Association Between Cardiovascular Disease and Complete Edentulism in a Nationally Representative U.S. Adults

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Article

Association Between Cardiovascular Disease and Complete Edentulism in a Nationally Representative U.S. Adults

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Abstract

(1) Background: Cardiovascular disease (CVD) and edentulism are major public health challenges with shared risk factors and overlapping inflammatory pathways. (2) Methods: This study investigates the association between complete tooth loss and cardiovascular disease in a nationally representative sample of U.S. adults using data from the 2015–2018 National Health and Nutrition Examination Survey (NHANES). A cross-sectional analysis was conducted among adults aged ≥30 years, incorporating clinically assessed dental status and self-reported CVD outcomes. Weighted multivariate logistic regression models were conducted to investigate the relationship between complete edentulism and different cardiovascular conditions adjusted for age, sex, race/ethnicity, education, income, BMI, and diabetes status. 3) Results: Individuals with cardiovascular conditions, including coronary heart disease, heart attack, stroke, and congestive heart failure, had higher odds of complete edentulism compared to those without cardiovascular conditions, with odds ratios ranging from 1.60 to 1.85 ($p < 0.01$). Older age, lower educational attainment, and lower income were also associated with higher odds of tooth loss. (4) Conclusions: This study contributes further to the existing evidence of oral-systemic health link, showing that individuals with cardiovascular conditions are more likely to be edentulous.

Keywords: cardiovascular disease; endodontics; missing tooth; tooth loss; NHANES; Cross sectional study

1. Introduction

Oral diseases such as dental caries, periodontitis are the most prevalent oral conditions worldwide [1,2]. It It is one of the leading public health concerns because of their widespread presence and their significant contribution to the global disease burden, which significantly increased between 1990 and 2015 [1,2]. Despite the advancement in medical and dentistry, the outcome of oral conditions has not improved over the last three decades [2–4]. Oral conditions continue to be a persistent challenge to health systems in most countries [2–4]. The number of people suffering from untreated oral diseases rose from an estimated 2.5 billion people in 1990 to 3.5 billion people in 2015 [2–4].

Tooth loss, whether partial or complete, is a noncommunicable condition influenced by various biological, behavioral, and socioeconomic factors [5–7]. Tooth loss is a long-term indicator of one's lifetime experience with dental disease [5–8]. As stated earlier, tooth loss (full or partial) substantially increases chewing problems, resulting in the ingestion of a high-fat, low-fiber diet [9,10]. Physical

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pain, psychological distress, functional impairment, and diminished quality of life are some of the major consequences of tooth loss, all leading to considerable healthcare costs [9,10]. Moreover, evidence shows that the loss of multiple teeth has been associated with multiple systemic health outcomes and various chronic conditions [7,8]. These include hypertension [11], diabetes mellitus [12], peripheral arterial disease [13], cardiovascular and cerebrovascular diseases [14], heart failure, stroke, and mortality [15], angina pectoris [16], overweight and obesity [17], chronic kidney disease [18], chronic obstructive pulmonary disease [19], dementia [20], depression [21], cognitive decline [22], and certain malignancies such as liver [23] and pancreatic cancer [24], as well as with the presence of multi-morbidity, defined as the coexistence of two or more chronic conditions [25–27]. From an epidemiological perspective, it is estimated that between 60% and 80% of the elderly population are affected by at least one chronic condition [28]. The interplay between adverse oral conditions, age, and chronic illness is one of the most significant challenges facing healthcare systems worldwide, with high prevalence among older people [28].

With increasing life expectancy, the impact of poor oral health on the quality of life in older adults has become an important public health concern [29,30]. This issue is particularly critical in low- and middle-income countries, where the management of dental caries and periodontal diseases often relies on tooth extraction rather than preventive or restorative approaches [29,30].

Cardiovascular disease (CVD) and oral diseases are among the most prevalent chronic conditions globally, and both are a major public health and economic concern [31]. In 2018, the Centers for Disease Control and Prevention (CDC) estimated that CVD accounted for $147 billion in lost productivity in the United States, with total costs including morbidity and mortality, projected to reach $1.1 trillion by 2035 [31]. Cardiovascular disease account for nearly one-third of all global deaths, and over 800,000 Americans experience new or recurrent coronary events each year, according to the American Heart Association (AHA) [32,33].Emerging studies have reported a link between oral and cardiovascular health; however, existing studies have relied on small or region-specific samples, limiting the generalizability of their findings to broader populations. There are few studies that control for socioeconomic and demographic variables comprehensively while still showing an independent effect of CVD on complete edentulism [34–37]. In addition, it is unclear, based on current knowledge which of various CVD subtypes (e.g., CHF vs. stroke) are most positively associated with edentulism [38].

To address this gap, the present study aims to evaluate the association between cardiovascular disease and complete edentulism using data from the 2015-2018 National Health and Nutrition Examination Survey (NHANES), which provides clinically assessed dental measures and comprehensive demographic, behavioral, and health-related variables. We hypothesize that individuals with cardiovascular disease are more likely to be completely edentulous, potentially due to the influence of systemic and local inflammation.

2. Materials and Methods

2.1. Study Population

This cross-sectional study utilized data from the National Health and Nutrition Examination Survey (NHANES), a nationally representative program conducted by the Centers for Disease Control and Prevention (CDC) [39]. NHANES collects comprehensive health, nutritional, and dental data through structured interviews, surveys, clinical examinations, and laboratory investigations. The study population included adults aged 30 years and older from the 2015–2016 and 2017-2018 NHANES cycles. Inclusion criteria required participants to have complete data on tooth loss, cardiovascular disease (CVD) status, and other confounding covariates. Participants with missing data on these variables were excluded from the analysis. Since 1999, the NHANES has provided nationally representative data on health con- ditions, diseases, and associated risk factors in the U.S. This study employs a rigorous methodology, incorporating surveys, laboratory analyses, and clinical assessments to generate comprehensive public health insights [39]. A multistage, stratified, and

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clustered probability sampling strategy is used by NHANES, ensuring that the collected data are representative of the civilian, non-institutionalized U.S. population. NHANES (National Health and Nutrition Examination Survey) is a program conducted by the National Center for Health Statistics (NCHS) that collects data prospectively through standardized protocols during its cross-sectional survey cycle. All the participants signed written informed consent form. We analyzed already collected, publicly available data of 2015–2016 and 2017-2018 NHANES dataset and we used it as a secondary data. This study was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. The study analyzed publicly available NHANES data from 2017 to 2018 and was classified as non-human research, making it exempt from an International Review Board (IRB) review. Nationally representative estimates reflecting the broader U.S. population were obtained by applying survey weights and accounting for NHANES' complex sampling design.

2.2. Definition of the Dependent Variable: Complete tooth loss

The primary outcome variable in this study was complete edentulism, defined as the absence of all natural permanent teeth, including third molars. This variable was operationalized as a binary construct, with "0" indicating individuals with dentition and "1" indicating individuals with complete tooth loss. According to the American Association of Oral and Maxillofacial Surgeons (AAOMS), edentulism refers to the loss of one or more functional teeth and is typically classified as either partial or complete, depending on the extent of tooth loss; common causes include dental caries, periodontal disease, and trauma [40]. For the purposes of this analysis, only individuals with complete edentulism were classified as cases and compared to those with preserved dentition. This binary classification enabled the assessment of the relationship between complete edentulism and cardiovascular disease within a cross-sectional epidemiologic framework.

2.3. Description of Independent Variable: Cardiovascular diseases

CVD status was determined from self-reported physician diagnoses of coronary heart disease, heart attack (myocardial infarction), stroke and congestive heart failure. These conditions were analyzed individually and also grouped into a combined 'heart disease' category for broader analysis. CVD status was coded as a binary variable (Yes/No), with "Yes" assigned to individuals reporting at least one of the listed diagnoses, and "No" to those reporting none.

2.4. The Potential Confounding Variable

In this study, several demographic and health-related variables were categorized for analysis. These factors were adjusted for during the analysis. Age was grouped into 19–44, 45–59, and ≥60 years and was analyzed as a continuous variable. was classified as a binary variable (male or female) while race was treated as a nominal variable with categories including Non-Hispanic White, Non-Hispanic Black, Hispanic, Non-Hispanic Asian, and other races. Education level was divided into three categories: less than high school, high school/GED and more than high school education. Income level (ratio of family income to federal poverty level) as a categorical ordinal variable was categorized into <100%FPL, 100%-99%FPL, 200%-399%FPL, 400%+FPL.

Body mass index (BMI) was categorized into underweight, normal, overweight, obese and analyzed as categorical ordinal variable. Diabetes status was assessed using a single question, "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" and responses were categorized into two groups: "no" for no diabetes and "yes" or "borderline" for the presence of diabetes or pre-diabetes.

2.5. Statistical Methods

Statistical analysis was conducted using descriptive statistics to summarize the sample characteristics. To compare groups with and without tooth loss, chi-square tests were used for

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categorical variables, while t-tests were used for continuous variables. To assess the relationship between tooth loss and CVD, a weighted multivariate binary logistic regression model was utilized, adjusting for potential confounding factors such as age, sex, education, race, body mass index, income level and diabetes status. Logistic regression models were applied to estimate odds ratios (ORs) with 95% confidence intervals (CIs) for the association between tooth loss and CVD, adjusting for the identified confounders. A p-value of less than 0.05 was considered statistically positive. All statistical analyses were performed using STATA 17 software (StataCorp LLC, College Station, TX, USA).

3. Results

Table 1 summarizes the weighted characteristics of the study population by complete edentulism status. Of the 11,287 participants, 1,763 (15.62%) were completely edentulous. The proportion of complete tooth loss was higher among those with heart disease (1.76%) compared to those without (6.42%) ($P < 0.0001$). Participants with a history of myocardial infarction had a complete tooth loss rate of 0.78%, while the rate among those without was 7.42% ($P < 0.0001$). Those with coronary heart disease had a rate of 0.74% compared to 7.39% among those without ($P < 0.0001$). For individuals with congestive heart failure, the rate was 0.58%, while it was 7.61% among those without ($P < 0.0001$). Stroke was linked to an edentulism rate of 0.64%, compared to 7.61% in those without stroke ($P < 0.0001$). Gender distribution showed similar proportions: 6.65% in males and 6.78% in females ($P = 0.53$). Edentulism was highest among White participants (7.41%), followed by Black (6.70%), Hispanic (2.72%), Asian (2.10%), and Others (1.87%) ($P = 0.00017$). Age differences were observed, with higher rates among older age groups, ranging from 0.28% in participants aged 6–11 to 3.14% in those above 60 years ($P < 0.0001$). Participants with lower education levels (0–11 years) had an edentulism rate of 2.13%, compared to 1.35% among those with more than a high school education ($P < 0.0001$). Edentulism was most frequent in the lowest income group (<100% FPL) at 30.42%, and it decreased with higher income levels ($P < 0.0001$). Among BMI categories, edentulism was observed at 2.52% among obese individuals and 1.97% among those with normal BMI ($P < 0.0001$). Diabetes status showed an edentulism rate of 1.24% among participants with diabetes and 10.99% among those without, with no notable difference across groups ($P = 0.0976$).

Table 1. Descriptive summary of population characteristics.

Independent variable		With Dentition (n)	%	Complete Tooth Loss (n)	%	Total (n)
Heart Disease*	No heart disease	8,583	84.5	1,378	6.42	9,961
	Have heart disease	941	7.33	385	1.76	1,326
Heart Attack (Myocardial Infarction MI)	Yes	356	2.78	165	0.78	521
	No	9,155	89.06	1,593	7.42	10,748

 doi:10.20944/preprints202507.0145.v1

Coronary Heart Disease (CHF)	Yes	349	3.08	160	0.74	509	
	No	9,147	88.78	1,590	7.39	10,737	
Congestive Heart Failure (CHF)	Yes	271	1.8	144	0.58	415	
	No	9,229	90.02	1,616	7.61	10,845	
Stroke	Yes	346	2.37	136	0.64	482	
	No	9,167	89.46	1,624	7.52	10,791	
Gender	Male	6,963	42.21	2,486	6.65	9,449	0.53
	Female	7,329	44.36	2,447	6.78	9,776	
Race/Ethnicity	Hispanic	4,065	15.14	1,351	2.72	5,416	
	White	4,474	52.46	1,742	7.41	6,216	
	Black	3,221	10.22	1,023	1.67	4,244	
	Asian	1,747	4.83	463	0.75	2,210	
	Others	785	3.92	354	0.87	1,139	
Age in years at screening	Less than 6	165	0.5	2,815	6.91	2,980	
	11-Jun	2,234	7.52	213	0.28	2,447	
	18-Dec	2,111	9.29	121	0.15	2,232	
	19-44	4,345	32.54	455	1.38	4,800	
	45-59	2,376	18.66	339	1.56	2,715	
	Above 60	3,061	18.07	990	3.14	4,051	
Education level	0-11	1,931	10.8	550	2.13	2,481	
	HS/Ged	2,118	21.46	443	2.48	2,561	
	>HS	5,466	59.58	762	3.55	6,228	
Ratio of family	<100%FPL	2,889	69.58	1,263	30.42	4,152	
	100%-99%FPL	3,564	74.46	1,222	25.54	4,786	<0.0001
	200%-399%FPL	3,382	77.18	1,000	22.82	4,382	
	400%+FPL	2,886	79.68	736	20.32	3,622	
BMI	Underweight	1,877	7.61	1,288	4.39	3,165	
	normal	4,268	26.16	453	1.97	4,721	
	Overweight	3,648	24.58	409	2.09	4,057	

 doi:10.20944/preprints202507.0145.v1

	Obese	4,355	30.68	463	2.52	4,818
Diabetes	Yes	1,365	7.38	384	1.24	1,749
	No	12,647	78.54	3,737	10.99	16,384
	borderline	273	1.67	58	0.17	331

* Heart Disease includes one or more of the following: CHD, MI, CHF, and stroke.

Table 2 displays weighted logistic regression results for factors related to complete tooth loss. Participants with a history of myocardial infarction had higher odds of tooth loss (OR = 1.78; 95% CI: 1.27–2.49; P = 0.001), while sex was not associated (OR = 1.04; 95% CI: 0.86–1.26; P = 0.648). Compared to younger adults, odds were higher among those aged 45–59 (OR = 2.23; 95% CI: 1.61–3.09) and ≥60 (OR = 4.31; 95% CI: 2.88–6.46) (P < 0.001 for both). Odds were lower among those with a high school diploma/GED (OR = 0.64; 95% CI: 0.50–0.82; P = 0.001) and more than high school education (OR = 0.40; 95% CI: 0.31–0.50; P < 0.001) compared to those with less education. Compared to individuals <100% FPL, lower odds were observed in the 200–399% (OR = 0.54; 95% CI: 0.37–0.78; P = 0.002) and ≥400% (OR = 0.38; 95% CI: 0.25–0.57; P < 0.001) FPL groups. No difference was found for the 100–199% FPL group (OR = 0.92; 95% CI: 0.69–1.23; P = 0.592). Compared to Hispanic individuals, odds of tooth loss were higher among Non-Hispanic White (OR = 1.54; P = 0.027), Black (OR = 1.62; P = 0.010), Asian (OR = 1.99; P = 0.005), and Other racial/ethnic groups (OR = 2.50; P = 0.001). Diabetes was not associated with tooth loss, with odds ratios of 1.13 (diagnosed; P = 0.367) and 1.12 (borderline; P = 0.631).

Table 2. Multiple logistic regression model for the association between heart disease and tooth loss.

Covariate	Odds Ratio	95% Confidence Interval	P-value
Heart attack (Myocardial Infarction)	1.78	1.27- 2.49	0.001
Sex	1.04	0.86- 1.26	0.648
Age (45-59)	2.23	1.61- 3.09	<0.001
Age (Above 60)	4.31	2.88-6.46	<0.001
Education (HS/GED)	0.64	0.50-0.82	0.001
Education (>HS)	0.40	0.31- 0.50	<0.001
Poverty (100%-199% FPL)	0.92	0.69- 1.23	0.592
Poverty (200%-399% FPL)	0.54	0.37- 0.78	0.002
Poverty (400%+ FPL)	0.38	0.25- 0.57	<0.001
Race (Non-Hispanic White)	1.54	1.05-2.25	0.027
Rece (Non-Hispanic Black)	1.62	1.13-2.33	0.010
Race (Non-Hispanic Asian)	1.99	1.25- 3.18	0.005
Race (Other)	2.50	1.53-4.09	0.001
Diabetes (Yes)	1.13	0.85-1.49	0.367

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Diabetes (Borderline)	1.12	0.68- 1.83	0.631
BMI (Normal)	0.71	0.23- 2.18	0.545
BMI (Overweight)	0.84	0.26- 2.66	0.760
BMI (Obese)	0.74	0.24- 2.25	0.596

Table 3 presents the logistic regression results examining the association between heart disease (CHD, MI, CHF, or stroke) and complete tooth loss. Individuals with heart disease had higher odds of tooth loss (OR = 1.70; 95% CI: 1.35–2.14; P < 0.001). Sex was not associated (OR = 1.04; 95% CI: 0.86–1.25; P = 0.664). Participants aged 45–59 years had higher odds compared to younger individuals (OR = 2.19; 95% CI: 1.59–3.02; P < 0.001), and those aged 60 and above had even higher odds (OR = 4.06; 95% CI: 2.72–6.07; P < 0.001). For education, individuals with a high school diploma or GED had lower odds than those with less than high school education (OR = 0.65; 95% CI: 0.50–0.83; P = 0.001), and those with education beyond high school had even lower odds (OR = 0.40; 95% CI: 0.32–0.50; P < 0.001). Regarding income, participants in the 200–399% FPL group had lower odds than those in the <100% FPL category (OR = 0.54; 95% CI: 0.37–0.78; P = 0.002), as did those in the ⩾400% FPL group (OR = 0.38; 95% CI: 0.26–0.58; P < 0.001). The 100–199% FPL group showed no difference (OR = 0.92; 95% CI: 0.69–1.22; P = 0.566). Compared to Hispanic individuals, the odds of complete tooth loss were higher among Non-Hispanic White (OR = 1.49; 95% CI: 1.02–2.19; P = 0.039), Non-Hispanic Black (OR = 1.57; 95% CI: 1.09–2.26; P = 0.017), Non-Hispanic Asian (OR = 1.99; 95% CI: 1.24–3.19; P = 0.006), and Other race/ethnicities (OR = 2.45; 95% CI: 1.48–4.06; P = 0.001). Diabetes was not associated with tooth loss (OR = 1.08; 95% CI: 0.82–1.42; P = 0.558) nor was borderline diabetes (OR = 1.06; 95% CI: 0.65–1.74; P = 0.785). For BMI, compared to underweight participants, the odds were 0.71 for normal weight (95% CI: 0.23–2.18; P = 0.542), 0.83 for overweight (95% CI: 0.26–2.64; P = 0.747), and 0.73 for obese individuals (95% CI: 0.24–2.20; P = 0.574).

Table 3. Multiple logistic regression model for the association between heart disease and tooth loss.

Variable	Odds Ratio	95% Confidence Interval	P-value
Heart Disease*	1.70	1.35- 2.14	<0.001
Sex	1.04	0.86- 1.25	0.664
Age (45-59)	2.19	1.59- 3.02	<0.001
Age (Above 60)	4.06	2.72- 6.07	<0.001
Education (HS/GED)	0.65	0.50- 0.83	0.001
Education (>HS)	0.40	0.32- 0.50	<0.001
Poverty (100%-199% FPL)	0.92	0.69- 1.22	0.566
Poverty (200%-399% FPL)	0.54	0.37- 0.78	0.002
Poverty (400%+ FPL)	0.38	0.26- 0.58	<0.001
Race (White)	1.49	1.02- 2.19	0.039
Race (Black)	1.57	1.09- 2.26	0.017

 doi:10.20944/preprints202507.0145.v1

Race (Asian)	1.99	1.24-3.19	0.006
Race (Other)	2.45	1.48- 4.06	0.001
Diabetes (Yes)	1.08	0.82- 1.42	0.558
Diabetes (Borderline)	1.06	0.65- 1.74	0.785
BMI (Normal)	0.71	0.23- 2.18	0.542
BMI (Overweight)	0.83	0.26- 2.64	0.747
BMI (Obese)	0.73	0.24- 2.20	0.574

* Heart Disease includes one or more of the following: CHD, MI, CHF, and stroke.

Table 4 displays the logistic regression results for the association between coronary heart disease (CHD) and complete tooth loss. Participants with CHD had higher odds of tooth loss (OR = 1.60; 95% CI: 1.16–2.20; P = 0.005). No association was observed for sex (OR = 1.03; 95% CI: 0.85–1.24; P = 0.721). Compared to younger adults, those aged 45–59 years had higher odds (OR = 2.26; 95% CI: 1.63–3.12; P < 0.001) and those aged 60 and above showed even greater odds (OR = 4.35; 95% CI: 2.90–6.52; P < 0.001). Individuals with a high school diploma or GED had lower odds than those with less than high school education (OR = 0.66; 95% CI: 0.51–0.85; P = 0.003), and those with more than high school education had lower odds as well (OR = 0.40; 95% CI: 0.31–0.51; P < 0.001). Regarding income, participants in the 200–399% FPL range had lower odds than those in the <100% FPL group (OR = 0.53; 95% CI: 0.37–0.78; P = 0.002), as did those in the ⩾400% FPL category (OR = 0.37; 95% CI: 0.25–0.56; P < 0.001). The 100–199% FPL group showed no difference (OR = 0.93; 95% CI: 0.70–1.23; P = 0.617).Compared to Hispanics, higher odds were seen in Non-Hispanic White (OR = 1.52; 95% CI: 1.03–2.24; P = 0.035), Non-Hispanic Black (OR = 1.62; 95% CI: 1.13–2.34; P = 0.010), Non-Hispanic Asian (OR = 1.99; 95% CI: 1.25–3.17; P = 0.005), and Other racial/ethnic groups (OR = 2.55; 95% CI: 1.54–4.21; P = 0.001). Diabetes was not associated with complete tooth loss (OR = 1.13; 95% CI: 0.85–1.52; P = 0.365) nor was borderline diabetes (OR = 1.08; 95% CI: 0.65–1.78; P = 0.751).For BMI, odds were 0.71 among individuals with normal weight (95% CI: 0.23–2.17; P = 0.537), 0.82 among those overweight (95% CI: 0.25–2.61; P = 0.731), and 0.74 among those with obesity (95% CI: 0.24–2.25; P = 0.593) compared to underweight participants.

Table 4. Multiple logistic regression model for the association between coronary heart disease and tooth loss.

Variable	Odds Ratio	95% Confidence Interval	P-value
Coronary heart disease	1.60	1.16- 2.20	0.005
Sex	1.03	0.85- 1.24	0.721
Age (45-59)	2.26	1.63- 3.12	<0.001
Age (Above 60)	4.35	2.90- 6.52	<0.001
Education (HS/GED)	0.66	0.51- 0.85	0.003
Education (>HS)	0.40	0.31- 0.51	<0.001
Poverty (100%-199% FPL)	0.93	0.70- 1.23	0.617
Poverty (200%-399% FPL)	0.53	0.37- 0.78	0.002

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Poverty (400%+ FPL)	0.37	0.25- 0.56	<0.001
Race (Non-Hispanic White)	1.52	1.03- 2.24	0.035
Race (Non-Hispanic Black)	1.62	1.13- 2.34	0.010
Race (Non-Hispanic Asian)	1.99	1.25-3.17	0.005
Race (Other)	2.55	1.54- 4.21	0.001
Diabetes (Yes)	1.13	0.85- 1.52	0.365
Diabetes (Borderline)	1.08	0.65- 1.78	0.751
BMI (Normal)	0.71	0.23 2.17	0.537
BMI (Overweight)	0.82	0.25- 2.61	0.731
BMI (Obese)	0.74	0.24 2.25	0.593

Table 5 shows the logistic regression model examining the association between congestive heart failure (CHF) and complete tooth loss. Participants with CHF had higher odds of tooth loss (OR = 1.85; 95% CI: 1.29–2.67; P = 0.002). Sex showed no association (OR = 1.01; 95% CI: 0.84–1.23; P = 0.840). Compared to younger adults, odds were higher among those aged 45–59 years (OR = 2.26; 95% CI: 1.64–3.11; P < 0.001) and ⩾60 years (OR = 4.42; 95% CI: 2.92–6.68; P < 0.001). Those with a high school diploma or GED had lower odds of tooth loss than those with less education (OR = 0.64; 95% CI: 0.50–0.83; P = 0.001), and those with more than high school education had even lower odds (OR = 0.39; 95% CI: 0.31–0.50; P < 0.001). For income, individuals in the 200–399% FPL group had lower odds than those below 100% FPL (OR = 0.53; 95% CI: 0.37–0.78; P = 0.002), as did those in the ⩾400% FPL group (OR = 0.38; 95% CI: 0.25–0.57; P < 0.001). No difference was observed for the 100–199% FPL group (OR = 0.92; 95% CI: 0.69–1.22; P = 0.556). Compared to Hispanic individuals, odds of tooth loss were higher among Non-Hispanic White (OR = 1.54; 95% CI: 1.04–2.27; P = 0.029), Non-Hispanic Black (OR = 1.59; 95% CI: 1.10–2.30; P = 0.014), Non-Hispanic Asian (OR = 1.97; 95% CI: 1.23–3.15; P = 0.006), and Other racial groups (OR = 2.61; 95% CI: 1.58–4.32; P < 0.001). Diabetes was not associated with tooth loss (OR = 1.12; 95% CI: 0.84–1.50; P = 0.404) nor was borderline diabetes (OR = 1.06; 95% CI: 0.64–1.74; P = 0.814). For BMI, the odds were 0.71 for normal weight (95% CI: 0.23–2.21; P = 0.552), 0.83 for overweight (95% CI: 0.26–2.67; P = 0.751), and 0.74 for obese individuals (95% CI: 0.24–2.22; P = 0.581) compared to underweight participants.

Table 5. Multiple logistic regression model for the association between congestive heart failure and tooth loss.

Variable	Odds Ratio	95% Confidence Interval	P-value
Congestive HF	1.85	1.29- 2.67	0.002
Sex	1.01	0.84- 1.23	0.840
Age (45-59)	2.26	1.64- 3.11	<0.001
Age (Above 60)	4.42	2.92- 6.68	<0.001
Education (HS/GED)	0.64	0.50- 0.83	0.001
Education (>HS)	0.39	0.31- 0.50	<0.001

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Poverty (100%-199% FPL)	0.92	0.69- 1.22	0.556
Poverty (200%-399% FPL)	0.53	0.37- 0.78	0.002
Poverty (400%+ FPL)	0.38	0.25- 0.57	<0.001
Race (Non-Hispanic White)	1.54	1.04- 2.27	0.029
Race (Non-Hispanic Black)	1.59	1.10- 2.30	0.014
Race (Non-Hispanic Asian)	1.97	1.23- 3.15	0.006
Race (Other)	2.61	1.58- 4.32	<0.001
Diabetes (Yes)	1.12	0.84- 1.50	0.404
Diabetes (Borderline)	1.06	0.64- 1.74	0.814
BMI (Normal)	0.71	0.23- 2.21	0.552
BMI (Overweight)	0.83	0.26- 2.67	0.751
BMI (Obese)	0.74	0.24- 2.22	0.581

Table 6 presents regression results for the association between stroke and complete tooth loss. Participants with a history of stroke had higher odds of tooth loss (OR = 1.64; 95% CI: 1.17–2.29; P = 0.005), while sex was not associated (OR = 1.01; 95% CI: 0.84–1.23; P = 0.849).Compared to younger adults, odds were higher among those aged 45–59 years (OR = 2.26; 95% CI: 1.64–3.12; P < 0.001) and ⩾60 years (OR = 4.44; 95% CI: 2.95–6.69; P < 0.001). Participants with a high school diploma had lower odds than those with less education (OR = 0.64; 95% CI: 0.50–0.83; P <0.001), and those with education beyond high school had even lower odds (OR = 0.40; 95% CI: 0.31–0.50; P < 0.001). Lower odds were observed in the 200–399% FPL group (OR = 0.54; 95% CI: 0.37–0.78; P = 0.002) and the ⩾400% FPL group (OR = 0.38; 95% CI: 0.25–0.57; P < 0.001), with no difference in the 100–199% FPL group (OR = 0.92; 95% CI: 0.69–1.23; P = 0.601).Compared to Hispanic individuals, the odds of tooth loss were higher among Non-Hispanic White (OR = 1.55; 95% CI: 1.05–2.27; P = 0.027), Non-Hispanic Black (OR = 1.60; 95% CI: 1.11–2.32; P = 0.013), Non-Hispanic Asian (OR = 2.01; 95% CI: 1.26– 3.20; P = 0.005), and Other racial/ethnic groups (OR = 2.58; 95% CI: 1.56–4.29; P = 0.001). Diabetes was not associated with tooth loss (OR = 1.12; 95% CI: 0.85–1.49; P = 0.390), nor was borderline diabetes (OR = 1.06; 95% CI: 0.65–1.72; P = 0.787). For BMI, compared to underweight individuals, the odds of tooth loss were lower in the normal (OR = 0.68; 95% CI: 0.22–2.09; P = 0.499), overweight (OR = 0.80; 95% CI: 0.25–2.53; P = 0.698), and obese (OR = 0.72; 95% CI: 0.24–2.17; P = 0.557) categories.

Table 6. Multiple logistic regression model for the association between stroke and tooth loss.

Variable	Odds Ratio	95% Confidence Interval	P-value
Stroke	1.64	1.17- 2.29	0.005
Sex	1.01	0.84- 1.23	0.849
Age (45-59)	2.26	1.64- 3.12	<0.001
Age (Above 60)	4.44	2.95- 6.69	<0.001

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Education (HS/GED)	0.64	0.50- 0.83	<0.001
Education (>HS)	0.40	0.31- 0.50	<0.001
Poverty (100%-199% FPL)	0.92	0.69- 1.23	0.601
Poverty (200%-399% FPL)	0.54	0.37- 0.78	0.002
Poverty (400%+ FPL)	0.38	0.25- 0.57	<0.001
Race (Non-Hispanic White)	1.55	1.05- 2.27	0.027
Race (Non-Hispanic Black)	1.60	1.11- 2.32	0.013
Race (Non-Hispanic Asian)	2.01	1.26- 3.20	0.005
Race (Other)	2.58	1.56- 4.29	0.001
Diabetes (Yes)	1.12	0.85- 1.49	0.390
Diabetes (Borderline)	1.06	0.65- 1.72	0.787
BMI (Normal)	0.68	0.22- 2.09	0.499
BMI (Overweight)	0.80	0.25- 2.53	0.698
BMI (Obese)	0.72	0.24- 2.17	0.557

4. Discussion

The present study investigated the association between cardiovascular disease and tooth loss in a large, nationally representative sample of U.S adults. Our analysis demonstrated a positive association between complete tooth loss and all major types of cardiovascular disease, including heart attack, coronary heart disease, stroke, and congestive heart failure. Congestive heart disease was found to have the strongest association with tooth loss. This study is among the few that have comprehensively examined the association between complete edentulism and various cardiovascular disease subtypes within a U.S. population, while accounting for a wide range of demographic and health-related confounders. A cross-sectional study in (2021) conducted a population-based survey in older Mexican adults support our findings of the association between complete edentulism and chronic diseases, including cardiovascular and cerebrovascular events [41]. Additionally, a case control study in (2022) reported that patients under 70 years old who had experienced myocardial infarction showed positively higher rates of edentulism, implicating tooth loss as a correlate of cardiovascular pathology [42]. Furthermore, a 7-Year follow-up prospective single cohort study in (2024) examined cardiovascular patients undergoing full-arch implant-prosthetic rehabilitation and noted the high prevalence of edentulism in this group, framing it within the broader context of systemic health [43].

One of the potential mechanisms underlying this association is the presence of chronic low-grade systemic inflammation (termed “inflammaging”, a defining feature shared by both periodontitis and atherosclerosis [44]. Inflammatory mediators such as acute-phase proteins, pro-inflammatory cytokines (e.g., TNF-α, IFN-γ IL-1β, IL-6, IL-2), C-reactive protein (CRP) and elevated leukocyte counts are often elevated in both conditions [44–46]. These immune signals contribute not only to vascular dysfunction but also to periodontal tissue breakdown, which highlight inflammation as a common pathway in the pathophysiology of both diseases [44–46]. In patients with CVD, these pro-inflammatory mediators are often upregulated due to endothelial dysfunction, lipid oxidation,

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and immune activation [44–46]. Once released into the bloodstream, these cytokines, such as IFN-γ, TNF-α, and interleukins, can disrupt host-microbial homeostasis at distant sites, including the periodontium [44–46]. This disruption triggers exaggerated immune responses to oral pathogens, heightening local inflammation in the gingival tissues [44–46]. As this inflammatory cascade progresses, it stimulates the release of tissue-destructive enzymes and signaling molecules such as matrix metalloproteinases (MMPs), reactive oxygen species (ROS), and receptor activator of nuclear factor kappa-B ligand (RANKL) [47,48]. These mediators collectively drive the degradation of connective tissue and alveolar bone, weakening the periodontium and increasing vulnerability to attachment loss and eventual tooth loss [47,48].

Moreover, individuals with CVD often show signs of immune dysregulation [49,50]. Neutrophil chemotaxis, phagocytic capacity, and oxidative burst, key components of innate immunity, are often impaired [51,52]. These changes reduce the body's ability to clear pathogenic biofilms from the gingival sulcus [51,52]. Meanwhile, macrophages tend to shift toward a pro-inflammatory M1 phenotype, sustaining cytokine release without effective resolution of inflammation [53]. T-cell regulation is also disturbed, with a decline in regulatory T-cell activity and a rise in senescent CD8+ T cells, which amplify the inflammatory burden in periodontal tissues [54].

Beyond inflammatory pathways, vascular health plays a key role in oral outcomes [55,56]. CVD is often associated with impaired vascular perfusion and endothelial damage, which can reduce blood flow to the gingiva and periodontal structures [55,57]. This limited circulation restricts oxygen and nutrient delivery, delaying tissue repair and compromising healing [55,57]. As a result, the periodontium becomes more vulnerable to breakdown, setting the stage for tooth loss [55,57].

In contrast, periodontal pathogens are known to trigger platelet aggregation, a critical step in thrombus formation, which can worsen atherosclerotic lesions [58–61]. This pro-thrombotic potential adds a further risk to systemic health [58–61]. Additionally, tooth loss itself has been correlated with non-invasive markers of subclinical atherosclerosis, including carotid artery wall thickening, arterial stenosis, and plaque formation [58–62]. These vascular changes reflect the far-reaching consequences of oral disease on systemic health [58–62].

It is worth noting that pharmacologic management of cardiovascular disease (CVD) commonly involves the long-term use of medications such as antihypertensives (e.g., calcium channel blockers, ACE inhibitors), beta-adrenergic blockers, and diuretics [63,64]. While these medications are essential for controlling blood pressure and preventing cardiovascular events, they often induce xerostomia (dry mouth), either through anticholinergic activity or diuretic-induced dehydration [63,64]. Saliva plays a vital role in buffering oral pH, modulating microbial flora, supporting mechanical cleansing [65]. When salivary flow is reduced, especially over time, oral self-cleansing becomes impaired [66]. This enhances bacterial colonization and plaque accumulation along the gingival margins, particularly by pathologic species such as Porphyromonas gingivalis and Aggregatibacter actinomycetemcomitans [66]. As a result, these conditions promote periodontal inflammation, enamel demineralization, and clinical attachment loss [67].

Evidence has shown that access to dental care significantly influences oral health outcomes [68,69]. Patients with chronic cardiovascular conditions often face barriers to maintaining regular oral healthcare [68,69]. These may include physical limitations, financial burdens, completing health priorities, or medication burdens [68,69]. In such contexts, oral hygiene routines may decline, which may contribute to the accumulation of dental plaque and the progression of periodontal disease [68,69]. In addition, behavioral risk factors such as smoking, infrequent dental visits, or inadequate hygiene can compound these challenges, accelerating the pathway toward edentulism [70].

Furthermore, emerging evidence supports a strong association between oral infections and systemic diseases, with invasive oral pathogens playing a key role in triggering systemic inflammatory responses through the release of mediators [71]. This connection is particularly relevant for individuals with chronic conditions like cardiovascular disease (CVD), where biological and immunological changes may amplify the risk of oral deterioration, including tooth loss [71].

 doi:10.20944/preprints202507.0145.v1

Collectively, this evidence highlights a multifactorial and synergistic relationship between cardiovascular disease and oral health decline. Shared inflammatory pathways, impaired immune responses, compromised vascular function, medication side effects, and behavioral determinants all interact to increase susceptibility to complete tooth loss in individuals with CVD. Recognizing these overlapping mechanisms emphasizes the need for integrated medical-dental care models, especially for individuals managing chronic systemic diseases.

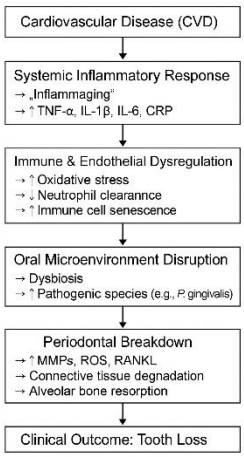

Figure 1. Proposed pathway illustrating the inflammatory and immunological mechanisms linking cardiovascular disease to tooth loss.

4.1. Limitation of Research

Despite its strengths, this study has several limitations that should be acknowledged. First, its cross-sectional design precludes any determination of causality between cardiovascular disease and complete edentulism. The directionality of the association stays uncertain, and longitudinal studies are necessary to confirm temporal relationships. Second, although the analysis adjusted for multiple confounders, the possibility of residual confounding cannot be entirely excluded, especially for factors such as smoking history, medication use, or oral hygiene practices, which were not fully accounted for in this dataset. Third, cardiovascular disease status was self-reported, which may introduce recall bias or misclassification. Finally, while NHANES includes clinical dental assessments, it does not capture the specific causes of tooth loss, such as trauma versus periodontal disease, which may influence the interpretation of the observed associations.

This study has several noteworthy strengths. The use of data from the National Health and Nutrition Examination Survey (NHANES) enhances the study's external validity, as NHANES employs a large, nationally representative sample of U.S. adults and includes both clinical dental assessments and self-reported cardiovascular outcomes. Additionally, the study evaluates multiple subtypes of cardiovascular disease (heart attack, coronary heart disease, congestive heart failure, and stroke), allowing for a more detailed understanding of how various forms of CVD are associated with complete tooth loss. Moreover, the analysis incorporates comprehensive adjustment for demographic, socioeconomic, and health-related confounders.

4.2. Future Perspectives

Future research should aim to build upon these findings by utilizing longitudinal study designs to better determine causal relationships between cardiovascular disease and edentulism. Prospective cohort studies could help determine the temporal sequence and clarify whether tooth loss contributes to cardiovascular risk, or vice versa. In addition, future analyses should incorporate biomarkers of inflammation, detailed oral health histories, and objective cardiovascular assessments to explore the underlying biological mechanisms more precisely. Including variables such as smoking status, oral hygiene behaviors, access to dental care, and medication use would provide a more comprehensive

 doi:10.20944/preprints202507.0145.v1

understanding of the multifactorial relationship between oral and systemic health. From a clinical standpoint, interdisciplinary strategies that integrate dental evaluations into cardiovascular risk assessments could enhance early identification of at-risk individuals. Public health policies should also emphasize the importance of maintaining oral health as a preventive measure against systemic diseases, particularly among underserved and aging populations.

5. Conclusion

This study demonstrates a positive association between cardiovascular disease and complete edentulism among U.S. adults. Individuals with congestive heart failure had higher likelihood of complete edentulism. These findings are consistent with the growing body of evidence supporting association between oral and cardiovascular disease through common biologic pathways, such as chronic inflammation, immune dysregulation, and endothelial dysfunction. Recognizing edentulism not only as a dental outcome but also as a potential marker of systemic disease burden may enhance both clinical and public health strategies.

For clinicians, these results emphasize the value of including oral health assessments, particularly edentulism, in comprehensive evaluations of cardiovascular risk. Early referral to dental care providers could aid in prevention and promote holistic care. For policy makers, the findings highlight the urgent need to incorporate oral health into national chronic disease prevention frameworks. Expanding access to dental services for high-risk groups, such as older adults and low-income populations, may reduce the dual burden of tooth loss and cardiovascular disease. While this study focused on CVD as a predictor, the bidirectional interplay between oral and systemic health warrants ongoing investigation. Finally, interdisciplinary collaboration and greater investment in preventive oral care may play a fundamental role in improving overall population health.

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Informed Consent Statement: Not applicable.

Data Availability Statement: The data used in this article are publicly available and can be found at the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics: National Health and Nutrition Examination Survey (NHANES) Questionnaires, Datasets, and Related Documentation, available at the following website: Accessed December 4, 2023

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