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TOOTH SPECIFIC SURVIVAL ACROSS THE LIFESPAN: MAPPING THE NATURAL HISTORY OF PERMANENT DENTITION USING POPULATION-LEVEL DENTAL EXAMINATION DATA

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ABSTRACT

Background: Permanent teeth do not share a common life-course trajectory. Eruption timing, morphology, caries susceptibility, periodontal loading, restorative history, and clinical treatment decisions differ by tooth position. Medication burden may add a further layer of risk through salivary dysfunction and multimorbidity, yet population studies usually reduce dentition to a single tooth count.

Objective: To map age-specific retention of individual permanent teeth in U.S. adults and examine whether prescription-medication burden and a pragmatic xerogenic medication proxy are associated with natural-tooth retention.

Methods: We analyzed NHANES 2017–2018 dentition, demographic, prescription-medication, smoking, diabetes, medical-condition, and oral-health data. Adults aged ≥20 years with a completed dentition examination and positive MEC examination weight were included (n = 5,057). The primary dentition comprised 28 permanent teeth, excluding third molars. Natural retention was defined as a permanent natural tooth present; implants, absent teeth, and root fragments were classified as non-retained. Survey-weighted estimates incorporated MEC weights, strata, and primary sampling units. Fully adjusted models included age, age squared, sex, race/ethnicity, education, family income-to-poverty ratio, smoking status, diagnosed diabetes, multimorbidity, and dental-attendance recency. Medication exposure was modeled as 0, 1–4, and ≥5 prescriptions and as a continuous count; secondary analyses used a prespecified name-based proxy for potentially xerogenic prescription exposure.

Results: The survey-weighted mean age was 48.3 years; 51.9% were women. Participants retained a mean 23.30 of 28 natural teeth (95% CI, 22.83–23.76), 83.3% had ≥20 natural teeth, and 4.9% had none of the 28 teeth. Retention was highest for mandibular canines and lowest for mandibular first molars. Polypharmacy (≥5 prescriptions) was present in 17.0%. In the demographic and socioeconomic model, polypharmacy was associated with fewer retained teeth; however, after additional adjustment for smoking status, diagnosed diabetes, multimorbidity, and recency of dental attendance, the association was markedly attenuated (adjusted difference, −0.37 teeth; 95% CI, −1.58 to 0.84; $p = 0.527$). Medication count was likewise not associated with retained-tooth count in the fully adjusted model (−0.04 teeth per additional prescription; 95% CI, −0.17 to 0.09; $p = 0.493$). A burden of ≥2 pragmatic xerogenic-proxy medications showed borderline evidence for fewer retained teeth (−0.71; 95% CI, −1.44 to 0.01; $p = 0.054$), but not for functional dentition. No tooth-specific polypharmacy association survived false-discovery-rate correction.

Conclusions: Retention differed substantially by tooth position and age, with molars showing earlier population loss than anterior teeth. Apparent associations between medication burden and tooth retention were substantially reduced after accounting for smoking, diabetes, multimorbidity, and dental-care recency, suggesting that health status and related confounding explain an important part of the medication–dentition relationship. Tooth-specific mapping remains clinically informative, while medication effects require longitudinal designs with stronger exposure measurement.

KEYWORDS: tooth retention; tooth loss; permanent dentition; NHANES; polypharmacy; xerostomia; pharmacoepidemiology; dental public health

1. INTRODUCTION

Tooth loss is often treated as a single endpoint, but permanent teeth are not epidemiologically interchangeable. First molars erupt early, accumulate decades of caries and restorative exposure, and carry substantial occlusal

loads; canines and incisors follow different clinical trajectories. Counts of remaining teeth are useful for describing functional dentition and edentulism, but they obscure this anatomical variation. [1, 2, 3, 4]

A life-course perspective is particularly relevant because tooth loss reflects accumulated biological, behavioral, social, and treatment processes rather than a single disease event. Longitudinal studies and recent life-course synthesis link tooth loss with socioeconomic disadvantage, smoking, oral-health behaviors, dental attendance, chronic disease, and earlier caries experience. [5, 6, 7, 25]

Medication exposure may modify this pathway. Many commonly used medicines can reduce salivary secretion or contribute to dry mouth through anticholinergic, sympatholytic, central nervous system, diuretic, and other mechanisms. [8, 9, 10, 11, 12] Saliva buffers acids, supports remineralization, lubricates oral tissues, assists swallowing, and contributes to microbial homeostasis; persistent salivary dysfunction can therefore increase susceptibility to caries and other oral complications. [17, 18, 19, 20]

The epidemiology is complicated by confounding because polypharmacy rises steeply with age and multimorbidity, while the conditions that prompt prescribing may themselves be related to oral health. Recent reviews nevertheless show a fairly consistent association between medication burden and xerostomia or hyposalivation, whereas evidence for tooth number and edentulism is less consistent. [26, 27, 30, 38] Register-based evidence also indicates that several xerogenic medication categories are associated with subsequent extraction or restorative procedures. [29]

NHANES provides the tooth-level examination data needed for this analysis. Calibrated dental examiners record the status of each tooth, and the prescription files contain past-month medication use, medication counts, and generic drug names. Population estimates were calculated using the examination weights, strata, and primary sampling units specified for the survey design. 13, 14, 15, 33

We addressed three questions. We first described retention of each of the 28 non-third-molar permanent teeth across adult age groups. We then tested the association of prescription burden with total tooth count and functional dentition using sequential adjustment for demographic, socioeconomic, behavioral, and health-related factors. Finally, we examined a pragmatic proxy for potentially xerogenic medication burden and selected therapeutic groups. Because NHANES is cross-sectional and does not record when a tooth was lost, the age patterns reported here are population profiles rather than prospective tooth-level survival estimates.

2. MATERIALS AND METHODS

2.1 Data source and study population

We performed a secondary analysis of the publicly available NHANES 2017–2018 cycle. Seven participant-level modules were linked: Oral Health–Dentition (OHXDEN_J), Demographics (DEMO_J), Prescription Medications (RXQ_RX_J), Smoking–Cigarette Use (SMQ_J), Diabetes (DIQ_J), Medical Conditions (MCQ_J), and Oral Health Questionnaire (OHQ_J). The oral examination was conducted in mobile examination centers by trained dental examiners using standardized protocols. Prescription-medication information referred to medicines used during the preceding 30 days and was collected during the household interview. [13, 14, 32, 33, 34, 35, 36]

Files were linked by respondent sequence number (SEQN). Adults aged ≥20 years were eligible for the primary analysis if they had completed dentition status and a positive MEC examination weight, yielding 5,057 participants. Models requiring education and family income-to-poverty ratio included 4,398 adults in the core adjustment set. After addition of smoking, diabetes, multimorbidity, and dental-attendance variables, the fully adjusted complete-case sample comprised 4,292 adults.

2.2 Tooth-specific outcomes

The primary dentition comprised Universal tooth numbers #2–15 and #18–31. Third molars were excluded a priori because congenital absence, impaction, and prophylactic removal make non-retention etiologically different from loss of other permanent teeth. For each tooth, NHANES coding distinguishes a permanent natural tooth, implant, absent tooth, root fragment, primary tooth, and unassessable status. [13]

Natural-tooth retention was coded 1 when the permanent tooth was present. Implants, absent teeth, and permanent root fragments were coded 0 because none represents survival of the original functional natural tooth. Primary teeth and unassessable observations were excluded from the relevant tooth-specific denominator. Participant-level secondary outcomes were the number of natural teeth among the 28 positions, functional dentition (≥20 natural teeth), and complete non-retention of all 28 positions.

2.3 Medication exposure

The NHANES prescription file has one record per reported prescription product for participants using medication. We collapsed these records to one row per participant. RXDCOUNT was used as the principal medication-count measure; participants reporting no past-month prescription use were assigned a count of zero. Medication burden was analyzed as 0, 1–4, and ≥5 prescriptions, with ≥5 representing polypharmacy, and as a continuous count. [14]

For a secondary pharmacological analysis, generic drug names were used to construct a prespecified pragmatic proxy for medicines commonly associated with xerostomia or salivary effects. The proxy included antidepressant and other psychotropic agents, urological antimuscarinics, selected antihistamines, diuretics, and centrally acting muscle relaxants represented in the NHANES prescription file. Exposure was summarized as 0, 1, or ≥2 such prescriptions. This is not a validated anticholinergic-burden scale and was therefore treated as an exploratory mechanistic proxy rather than a definitive pharmacological classification. [8, 9, 26, 28]

2.4 Covariates and causal framework

Covariates were selected a priori from the conceptual framework. The core adjustment set comprised age, sex, race/ethnicity, education, and family income-to-poverty ratio. Age was modeled in centered decade units with a quadratic term. Extended models additionally included cigarette-smoking status (never, former, current), self-reported physician-diagnosed diabetes, multimorbidity, and recency of dental attendance. Multimorbidity was summarized as 0, 1, or ≥2 self-reported chronic conditions from the NHANES Medical Conditions questionnaire, excluding diabetes because it was modeled separately. Dental attendance was classified as within the previous year versus >1 year ago or never. [34, 35, 36, 37]

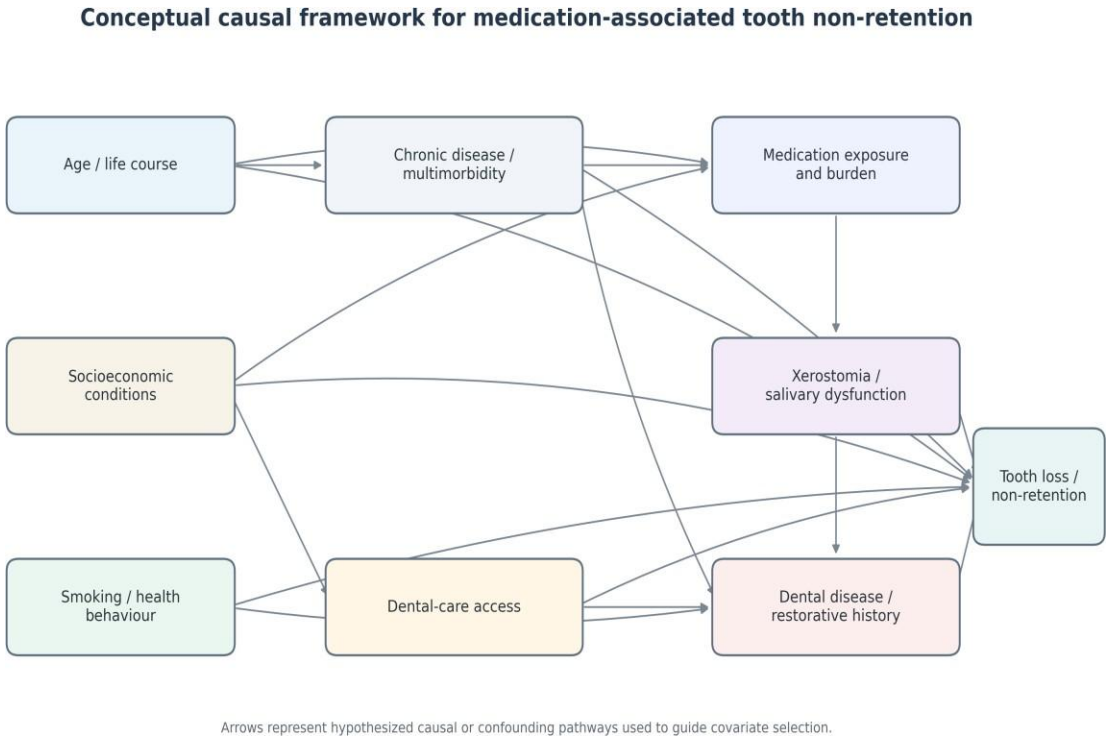


Figure 1. Conceptual causal framework for medication-associated tooth non-retention.

2.5 Statistical analysis

All descriptive population estimates used the 2-year MEC examination weight (WTMEC2YR) and accounted for NHANES masked variance strata (SDMVSTRA) and primary sampling units (SDMVPSU). Standard errors for weighted proportions and means were obtained by Taylor linearization at the stratum-PSU level.

Tooth-specific retention was estimated overall and within six age groups (20–29, 30–39, 40–49, 50–59, 60–69, and 70–80 years). Teeth were also aggregated into incisors, canines, premolars, first molars, and second molars. Weighted generalized linear models were fitted for medication analyses. Linear identity-link models were used for retained-tooth count, and logistic models for functional dentition and individual-tooth retention. The regression variance estimator used a design-based sandwich matrix formed from weighted score contributions aggregated within PSU and stratum.

Medication models were estimated sequentially. Model 1 adjusted for age, age squared, sex, race/ethnicity, education, and income-to-poverty ratio. Model 2 additionally adjusted for smoking status, diagnosed diabetes, multimorbidity, and dental-attendance recency and was treated as the principal confounding-adjusted analysis. Continuous medication count assessed dose-response. The same extended adjustment set was applied to xerogenic-proxy, therapeutic-group, and individual-tooth analyses. For the 28 individual-tooth polypharmacy tests, Benjamini–Hochberg false-discovery-rate adjustment was applied; two-sided $p < 0.05$ defined statistical significance. Analyses were performed in Python using pandas, NumPy, SciPy, statsmodels, and custom design-based variance functions.

NHANES public-use data are de-identified. The parent survey obtained ethics approval and participant consent under NCHS procedures. Reporting follows the principles of STROBE for cross-sectional observational studies. [16]

3. RESULTS

3.1 Analytic sample and overall dentition

The analytic sample included 5,057 adults aged 20–80 years. The survey-weighted mean age was 48.3 years (SE 0.55), and 51.9% (95% CI 50.2–53.6%) were women. Past-month prescription medication use was reported by

58.5% (95% CI 55.3–61.7%), while 17.0% (95% CI 15.1–18.9%) met the ≥5-medication definition of polypharmacy.

Adults retained a survey-weighted mean of 23.30 natural teeth among the 28 non-third-molar positions (95% CI 22.83–23.76). Functional dentition was present in 83.3% (95% CI 81.2–85.5%), whereas 4.9% (95% CI 3.8–6.1%) had none of the 28 natural teeth.

Table 1. Survey-weighted characteristics of the analytic sample

Characteristic	Estimate	95% CI
Participants, unweighted n	5,057	—
Age, years	48.3	47.2–49.4
Women, %	51.9	50.2–53.6
Any prescription medication, %	58.5	55.3–61.7
Polypharmacy (≥5 prescriptions), %	17.0	15.1–18.9
Natural teeth retained, mean of 28	23.30	22.83–23.76
Functional dentition (≥20 teeth), %	83.3	81.2–85.5
No natural teeth among 28 positions, %	4.9	3.8–6.1
Any pragmatic xerogenic-proxy medication, %	26.1	23.9–28.3
Any psychotropic-proxy medication, %	16.5	14.7–18.3
Any diuretic, %	10.6	9.4–11.8

3.2 Tooth-specific retention across age

Retention varied substantially by tooth position. The mandibular canines were the most consistently retained teeth: #27 was present in 93.7% and #22 in 93.4% of the target population. The mandibular first molars were the least retained: #30, 71.3%, and #19, 71.4%. Maxillary second molars and first molars also ranked among the least retained positions. The dental-arch map shows that posterior teeth were less often retained than anterior teeth.

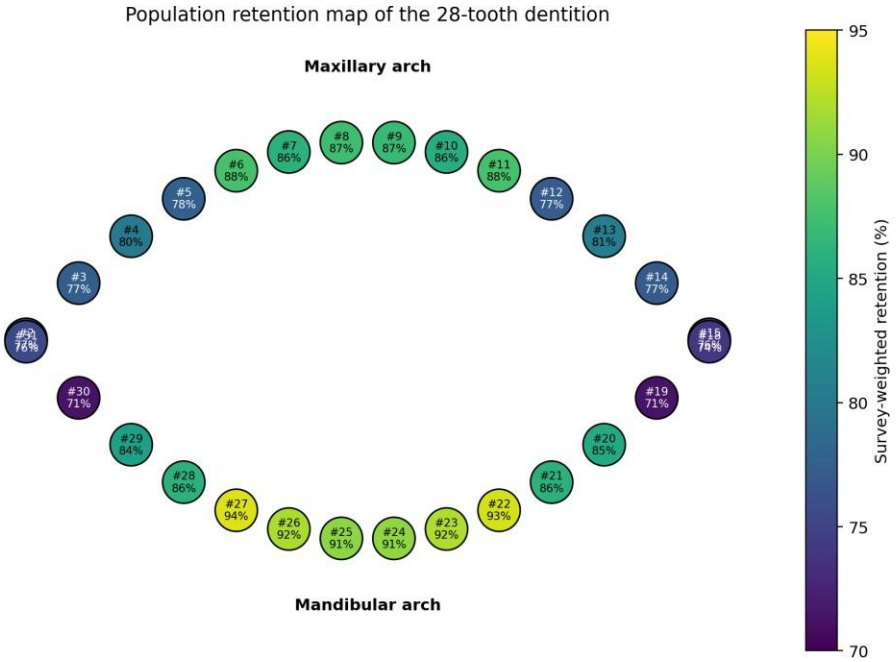


Figure 2. Population retention map of the 28-tooth dentition. Percentages are survey-weighted; third molars are excluded.

Age gradients were pronounced and anatomically ordered. First-molar retention decreased from 95.7% at ages 20–29 to 88.6% at 30–39, 80.7% at 40–49, 67.2% at 50–59, 55.1% at 60–69, and 50.8% at 70–80. Second molars followed a similar trajectory, falling from 95.9% to 50.1%. In contrast, canine retention remained above 90% through ages 50–59 and was still 73.9% at ages 70–80. Incisors declined from 99.1% to 69.6% across the same age span.

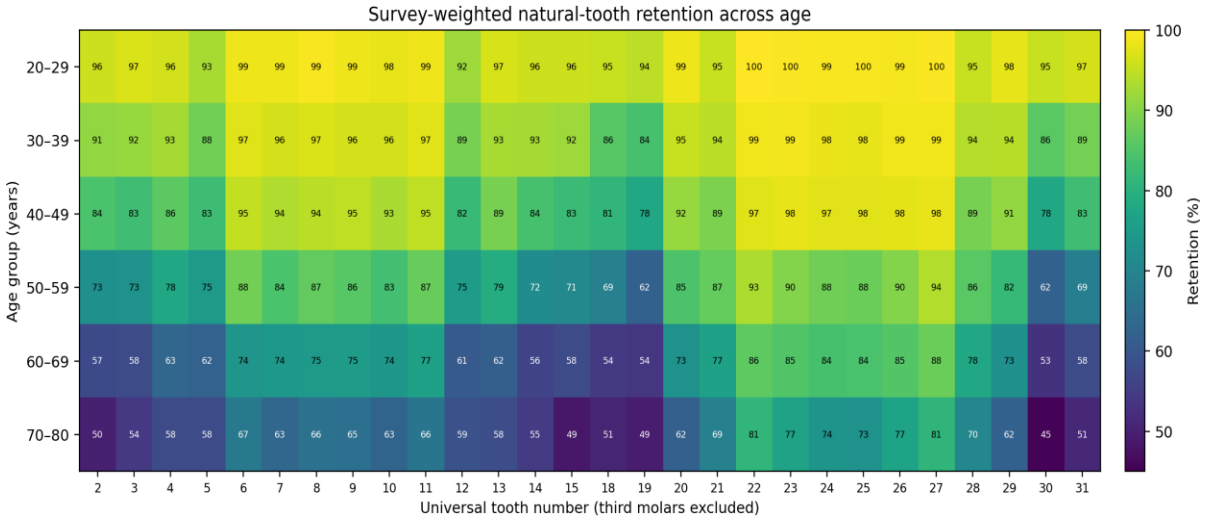


Figure 3. Survey-weighted natural-tooth retention by age group and Universal tooth number.

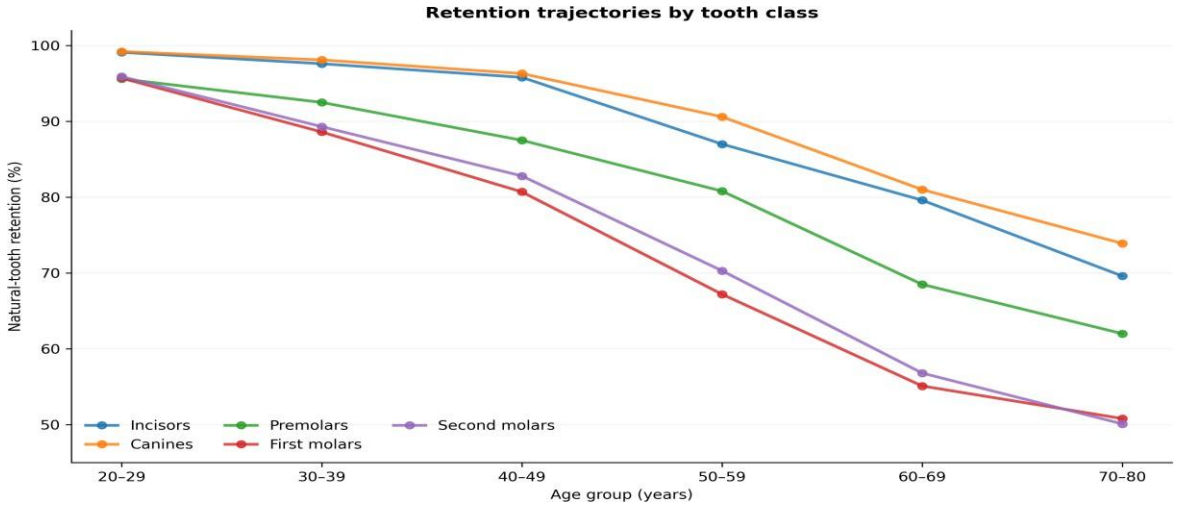


Figure 4. Retention trajectories by tooth class.

Table 2. Survey-weighted retention by tooth class and age group (%)

Age	Incisors	Canines	Premolars	First molars	Second molars
20–29	99.1	99.2	95.6	95.7	95.9
30–39	97.6	98.1	92.5	88.6	89.3
40–49	95.8	96.3	87.5	80.7	82.8
50–59	87.0	90.6	80.8	67.2	70.3
60–69	79.6	81.0	68.5	55.1	56.8
70–80	69.6	73.9	62.0	50.8	50.1

3.3 Medication burden and dentition

In the core demographic and socioeconomic model, adults using ≥5 prescriptions retained 1.27 fewer teeth than nonusers (95% CI, −2.37 to −0.16; p = 0.027). After further adjustment for smoking, diagnosed diabetes,

multimorbidity, and dental-attendance recency, this estimate was substantially attenuated and no longer statistically significant (adjusted difference, −0.37 teeth; 95% CI, −1.58 to 0.84; $p = 0.527$). Adults using 1–4 prescriptions also did not differ from nonusers in the fully adjusted model (+0.11 teeth; 95% CI, −0.47 to 0.70; $p = 0.684$).

The earlier dose-response pattern also disappeared after extended adjustment. Each additional prescription was associated with −0.04 retained teeth (95% CI, −0.17 to 0.09; $p = 0.493$). For functional dentition, polypharmacy versus no prescription use was not associated with the odds of retaining ≥20 natural teeth (OR, 0.93; 95% CI, 0.50–1.76; $p = 0.819$), and the continuous medication-count estimate was similarly null (OR per additional prescription, 1.007; 95% CI, 0.963–1.054; $p = 0.734$).

Table 3. Adjusted associations between medication exposure and dental outcomes

Exposure	Outcome	Fully adjusted effect	95% CI	p
1–4 prescriptions vs 0	Number of natural teeth	+0.11 teeth	−0.47 to +0.70	0.684
≥5 prescriptions vs 0	Number of natural teeth	−0.37 teeth	−1.58 to +0.84	0.527
Each additional prescription	Number of natural teeth	−0.04 teeth	−0.17 to +0.09	0.493
≥5 prescriptions vs 0	Functional dentition	OR 0.93	0.50–1.76	0.819
Each additional prescription	Functional dentition	OR 1.007	0.963–1.054	0.734
1 xerogenic-proxy drug vs 0	Number of natural teeth	−0.20 teeth	−0.99 to +0.59	0.601
≥2 xerogenic-proxy drugs vs 0	Number of natural teeth	−0.71 teeth	−1.44 to +0.01	0.054
≥2 xerogenic-proxy drugs vs 0	Functional dentition	OR 0.80	0.53–1.20	0.261

Fully adjusted models include age, age squared, sex, race/ethnicity, education, family income-to-poverty ratio, smoking status, diagnosed diabetes, multimorbidity, and dental-attendance recency. OR indicates odds ratio.

3.4 Tooth-specific medication associations and multiplicity

At the individual-tooth level, none of the fully adjusted polypharmacy associations reached conventional statistical significance. The smallest nominal p value was 0.212 (tooth #15; OR, 0.76; 95% CI, 0.49–1.19), and the smallest Benjamini–Hochberg false-discovery-rate adjusted q value was 0.937. Thus, the extended models provide no evidence that polypharmacy is associated with loss of a particular tooth position.

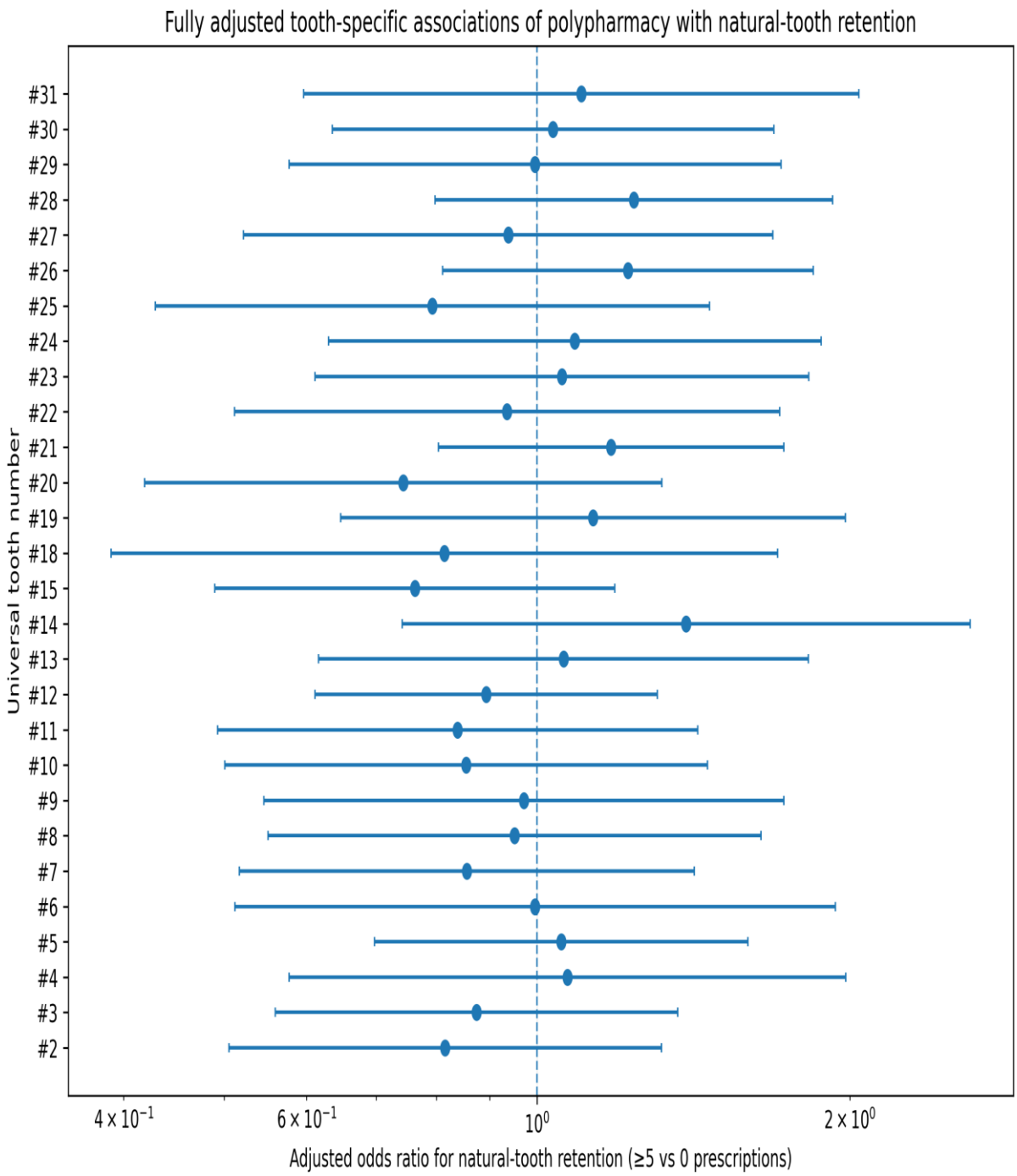


Figure 5. Fully adjusted tooth-specific odds ratios for natural-tooth retention comparing ≥5 prescriptions with no prescription use. Models adjust for age, age squared, sex, race/ethnicity, education, income-to-poverty ratio, smoking status, diabetes, multimorbidity, and dental-attendance recency.

3.5 Exploratory pharmacological group analyses

The pragmatic xerogenic proxy identified approximately one quarter of adults as using at least one potentially xerogenic prescription. After full confounding adjustment, one proxy medication was not associated with retained-tooth count (−0.20 teeth; 95% CI, −0.99 to 0.59; $p = 0.601$). Exposure to ≥2 proxy medications was associated with 0.71 fewer teeth, but the confidence interval included the null (95% CI, −1.44 to 0.01; $p = 0.054$). The corresponding association with functional dentition was also not statistically significant (OR, 0.80; 95% CI, 0.53–1.20; $p = 0.261$).

None of the prespecified exploratory medication groupings remained statistically significant after extended adjustment. Psychotropic exposure was associated with −0.31 retained teeth ($p = 0.432$), diuretic exposure with −0.02 teeth ($p = 0.961$), and the antihistamine proxy with −1.67 teeth ($p = 0.075$). Centrally acting muscle relaxants showed a similarly imprecise association (−1.81 teeth; $p = 0.068$). These analyses remain exploratory because therapeutic groups were generated from generic-name rules and some medication classes were uncommon.

4. DISCUSSION

The permanent dentition showed a clear anatomical pattern of retention. The age pattern differed by tooth position: posterior tooth retention declined more sharply than anterior tooth retention. By ages 70–80 years, only about half of first and second molars remained, compared with nearly three quarters of canines. This contrast is clinically plausible because molars erupt earlier, have complex occlusal anatomy, bear substantial functional loads, and commonly enter repeated restorative cycles. These differences are obscured when dentition is summarized only as a total tooth count. 5, 6, 24

The overall estimates also showed considerable tooth loss. Adults retained an average of 23.3 of the 28 non-third-molar teeth, and roughly one in twenty had lost all 28. These estimates are compatible with the broader literature describing large age and socioeconomic gradients in U.S. tooth loss and with national and global assessments that continue to identify severe tooth loss as an important public-health problem. 1, 2, 4, 6, 21, 22, 23, 24

Medication burden initially appeared to be associated with lower tooth retention, but that relationship changed materially after broader confounding control. The estimated difference for polypharmacy decreased from approximately 1.3 fewer retained teeth in the core model to 0.37 fewer teeth in the fully adjusted model, with the latter estimate compatible with no association. The change in the estimate after adjustment suggests that underlying illness, smoking, socioeconomic circumstances, and patterns of dental care account for an important part of the observed medication–dentition relationship.

This pattern is consistent with recent evidence linking polypharmacy more consistently to xerostomia and hyposalivation than to tooth loss itself. A 2026 systematic review and meta-analysis found that polypharmacy was associated with approximately doubled odds of dry mouth, while evidence for tooth number and edentulism remained inconsistent. 27 A 2026 scoping review similarly concluded that xerogenic or anticholinergic burden often tracks salivary dysfunction more consistently than medication count alone. 26 A 2025 register-based study also reported a strong gradient between medication number and diagnosed xerostomia. 38 The present association between the exploratory xerogenic burden and retained-tooth count is compatible with a salivary pathway, although this cross-sectional analysis cannot establish mediation through saliva. Recent pooled evidence also places both xerostomia and hyposalivation at roughly one-third prevalence among adults aged 60 years or older, showing that salivary symptoms are common in later life. 32

Additional studies have reported related findings. High anticholinergic burden has been associated with hyposalivation and xerostomia in older adults. 28 In Swedish register data, sustained exposure to selected xerogenic drug categories predicted subsequent extraction or restorative procedures, providing longitudinal support for medication-related dental outcomes. 29 Cross-sectional nursing-home data also show that polypharmacy and multimorbidity cluster with poor dental status, although those associations are difficult to disentangle causally. 31 Taken together, these studies suggest attention to pharmacological burden, underlying illness, and duration of exposure rather than medication count alone.

The tooth-specific models produced a similar result. In the fully adjusted analysis, no individual tooth showed even a nominal polypharmacy association at $p < 0.05$, and all 28 tests remained nonsignificant after false-discovery-rate correction. These results do not support attributing the anatomical pattern of tooth loss to medication burden on the basis of these cross-sectional data.

Confounding by indication remains an important limitation. People taking several medicines generally differ from nonusers in multimorbidity, frailty, healthcare contact, and health behaviors. The present extended models directly incorporated smoking, diagnosed diabetes, a chronic-condition burden measure, and dental-attendance recency, which materially reduced the medication estimates. Residual confounding is still possible because the public-use files do not capture lifetime disease severity, cumulative medication exposure, adherence, all over-the-counter medicines, diet, detailed periodontal history, or long-term patterns of dental access.

For dental public health, the tooth map provides information that complements the medication analyses. Prevention can be timed and targeted to the parts of the dentition that show the earliest population decline. The steep loss of molar retention beginning in middle adulthood supports long-term strategies focused on fissure protection, caries control, periodontal maintenance, endodontic and restorative longevity, and preservation-oriented decision making before extraction becomes the default endpoint.

In medical and pharmacy practice, oral adverse effects can be considered during medication review, but these cross-sectional findings do not justify discontinuing clinically necessary medicines. Medication review can include questions about persistent dry mouth, concurrent salivary-inhibiting medicines, and whether preventive dental care has kept pace with systemic treatment. When clinically appropriate, prescribers, pharmacists, and dentists can coordinate medication review, hydration and salivary-stimulation measures, topical fluoride, and earlier dental surveillance. 11, 18

4.1 Strengths and limitations

Strengths include examiner-recorded tooth status, a nationally representative probability sample, explicit differentiation of natural teeth from implants and root fragments, linkage to participant-level prescription data, design-based variance estimation, anatomically resolved outcomes, and correction for multiplicity in the 28 tooth-specific medication models. Excluding third molars from the primary analysis also reduced ambiguity from agenesis and prophylactic extraction.

Several limitations are important. First, NHANES is cross-sectional; neither the timing nor the reason for tooth loss is known, so the age-specific curves are population retention profiles rather than Kaplan–Meier survival

functions. Second, past-month prescription use is an imperfect proxy for medication exposure during the years in which dental disease developed. Third, generic-name grouping is not equivalent to a validated anticholinergic or xerogenic burden scale and does not capture dose, adherence, cumulative duration, or most over-the-counter exposure. Fourth, smoking, diabetes, multimorbidity, and dental-attendance recency were incorporated in the extended models, but these measures are self-reported and do not eliminate confounding by disease severity, indication, frailty, health literacy, or lifetime dental-care access. Fifth, tooth absence may reflect trauma, orthodontic extraction, congenital variation, or treatment preference as well as disease. Finally, the U.S. noninstitutionalized population does not represent nursing-home populations, in whom both polypharmacy and oral disease may be more severe.

5. CONCLUSION

Permanent-tooth retention across adulthood is strongly position-specific: molars show the earliest and deepest population decline, whereas canines and incisors are comparatively resilient. The apparent association between prescription burden and tooth retention was not robust to fuller adjustment for smoking, diabetes, multimorbidity, and dental-attendance recency. A pragmatic xerogenic-medication burden showed borderline evidence of a lower tooth count but no clear association with functional dentition. Tooth-specific estimates provide a detailed population view of oral aging. Longitudinal data with stronger exposure measurement are needed before medication use can be linked to subsequent tooth loss.

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