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Fissure Sealant Status, Recent Cariogenic Snack Intake, and Dental Floss Use in Relation to Permanent-Tooth Caries Experience Among Korean 12-Year-Olds: A Complex-Survey Analysis

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Highlights

What are the main findings?

- This analysis included 11,338 Korean 12-year-olds (weighted caries-experience prevalence, 60.7%). Female sex (aPR 1.096) and no current fissure sealants (aPR 1.095) were associated with higher prevalence; one episode of cariogenic snacks compared with two or more was associated with lower prevalence (aPR 0.947).

What is the implications of the main finding?

- Dental floss non-use was not independently associated with cumulative DMFT, and regional associations observed among dental attenders were not evident in the full analytic sample. These cross-sectional results do not establish preventive effects.

Abstract

Background/Objectives: Because restriction to dental attenders may introduce selection bias and odds ratios overstate associations for a common outcome, we analyzed the 2024 Korea National Children's Oral Health Survey using prevalence ratios, focusing on fissure sealant status, previous-day cariogenic snack intake, and previous-week dental floss use in relation to cumulative permanent-tooth caries experience. Methods: This cross-sectional secondary analysis included 11,338 of 12,309 surveyed 12-year-olds after excluding 971 with noninformative snack-frequency responses; 103 children reporting zero toothbrushing were retained. The outcome was DMFT ≥ 1. Survey-adjusted modified Poisson regression estimated prevalence ratios using sampling weights, 26 strata, and 252 school clusters. Restricted dental-attender and alternative-outcome analyses evaluated robustness. Results: Weighted caries-experience prevalence was 60.7%, and mean DMFT was 1.94. In the multivariable model, females (adjusted prevalence ratio (aPR) 1.096; 95% CI 1.045–1.150) and children without current sealants (aPR 1.095; 95% CI 1.047–1.145) had higher caries prevalence. Once-daily versus at least twice-daily cariogenic snack intake was associated with lower prevalence (aPR 0.947; 95% CI 0.909–0.987), whereas no snack intake was imprecise (aPR 0.951; 95% CI 0.885–1.021). Floss non-use was not associated (aPR 0.999; 95% CI 0.964–1.035), and regional contrasts were non-significant in the full analytic sample. Conclusions: Sex, observed sealant presence, and one-day snack frequency were associated with cumulative caries experience, without establishing temporal sequence or a causal preventive effect. Dental floss results were inconclusive for habitual flossing and proximal

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caries, and regional findings were selection-sensitive. Prospective research with repeated exposure measures is warranted.

Keywords: dental caries; pit and fissure sealants; cariogenic snacks; dental floss; child; complex survey; prevalence ratio; cross-sectional studies

1. Introduction

Dental caries is a major chronic oral condition in childhood and contributes to inequalities in health and treatment needs [1–5]. The World Health Organization recognizes 12 years as a benchmark age for population monitoring of permanent dentition [6]. The 2024 Korea National Children's Oral Health Survey (KNCOHS), which sampled 12,309 twelve-year-olds, reported a weighted prevalence of permanent-tooth caries experience of approximately 60.3% [7,8]. Both clinical caries status and its social distribution warrant close examination; however, DMFT is a cumulative index that includes untreated, missing, and previously restored permanent teeth.

Current pit and fissure sealant status is an indicator of the preventive care received, while randomized trial evidence and clinical guidelines support sealant placement for preventing occlusal caries in appropriate clinical settings [9–12]. Frequent consumption of free sugars has also been linked to caries development in longitudinal and intervention evidence [13–18]. Nonetheless, sealant presence at examination and snack consumption on only the preceding day are not historical exposure measures. Sealants may reflect selection into dental care, caries-related treatment decisions, and sealant loss; recent snack choices may follow a dental diagnosis or dietary advice. Cross-sectional associations with cumulative DMFT should therefore be distinguished from established preventive efficacy.

The potential association of dental floss use with dental caries also deserves careful qualification. Previous work has examined interdental cleaning and proximal caries [19], but a 2019 systematic review found no direct randomized evidence for interproximal caries outcomes in the principally adult interdental-cleaning trials [20]. Moreover, reporting any floss use during one preceding week cannot represent sustained technique, parental supervision, or historical use. Broader family factors—including parental education, food and oral-health literacy, and access to care—may shape children's exposures and disease experience; a recent study of maternal food literacy identified relevant contextual determinants, although food literacy itself was not significantly associated with child DMFT in simple analyses [21–26].

A previous national report using KNCOHS 2024 investigated sex, region, economic circumstances, sealants, oral hygiene products, and cariogenic dietary behavior [8]. Simply replicating those associations would add little. A further concern arises when analyses are restricted to children reporting a dental visit, for example to include dental-clinic education, which is not asked of nonattenders. Such a restriction could condition on care access related to both restorative treatment and observed DMFT, while odds ratios would overstate prevalence ratios for a common outcome. Evaluating the whole eligible analytic population, including children with zero previous-day brushing, and prioritizing survey-adjusted prevalence ratios can show how sensitive these associations are to such analytic choices.

Accordingly, this study analyzed the 2024 KNCOHS to estimate survey-adjusted prevalence associations of current sealant status, previous-day cariogenic snack frequency, and previous-week dental floss use with DMFT ≥ 1 among Korean 12-year-olds without conditioning on recent dental attendance. We additionally investigated sex and regional differences, DMFT component severity, variable-specific nonresponse, adjusted model

blocks, and selected sensitivity and interaction analyses. We hypothesized that absence of sealants and more frequent snacks would be associated with higher DMFT prevalence and assessed whether an independent association with floss non-use was evident. All questions concern observational associations, not preventive treatment efficacy or causal mediation.

2. Materials and Methods

2.1. Survey Design and Data Source

We conducted a secondary, cross-sectional analysis of anonymized participant-level data from KNCOHS 2024 [7,8]. The original survey sampled educational institutions using a stratified, two-stage cluster design. For 12-year-olds, schools were primary sampling units and school classes were sampled within institutions. The released 12-year-old microdata comprise 26 strata, 252 school clusters, and an examination weight (F_WGT). Residential location was grouped as Gu (metropolitan district), Si (city), or Gun (county). The design degrees of freedom were 252 minus 26 = 226. All reported population-weighted summaries pertain to specified analytic domains rather than automatically to the full national survey. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies [27] (Supplementary Table S1).

2.2. Study Population and Selection

The original survey included 20,055 five- and twelve-year-old respondents, comprising 7746 children aged 5 and 12,309 aged 12. Of the 12,309 twelve-year-olds, 971 gave a noninformative ("do not know") response to previous-day cariogenic snack frequency; these children were excluded from the principal complete-case analysis. No other principal exposure, covariate, outcome, or survey-design field was missing after applying the prespecified substantive response definitions. Thus, the primary analytic cohort comprised 11,338 children (Table 1). Importantly, all 103 children in this cohort reporting zero toothbrushing the previous day were retained and grouped with those brushing once (0–1 times). The 3252 children without a dental visit in the preceding year remained eligible because dental-clinic oral-health education was not used as a primary covariate.

Table 1. Participant characteristics of the primary analytic cohort (n = 11,338).

Characteristic	Category	Unweighted n	Weighted %
Sex	Male	6131	51.4
	Female	5207	48.6
Residential area	Gun	1576	6.6
	Gu	4978	38.5
	Si	4784	55.0
Perceived household income	High	5540	49.0
	Middle	5147	45.1
	Low	651	5.8
Toothbrushing (previous day)	0–1	1050	9.4
	2	5902	51.8
	3+	4386	38.8
Mouthwash (preceding week)	Yes	3692	33.3
	No	7646	66.7

Table 1. *Cont.*

Characteristic	Category	Unweighted n	Weighted %
Fissure sealant present	Yes	6386	57.8
	No	4952	42.2
Cariogenic snacks (previous day)	2+	7096	63.0
	1	3152	27.5
	0	1090	9.4
Floss (preceding week)	Yes	4395	39.9
	No	6943	60.1

Weighted percentages use F_WGT with 26 strata and 252 school clusters. n, unweighted number of participants; Gun, county; Gu, metropolitan district; Si, city.

For sensitivity analyses, a dental-attender subgroup was defined among the 8757 children reporting a dental visit in the preceding year; after exclusion of 671 noninformative snack responses, it comprised 8086 participants, including 55 children with zero previous-day brushing (Figure 1).

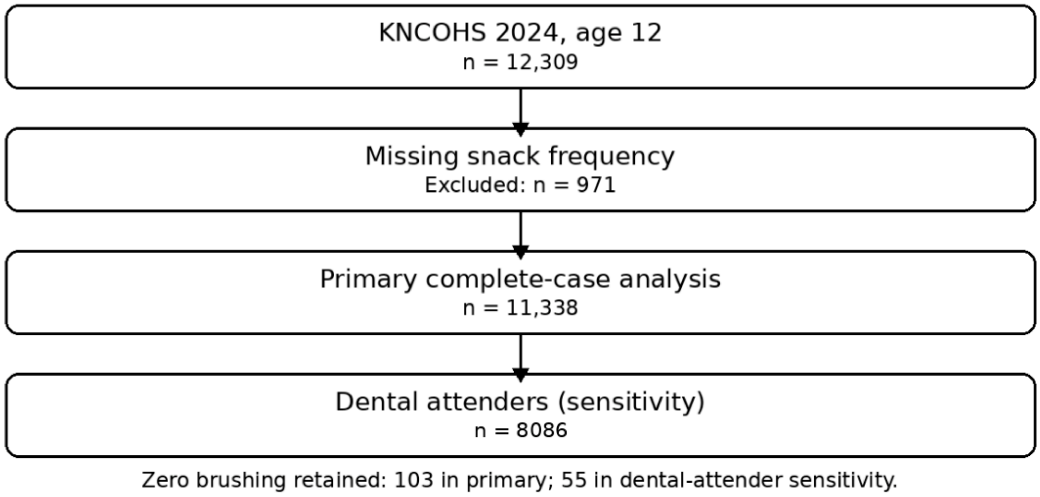


Figure 1. Participant selection in KNCOHS 2024.

The primary cohort (n = 11,338) retains children reporting zero brushing; dental-clinic education is structurally inapplicable to nonattenders and is analyzed only in the dental-attender subgroup.

2.3. Measures

The outcome was any permanent-tooth caries experience, defined as DMFT $\geq$ 1 versus DMFT = 0 using clinical records. The raw DMFT_P index was reconciled for every 12-year-old participant with its components: decayed (DT_P), missing due to caries (MT_P), and filled (FT_P) permanent teeth. Continuous DMFT and its three components were summarized as survey-weighted means with design-based standard errors. A secondary severity-related dichotomy was DMFT $\geq$ 2.

The exposure variables were examination-observed fissure sealant presence on at least one permanent tooth (PREV_SEA; yes/no), self-reported cariogenic snack occasions during the preceding day (X7; 0, 1, or $\geq$2, with "do not know" treated as noninformative), and any self-reported floss use during the preceding week (X5_1_M; any use versus none). These are contemporary measures and may not reflect exposure preceding accumulation of decayed, missing, or filled teeth.

2.4. Covariates and Conceptual Adjustment Framework

The adjustment set reflected a child oral-health conceptual framework [21] rather than significance-based variable selection: sex, residential area (Gun reference), perceived household economic standing (high/upper-middle combined, middle, lower-middle/low combined), previous-day toothbrushing frequency (0–1, 2, ≥3), and mouthwash use in the preceding week (any versus none). Demographic and contextual characteristics were entered before reported oral hygiene measures; sealants, then snack frequency and floss were entered in later descriptive blocks. Because contemporaneous behaviors and sealants may have changed following prior caries or dental treatment, the adjusted coefficients are not interpreted as causal effects or as estimates of mediated pathways.

Dental-clinic oral-health education (X2_2) was omitted from the principal model because it was asked only of children reporting a recent dental visit (n = 8757), with 3552 structurally inapplicable responses in the full age-12 sample. Excluding nonattenders merely to retain this secondary covariate would introduce selection on dental care utilization. Education was added only in a restricted-attender sensitivity model. Fluoride toothpaste use (X6) and erosive beverage intake (X8) lacked usable substantive responses for 6611/12,309 (53.7%) and 466/12,309 (3.8%) children, respectively; to preserve a common primary analytic sample, they were included separately in complete-response sensitivity models, with the substantial selection induced by fluoride response completeness explicitly acknowledged (Supplementary Table S2).

2.5. Clinical Examination and Measurement Quality

Clinical tooth-level outcomes and sealants were obtained from the KNCOHS standardized examination data [7,8]. The national survey's technical protocols include clinical recording standards and examiner training. The public-use 2024 participant file does not, however, contain examiner identifiers, paired re-examinations, or numerical inter-/intra-examiner agreement coefficients for caries or sealants; these cannot validly be estimated from one examination per child. Consequently, no 2024 kappa coefficient is asserted here, and the absence of independently accessible 2024 calibration figures is a measurement-quality limitation. Earlier survey quality documentation should not be misrepresented as measurement of the 2024 survey's reliability.

2.6. Survey-Weighted Statistical Analysis

All analyses employed the original examination weights F_WGT, stratum identifier STRATA, and primary sampling unit SCHOOL_N. Adjusted and crude prevalence ratios (PRs) were estimated using pseudo-likelihood modified Poisson regression with a log link for the binary outcome and robust, stratum-centered, school-cluster Taylor-linearized variance estimation. At each stratum, centered primary-unit estimating-equation totals were multiplied by $n_h/(n_h-1)$; tests and 95% confidence intervals used 226 survey design degrees of freedom. Subpopulation standard errors preserved the original full-sample primary sampling units. The analyses used Python 3.13 (Python Software Foundation, Wilmington, DE, USA), statsmodels 0.14.6 (https://www.statsmodels.org), and custom stratified-cluster sandwich variance routines; complex-sample logistic point estimates were reproduced in the dental-attender subgroup as a limited check; this does not independently validate modified Poisson standard errors or design-based Wald tests. ChatGPT (GPT-6; OpenAI, San Francisco, CA, USA) assisted with drafting the analysis code and editing prose; all numerical estimates were computed from the 2024 KNCOHS microdata.

Table 2 gives unweighted category sample sizes and design-weighted caries prevalence within each exposure row, including 95% confidence intervals, with design-adjusted univariable Wald F tests for group differences. Table 3 reports crude and mutually ad-

justed PRs from an identical analytic sample. Descriptive four-block models entered (1) demographics and contextual variables, (2) brushing and mouthwash, (3) sealants, and (4) snack intake and floss; adjusted joint Wald F tests assessed the association of each newly entered block but were not used to decide confounder selection. Companion adjusted odds ratios were computed with the same complex design only as secondary effect-scale comparisons (Supplementary Table S3).

Table 2. Design-weighted caries-experience prevalence within each exposure group.

Variable	Category	Caries n/N	Weighted % (95% CI)	*p* *
Sex	Male	3512/6131	57.8 (55.5–60.1)	<0.001
	Female	3349/5207	63.7 (61.7–65.8)	
Residential area	Gun	989/1576	64.8 (60.7–68.9)	0.121
	Gu	3040/4978	61.3 (59.2–63.4)	
	Si	2832/4784	59.7 (57.1–62.4)	
Perceived household income	High	3374/5540	60.4 (58.6–62.3)	0.921
	Middle	3081/5147	60.9 (58.7–63.2)	
	Low	406/651	60.4 (55.8–65.0)	
Toothbrushing (previous day)	0–1	641/1050	60.1 (56.1–64.1)	0.798
	2	3566/5902	61.0 (59.2–62.9)	
	3+	2654/4386	60.3 (58.1–62.5)	
Mouthwash (preceding week)	Yes	2254/3692	61.0 (58.6–63.3)	0.708
	No	4607/7646	60.5 (58.6–62.4)	
Fissure sealant present	Yes	3690/6386	58.2 (56.4–60.0)	<0.001
	No	3171/4952	64.1 (61.4–66.8)	
Cariogenic snacks (previous day)	2+	4372/7096	61.9 (60.0–63.8)	0.018
	1	1857/3152	58.5 (56.2–60.8)	
	0	632/1090	58.7 (54.5–62.9)	
Floss (preceding week)	Yes	2686/4395	60.7 (58.6–62.7)	0.996
	No	4175/6943	60.7 (58.8–62.5)	

* Design-adjusted univariable Wald F test, 226 denominator degrees of freedom. Percentages are weighted within each row/category. Confidence intervals use Taylor linearization preserving source design PSUs. Statistical testing for descriptive group differences is exploratory. n/N, number of children with caries experience (DMFT $\geq$ 1)/number of children in the category (unweighted); *p*, *p*-value; CI, confidence interval; DMFT, decayed, missing, and filled permanent teeth; Gun, county; Gu, metropolitan district; Si, city.

Table 3. Crude and adjusted survey-weighted prevalence ratios for permanent-tooth caries experience, defined as decayed, missing, and filled permanent teeth (DMFT) ≥ 1.

Variable	Category	Crude PR (95% CI)	Adjusted PR (95% CI)	Adjusted *p*-Value
Sex	Male	1.000 (reference)	1.000 (reference)	—
	Female	1.103 (1.052–1.156)	1.096 (1.045–1.150)	<0.001
Area	Gun	1.000 (reference)	1.000 (reference)	—
	Gu	0.946 (0.878–1.018)	0.959 (0.889–1.034)	0.272
	Si	0.922 (0.853–0.996)	0.932 (0.862–1.008)	0.080
Household income	High	1.000 (reference)	1.000 (reference)	—
	Middle	1.008 (0.968–1.050)	1.005 (0.964–1.047)	0.819
	Low	0.999 (0.932–1.071)	0.993 (0.927–1.063)	0.832
Toothbrushing	0–1	1.000 (reference)	1.000 (reference)	—
	2	1.016 (0.955–1.081)	1.013 (0.952–1.078)	0.689
	≥3	1.004 (0.943–1.069)	1.000 (0.939–1.065)	0.993
Mouthwash	Yes	1.000 (reference)	1.000 (reference)	—
	No	0.992 (0.953–1.033)	0.994 (0.953–1.038)	0.800
Fissure sealants	Present	1.000 (reference)	1.000 (reference)	—
	Absent	1.102 (1.054–1.152)	1.095 (1.047–1.145)	<0.001
Cariogenic snacks	≥2	1.000 (reference)	1.000 (reference)	—
	1	0.944 (0.906–0.984)	0.947 (0.909–0.987)	0.010
	0	0.948 (0.883–1.018)	0.951 (0.885–1.021)	0.163
Floss (1 week)	Used	1.000 (reference)	1.000 (reference)	—
	Not used	1.000 (0.967–1.034)	0.999 (0.964–1.035)	0.959

DMFT, decayed, missing, and filled permanent teeth; PR, prevalence ratio; CI, confidence interval; Gun, county; Gu, metropolitan district; Si, city. Adjusted PRs were mutually adjusted for all variables listed in the table.

Sensitivity analyses (Supplementary Tables S3–S5) repeated models among dental attenders (including zero brushing); with DMFT ≥ 2; with fluoride-toothpaste responses

complete; with erosive beverage responses complete; and with dental-clinic education in the eligible dental-attender subsample. Prespecified-effect interpretation focused on the main full-population analysis; sex by sealants, snacks, and floss interaction terms were examined as exploratory design-adjusted Wald tests. Statistical significance was defined as two-sided $p < 0.05$, with emphasis placed on confidence interval magnitude and consistency rather than on isolated threshold-crossing.

3. Results

3.1. Participant Flow and General Characteristics

Of 12,309 twelve-year-old respondents, 11,338 (92.1%) contributed to the primary analysis after 971 noninformative snack-frequency responses were excluded (Figure 1). The primary cohort included 6131 boys and 5207 girls, 6386 children with an examination-recorded sealant, and 103 who reported no brushing on the preceding day. A total of 6861 participants had DMFT ≥ 1; their design-weighted prevalence was 60.67% (95% CI 58.98–62.36), compared with 60.26% in all 12,309 surveyed children. The 60.67% figure is an analytic-sample estimate and should not be presented as the official full-survey national estimate (Table 1).

3.2. Weighted Caries Prevalence by Exposure Category

Weighted prevalence within girls was 63.7% versus 57.8% in boys, and was 64.1% among children without sealants versus 58.2% among those with sealants. Children reporting ≥ 2 cariogenic snacks on the preceding day had a weighted prevalence of 61.9%, compared with 58.5% reporting one and 58.7% reporting none. These are within-category prevalence estimates rather than column composition percentages (Table 2).

3.3. Survey-Adjusted Prevalence Ratios for DMFT ≥ 1

In the fully adjusted modified Poisson model, female sex (aPR 1.096; 95% CI 1.045–1.150) and absence of current sealants (aPR 1.095; 95% CI 1.047–1.145) were associated with higher DMFT ≥ 1 prevalence. One snack occasion versus ≥ 2 was associated with lower prevalence (aPR 0.947; 95% CI 0.909–0.987), whereas zero reported snacks showed a similar point estimate but greater uncertainty (aPR 0.951; 95% CI 0.885–1.021). Floss non-use showed no independent association (aPR 0.999; 95% CI 0.964–1.035). Neither Gu nor Si was significantly different from Gun in the adjusted primary model (Table 3).

All adjusted covariates were entered simultaneously; reference categories appear above. Adjusted prevalence ratios were estimated using weighted modified Poisson log-link regression with stratified, school-cluster robust variance and 226 design df. OR results appear in Supplementary Table S3.

3.4. DMFT Severity and Model-Block Comparisons

The weighted mean DMFT was 1.939 (SE 0.053). Weighted mean DT, MT, and FT were 0.123 (SE 0.010), 0.0013 (SE 0.0006), and 1.815 (SE 0.049), respectively, highlighting the importance of prior restorative care in the cumulative outcome. The descriptive addition of brushing/mouthwash (joint $F(3, 226) = 0.186$; $p = 0.906$) did not materially improve adjusted associations, while the sealant block did ($F(1, 226) = 16.315$; $p < 0.001$). The added snack/floss block had $F(3, 226) = 2.426$; $p = 0.066$. These joint tests describe block associations and do not identify causal pathways (Supplementary Table S6).

3.5. Robustness and Exploratory Interactions

The dental-attender sensitivity cohort comprised 8086 children including 55 with no brushing; its adjusted PR for absence of sealants was 1.119 (95% CI 1.065–1.176), whereas

the main full-cohort estimate was 1.095. The regional associations were significant only among dental attenders (Gu aPR 0.911, 95% CI 0.844–0.983; Si aPR 0.903, 95% CI 0.832–0.979) and were absent in the main sample (Table 3). The alternative DMFT $\geq$ 2 model retained sealant (aPR 1.376) and sex (aPR 1.139) associations, whereas the one-snack contrast was not significant (aPR 0.977; 95% CI 0.923–1.033).

Among 5348 children with usable fluoride-toothpaste responses, the sealant estimate remained above one (aPR 1.114; 95% CI 1.050–1.182), but the one-snack estimate crossed the null (aPR 0.945; 95% CI 0.892–1.002). The analysis controlling for erosive beverage intake included 11,131 children and retained the focal sex, sealant, and one-snack contrasts (Supplementary Tables S3–S5). Exploratory sex-by-sealant (p = 0.684), sex-by-snack (p = 0.064), and sex-by-floss (p = 0.085) interactions were not significant; no sex-differential association was inferred (Supplementary Table S7).

4. Discussion

Using a survey-weighted analytic cohort of 11,338 Korean 12-year-olds, we found cross-sectional associations of female sex, current absence of fissure sealants, and one previous-day cariogenic snack contrast with cumulative permanent-tooth caries experience. We retained 103 children reporting zero brushing, did not restrict eligibility to recent dental attenders, and used prevalence ratios as the primary effect measure. The weighted caries prevalence of 60.7% in this complete-case cohort closely approximated, but must not replace, the official 60.3% prevalence among all 12,309 surveyed 12-year-olds [7,8]. The main interpretative contribution is not discovery of new causal dental interventions but demonstration of how cohort selection, effect metric, and short behavior recall affect associations.

The use of prevalence ratios materially changes the apparent clinical magnitude of some associations. Absence of sealants had a multivariable aPR of 1.095 compared with an adjusted odds ratio of 1.266 in the same main cohort; these are not interchangeable measures because more than three-fifths had DMFT $\geq$ 1. In absolute terms, 64.1% of children without current sealants and 58.2% with sealants had recorded cumulative caries experience. The difference is a descriptive cross-sectional contrast and does not quantify caries events prevented by sealants. Independent randomized and longitudinal evidence supports the value of properly placed sealants [10–12], but it should not be conflated with these estimates.

The sealant association may be affected by reverse causation and indication or access mechanisms. Children with an earlier caries history may have received treatment instead of sealants on affected surfaces, and high-risk children may have been prioritized for sealant placement. Conversely, families using dental services regularly could show both more sealants and more historical fillings; children may also have lost previously placed sealants. Because neither treatment dates, tooth-specific sealant retention, baseline caries, nor care-seeking trajectory was available, directionality cannot be established. Thus, the adjusted sealant association is an indicator of current oral-health history and care experience, not direct observational proof that sealants lowered caries in these children.

Reported cariogenic snack frequency likewise demands interpretation as a one-day observation, not a long-term dietary exposure. The aPR estimates for one snack (0.947) and zero snacks (0.951) versus two or more were almost identical; yet, the no-snack interval was wider owing to fewer observations; a graded dose–response was neither demonstrated nor formally tested. Day-to-day variation, systematic underreporting, household food access, dietary changes after caries diagnosis, and residual confounding may explain part of this modest association. Although limiting free sugars is supported by broader prospective and mechanistic evidence [13–17], the present cross-sectional survey cannot establish a particular one-day snack intervention threshold or attributable preventive benefit.

Floss non-use in the preceding week was essentially null in the primary model (aPR 0.999; 95% CI 0.964–1.035), and this pattern was broadly consistent across sensitivity analyses. The estimate pertains to reported use over seven days and any past permanent-tooth caries, not a supervised intervention, habitual effective interdental cleaning, or proximal-surface incident lesions. The relevant Cochrane systematic review found adult trial evidence primarily on gingivitis and plaque rather than proximal caries outcomes [20]; application to children is uncertain. Consequently, the present finding neither establishes that flossing is ineffective nor that sustained or technically correct flossing does not affect future proximal caries.

Female sex was associated with approximately 10% higher prevalence after measured adjustments; possible explanations such as eruption timing, hormonal influences, and longer exposure of permanent teeth are plausible from the prior literature but were not observed directly in our data [28,29]. Sex-specific effect modification by sealants, snacks, or floss did not reach significance in exploratory interaction analyses. Geographic differences provide a stronger warning about selection: models restricted to dental attenders suggested lower caries prevalence in Gu and Si than Gun, but the 11,338-person primary model did not. Conditioning on previous dental attendance can select individuals according to care access, socioeconomic position, and prior disease and should not be used as direct evidence for population-wide rural–urban disparities [21–24,30].

The full sample's weighted mean DMFT was dominated by the filled component (mean FT 1.815 of DMFT 1.939). This is relevant because restoration depends partly on dental care access as well as earlier disease. Restriction to dental attenders selected 8086 individuals with weighted caries prevalence 61.8%, while included nonattenders had prevalence 57.7%; both clinical and service-use mechanisms may contribute. The finding supports avoiding a clinic-attendance restriction, although the residual exclusion of 971 children without informative snack responses (7.9% of age-eligible respondents) can still introduce selection bias. In addition, perceived household income is a crude measure of socioeconomic context, and parental education, health literacy, health service navigation, family dietary environment, total fluoride exposure, and previous preventive-treatment trajectories were not available. A recent study from Türkiye identifies these family-level factors as relevant context, but its small, younger sample and null simple maternal food-literacy association do not establish generalizability to the present cohort [26].

We also examined additional explanatory factors in sensitivity analyses. Erosive beverage adjustment left the major estimates broadly unchanged, but fluoride-toothpaste response completeness was low: only 5348 members of the principal sample supplied usable yes/no fluoride data. Although the sealant association persisted in this subset, reduced sample size and selective nonresponse made the snack estimate less precise. Residual confounding remains possible, and neither the nonsignificance of toothpaste use within respondents nor the consistency of selected coefficients proves the omitted confounding is absent. The four descriptive model blocks were accompanied by design-adjusted joint tests, but changes in coefficients between blocks cannot be interpreted as causal mediation.

This study is limited by its cross-sectional design and mismatch between cumulative DMFT and measurements from only the preceding day/week, which precludes assigning temporal ordering. The binary DMFT ≥ 1 outcome combines very different disease histories; companion component averages and a DMFT ≥ 2 sensitivity analysis only partly address severity. Sealant status is current presence, not prior placement or sustained retention. Although the survey used clinical examination data, quantitative calibration reliability coefficients specific to 2024 caries and sealants could not be recovered from the participant dataset; 2024 survey technical documentation is required to quantify them. Additional limitations include self-report, residual socioeconomic and family confounding, no ex-

ternal validation of dietary habituation, and uncertainty from excluding noninformative snack responses.

Implications for Future Research

Prospective cohorts should measure repeated daily diet and oral-hygiene behaviors; incident tooth- and surface-specific caries; sealant placement dates and retention; and detailed family, economic, fluoride, and service-access exposures. Pragmatic trials are better suited to evaluate whether access-oriented sealant delivery, repeated dietary counseling, family engagement, or mobile-health tools improve clinical outcomes. Digital and school–family interventions were not assessed in KNCOHS 2024 and are proposed only as hypotheses for future evaluation rather than findings established by the present analysis [31–33].

5. Conclusions

In a survey-weighted cross-sectional analysis of 11,338 Korean 12-year-olds, female sex, absence of examination-recorded fissure sealants, and one category contrast in previous-day cariogenic snack frequency were associated with cumulative permanent-tooth caries prevalence. Floss non-use was not independently associated with this outcome, and regional associations observed only among dental attenders were not evident in the full analytic sample. The sealant hypothesis was supported, the snack-frequency hypothesis received limited support because no graded association was demonstrated, and the floss hypothesis was not supported. Because exposures were measured concurrently or over brief recent windows while DMFT accrued historically, none of these associations establishes causality, prevention effectiveness, or a dietary intervention threshold. Longitudinal tooth-level studies remain necessary.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/children13111521/s1, Table S1: STROBE Cross-Sectional Reporting Checklist; Table S2: Participant Accounting and Variable-Specific Nonresponse; Table S3: Companion Survey-Adjusted Odds Ratios (Primary n = 11,338); Table S4: Sensitivity Models for Primary Contrasts; Table S5: Fluoride, Erosive Beverage and Education Response Sensitivity Models; Table S6: Outcome Component Descriptives and Block-Level Joint Tests; Table S7: Variable Definitions, Interaction Tests and Examination Reliability Scope.

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Informed Consent Statement: Informed consent was obtained from the legal guardians of all subjects involved in the original 2024 Korea National Children's Oral Health Survey. As this study used de-identified secondary data, the requirement for additional informed consent was waived by the Dankook University Institutional Review Board.

Data Availability Statement: The participant-level data were accessed from the Korea Disease Control and Prevention Agency (KDCA) 2024 public-use survey release subject to the agency's access and reuse conditions. Aggregate analysis outputs and reproducible code can be supplied by the authors; identifiable participant records are not distributed with the submission.

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