± 0.2‡	< .001‡
Hypertension, % (± SE)	20.4 (2.7)	18.5 (0.5)	.5	20.9 (1.7)	18.3 (0.6)	.1	21.0 (0.8)‡	16.7 (0.7)‡	< .001‡

* Determined by 2-sample *t* test for body mass index (BMI), systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, and lipid deciles; χ^2 test for hypertension.
† SE: Standard error.
‡ Statistically significant, $P < .05$.
§ LDL: Low-density lipoprotein.
¶ HDL: High-density lipoprotein.
# BP: Blood pressure.

TABLE 3

Regression analysis of oral health determinants of cardiometabolic risk.*

CARDIOMETABOLIC RISK: WAVE 4	TOOTH LOSS OR PERIODONTAL DISEASE: WAVE 4		DEFERRED DENTAL CARE: WAVE 1		DEFERRED DENTAL CARE: WAVE 4	
	ß (SE)†	*P*	ß (SE)	*P*	ß (SE)	*P*
BMI, Mean	0.67 (0.48)	.16	1.25 (0.35)‡	.001‡	0.86 (0.21)‡	< .001‡
Total Cholesterol Decile, Mean	−0.25 (0.19)	.20	−0.16 (0.11)	.15	0.05 (0.07)	.45
Triglycerides Decile, Mean	0.14 (0.19)	.46	−0.08 (0.14)	.56	0.05 (0.07)	.44
LDL§ Decile, Mean	−0.36 (0.20)	.08	−0.15 (10)	.14	0.01 (0.07)	.84
HDL¶ Decile, Mean	−0.34 (0.21)	.11	−0.13 (0.10)	.23	−0.02 (0.06)	.80
Systolic BP,# Mean	0.25 (86)	.77	0.23 (0.44)	.60	0.91 (0.29)‡	.002‡
Diastolic BP, Mean	0.01 (0.69)	.98	0.31 (0.36)	.39	1.00 (0.23)‡	< .001‡
Hypertension, %	1.07 (0.78 to 1.48)**	.67	1.00 (0.81 to 1.24)**	.99	1.16 (1.02 to 1.32)‡,**	.03‡

* Adjusted for age, sex, race/ethnicity, body mass index (BMI), poverty status, and parental education.
† SE: Standard error.
‡ Statistically significant, $P < .05$.
§ LDL: Low-density lipoprotein.
¶ HDL: High-density lipoprotein.
# BP: Blood pressure.
** Values are odds ratio (95% confidence interval).

diastolic blood pressure values, a lower TC decile, a lower LDL-c decile, and a lower HDL-c decile in unadjusted analyses (Table 2).

Deferred dental care in early adulthood was broadly associated with cardiometabolic markers in early adulthood in unadjusted analyses, including a higher BMI, higher TG concentration, HDL-c deciles, higher systolic and diastolic blood pressure values, and an increased odds of meeting blood pressure criteria for hypertension.

After adjusting for potential sociodemographic confounders, deferred dental care remained statistically associated with BMI ($\beta = 0.9$; 95% CI, 0.4 to 1.3; $P < .001$), systolic ($\beta = 0.9$; 95% CI, 0.4 to 1.5; $P = .002$) and diastolic ($\beta = 1.0$; 95% CI, 0.5 to 1.5; $P < .001$) blood pressure values, and odds of being hypertensive (OR = 1.2; 95% CI, 1.0 to 1.3; $P = .03$).

Reporting tooth loss or periodontal disease in the past month at wave 4 had no significant association with any cardiometabolic markers after adjusting for sociodemographic factors.

DISCUSSION

In this national longitudinal study of adolescents followed through early adulthood, we found that specific markers of oral health status were associated with elevated markers of cardiometabolic health. Deferred dental care during both adolescence and early adulthood predicted an elevated BMI and elevated systolic and diastolic blood pressure values during early adulthood, and it was associated with an increased likelihood of having blood pressure values within the hypertensive range. These findings, importantly, remained even after controlling for sociodemographic factors known to be associated with both dental and cardiometabolic health.

Although we found blood pressure values to be associated with oral health status markers, the magnitude was relatively small and the clinical significance of a difference of 1 to 2 mm Hg in blood pressure is unclear. The 1- to 2-point observed difference in BMI values, however, are certainly clinically significant and merit further study.

Although self-reported missing dentition and periodontal disease were associated with a lipid marker in unadjusted analyses, there were no observed associations between missing dentition and periodontal disease in adjusted analyses. Tooth loss in adulthood has been shown to be associated with cardiovascular disease.[25] Missing dentition in youth often results from different causes than in adults and the elderly and may thus represent different pathways for cardiometabolic risk. The lack of association between missing dentition and cardiometabolic markers in adolescent and early adulthood could be due to censoring, because the time frame of noting missing teeth within the past month is substantially shorter than that for reporting deferred care over the past year. In addition, given the known low prevalence of missing dentition,[15,16] a brief time frame for measuring incidence may further make it difficult to detect associations between missing dentition and cardiometabolic markers. Periodontal disease typically is a painless, indolent, long-term disease that most people are unaware of having unless informed by a dentist; thus, relying on identification of periodontal disease by self-report over a brief time likely results in underreporting.[26] Although prevalence data in children are more limited and children are thought to have a lower prevalence of destructive periodontal disease than adults, data from 2015 indicate that one-half of all adults in the United States have periodontal disease,[27] suggesting that the Add Health self-reported prevalence of 3% may be a substantial underestimation. Underreporting may accordingly be another explanation for the study's lack of association between periodontal disease and cardiometabolic risk.

This study is important because little is known about the role of dental status during adolescence and concomitant and future cardiometabolic health. Studies have assessed periodontal disease and cardiovascular health in adults with mixed results, but, given the long time over which cardiometabolic and cardiovascular disease progress, understanding risk factors that begin during adolescence may be of particular importance. Although studies have looked at associations between caries and obesity risk during youth, most studies have been cross-sectional, few have been national, and results have been conflicting.[28-30] A deeper understanding of how oral health affects biological markers of cardiometabolic risk during youth has been lacking. To our knowledge, this study is the first to report on associations between oral health markers and measured biomarkers of cardiometabolic risk in youth. Furthermore, the longitudinal nature of the study provides additional support to the finding of a relationship between oral health status in youth and future cardiometabolic risk.

This study has several limitations, including self-reported measures of oral health and the absence of parental oral health status. Participants may not be aware of having dental disease if they have not recently been seen by a dentist. Responses on oral health status may therefore underestimate the true rate of dental disease in this population and, in turn, the reported associations with cardiometabolic risk. Although we adjusted for sociodemographic markers available in the data set which are known to affect access to dental care, it is possible that additional unmeasured factors could influence access to dental care, including adult employment, occupation type, and insurance status, resulting in residual confounding. Similarly, there may be upstream factors that play a role in determining both oral health status and cardiometabolic risk, a plausible scenario that the study design of this cross-sectional sample with follow-up is not able to assess. Information on cardiometabolic markers is only available during early adulthood (wave 4); therefore, it is not possible to determine how these risk factors may have changed over time or to what degree deferred care during youth contributes to adult outcomes. The most recent wave of data collected was from 2008, and results collected today may differ. Despite these limitations, the strengths of this study include the use of measured height and weight and serum biomarkers of cardiometabolic health, longitudinal follow-up over more than a decade, a nationally representative sample, and the use of a publicly available data set with well-described robust sampling methods.

These important findings highlight the need to further study the mechanisms and pathways through which oral health can affect cardiometabolic health, the stages at which dental outcomes most affect cardiometabolic health, and whether dental interventions during youth can improve future cardiometabolic risk and outcomes.

Two plausible pathways that merit further investigation are whether deferred dental care directly affects dentition which in turn directly affects dietary quality, leading to changes in inflammatory biomarker profiles and weight and whether poor dentition leads to lower self-efficacy, in turn altering dietary choices. Conversely, deferred dental care may be a marker for deferred overall medical care. Better understanding the relationships between deferred dental care and longitudinal markers of cardiometabolic health can help target future treatment efforts. Further investigation into oral and cardiometabolic health in both dental and medical settings, as well as ancillary health care settings in which adolescents with deferred dental care may be reachable, such as school and workplace health care settings, may help clarify if and to what degree oral and cardiometabolic health are related during adolescence and early adulthood. ■

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Disclosure. None of the authors reported any disclosures.

This study was presented in part at the Academic Pediatric Societies Meeting, May 9, 2017, San Francisco, CA.

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