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Longitudinal Associations between Dental Caries Increment and Risk Factors in Late Childhood and Adolescence

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Abstract

Objectives—To assess longitudinal associations between permanent tooth caries increment and both modifiable and non-modifiable risk factors, using best subsets model selection.

Methods—The Iowa Fluoride Study has followed a birth cohort with standardized caries exams without radiographs of the permanent dentition conducted at about ages 9, 13, and 17 years. Questionnaires were sent semi-annually to assess fluoride exposures and intakes, select food and beverage intakes, and tooth brushing frequency. Exposure variables were averaged over ages 7-9, 11-13, and 15 – 17, reflecting exposure two years prior to the caries exam. Longitudinal models were used to relate period-specific averaged exposures and demographic variables to adjusted decayed and filled surface increments (ADJCI) (n=392). The Akaike Information Criterion (AIC) was used to assess optimal explanatory variable combinations.

Results—From birth to age 9, 9-13, and 13-17 years, 24%, 30%, and 55% of subjects had positive permanent ADJCI, respectively. Ten models had AIC values within two units of the lowest AIC model and were deemed optimal based on AIC. Younger age, being male, higher mother's education, and higher brushing frequency were associated with lower caries increment in all 10 models, while milk intake was included in 3 of 10 models. Higher milk intakes were slightly associated with lower ADJCI.

Conclusions—With the exception of brushing frequency, modifiable risk factors under study were not significantly associated with ADJCI. When possible, researchers should consider presenting multiple models if fit criteria cannot discern among a group of optimal models.

Keywords

Adolescents; dental caries; increment; longitudinal; risk factors

Introduction

Despite declines in dental caries rates for many population groups attributed mostly to widespread use of fluoride in many forms, dental caries remains a major public health problem. Moreover, a small minority of children and adolescents have the majority of caries (1). Most studies of caries rates and risk factors have been cross-sectional (2 - 6), while most longitudinal studies have assessed incidence over a relatively short period of time (7 - 9). These studies generally agree that greater tooth brushing frequency and socioeconomic status are associated with better caries outcomes. However, studies of caries risk factors over longer periods are important to better understand the specifics of its etiology and develop improved preventive approaches. The Dunedin Cohort study, which has followed subjects for over four decades, has provided valuable insight on the effect of socioeconomic status (SES) as well as oral health beliefs and behaviors on oral health from childhood to adulthood (10, 11). We seek to confirm their results and examine the association between dietary intakes and caries increment in a contemporary cohort.

The current study allows us to identify factors associated with caries increment throughout adolescence, and understand their relative importance. In this analysis, we examine both modifiable and non-modifiable risk factors. While modifiable risk factors are of interest to practicing clinicians, identification of important non-modifiable risk factors is critical to determining which groups carry the burden of adolescent caries as well as identifying groups to target for caries intervention programs. The examination of beverage intakes over this extended period of time as well as the analysis technique used to identify a group of well-fitting models is relatively novel to the dental literature.

This analysis uses 10 years of follow-up data from the Iowa Fluoride Study (IFS) to identify associations between caries increments in the permanent dentition and dietary, behavioral, socioeconomic, and demographic factors. Longitudinal modeling techniques were used to account for correlated measurements for each subject over time. This modeling framework accommodates the reduced variability among repeated observations made on the same subject, which in turn increases power (12).

Methods

Iowa Fluoride Study

The IFS has been described in detail in previous publications, so study methods are outlined briefly here. Following approval by the Institutional Review Board of the University of Iowa, the IFS recruited new mothers and their infants from eight Iowa hospitals during the years 1992 – 1995 (13-17). These eight hospitals represented approximately 20% of all births in Iowa at the time of recruitment. During recruitment, areas representative of minority groups were oversampled. After parental consent was obtained, data on the children’s oral health behaviors and dietary habits were collected regularly from birth, which has allowed for estimation of each subject’s daily fluoride intake, brushing frequency, and dietary intakes. The IFS also conducted dental caries and fluorosis exams at about ages 5, 9, 13, and 17. There were 392 subjects who received dental examinations at each of the age 9, 13, and 17 visits, and these subjects were used in this analysis. During the dental examinations, each surface of each tooth present was assessed for cavitated caries and fillings by trained and calibrated examiners using a portable dental chair, mouth mirror, and exam light (14). The number of decayed and filled surfaces on the permanent teeth was calculated for the age 9 exam. For the 13 and 17 year exams, the adjusted caries increments (ADJCI) for the permanent teeth from ages 9-13 and ages 13-17 were calculated (18). Age 9 incidence is denoted as ADJCI throughout the manuscript.

Questionnaires

Questionnaires about subjects' dietary and oral health behaviors were sent to parents at regular six-month intervals during the period of interest for these analyses. Behavioral and dietary intake variables relevant to the permanent caries incidence at age 9 were averaged over questionnaires sent at ages 7.0, 7.5, 8.0, 8.5, and 9.0 years; those variables relevant to the ADJCI from ages 9 to 13 were averaged over questionnaires at ages 11.0, 11.5, 12.0, 12.5, and 13.0 years; and those variables corresponding to the ADJCI from ages 13 to 17 were averaged over questionnaires at ages 15.0, 15.5, 16.0, 16.5, and 17.0 years. All ADJCIs that did not have at least one questionnaire returned during the corresponding time period were excluded from the analysis.

Subjects' beverage and selected solid food intakes over the course of a week, as well as oral health habits such as daily tooth brushing frequency, were assessed with these questionnaires. Numbers of servings per week and average serving size were assessed and used to calculate estimated beverage intakes in total oz/day, which were classified into four categories: water and other sugar-free beverages, milk, sugar-sweetened beverages (SSB) which included soda-pop, and 100% juice. The estimated total daily fluoride intake calculation for each period summed estimated fluoride intake from water, other beverages, and selected foods that absorb water, as well as from dentifrice and dietary fluoride supplements. Fluoride levels were determined for the subjects' main water sources (home, school, or bottled water) by contacting the Iowa State Health Department and collecting water samples from subjects who used well water or water filtration systems and testing them using a fluoride-ion specific electrode (12,13). Then, fluoride concentrations were multiplied by the estimated daily quantity ingested. Fluoride intake from store-bought juices, juice-drinks, soft drinks and other beverages which the subject drank also were estimated based on ounces ingested and our assay of products' fluoride levels. The brand of toothpaste the subject used (and its fluoride concentration, including prescription level of 5000ppm), amount used, frequency of brushing, and estimated amount ingested were used to determine fluoride ingestion from dentifrice. Home water fluoride concentration was determined by the fluoride concentration (in ppm) of water from the subject's home water source. Families were asked about socioeconomic factors such as family income and the highest level of education attained by the subject's mother and father only at distinct times during the study. For these analyses, socioeconomic data collected during 2007 were used, as these data most closely matched the exposure and outcome periods. Also, SES at recruitment was artificially low for some parents attending graduate or professional school at the time of the subject's birth.

Statistical Analyses

Explanatory variables considered as potential predictors of ADJCI in this analysis were actual age at caries exam, sex, mother's highest educational level, family income, total estimated daily fluoride intake (mg F/day), fluoride concentration in the subject's home water source (ppm), average daily brushing frequency, and intakes of water and other sugar-free beverages (oz/day), milk (oz/day), SSB (oz/day), and 100% juice (oz/day). Mother's highest educational level in 2007 was dichotomized as less than a 4-year college degree versus a 4-year college degree or more, and family income in 2007 was dichotomized as less than $60,000 per year versus $60,000 per year or more.

Daily brushing frequency, home fluoride level, and intakes of fluoride, water and other sugar-free beverages, milk, SSB, and 100% juice were time-varying factors which were averaged over the pre-defined questionnaire periods listed in the first paragraph of the Questionnaires subsection. Summary statistics of these variables were calculated, and the Wilcoxon Rank-Sum test, the non-parametric version of the two-sample t-test, was used to assess the differences in DFS counts and ADJCI for binary explanatory variables (sex, mother's educational level category, and family income category) at each time period.

Permanent tooth incidence at age 9, and permanent tooth ADJCIs from 9-13, and 13-17 years were modeled using a Generalized Linear Mixed Model (GLMM), assuming a negative binomial distribution and employing a log link function. Due to the low percentage of non-integer responses (2.33%) and the fact that the negative binomial distribution models integer values, all non-integer ADJCIs were rounded to the nearest integer for GLMMs and left unrounded for all other results. Within-subject correlation was accommodated to account for the repeated outcome measures for each subject. In our GLMMs, we characterized this correlation through individual random effects for the model intercepts, which result in a subject-specific interpretation of the parameter estimates. Such interpretations assume that an individual's random effect is unique, and that the magnitude and direction of the effect reflects the subject's risk relative to other participants who share the same covariate values. Parameters were estimated by maximizing the Laplace approximation to the marginal log likelihood. An offset term was included in each model. The time-varying factors described in the previous paragraph were averaged as described in the Questionnaires subsection and used as time-varying covariates in these GLMMs. All analyses were performed using PROC GLIMMIX in SAS (version 9.4, SAS Institute Inc., Cary, NC). A macro was written to perform all possible subsets modelling (i.e., candidate models were fit and assessed based on all possible combinations of covariates).

In this analysis, the offset term adjusts for differences in the number of tooth surfaces susceptible to decay or fillings for each individual at each time point. For the permanent incidence at age 9, only permanent incisors and first molars were included, for a maximum offset of 52. For the latter 2 increment periods, a maximum offset of 128 surfaces was possible.

To evaluate the propriety of candidate models, the Akaike Information Criterion (AIC) was used (19). Model selection with AIC is a statistical method that allows users to compare the penalized fit of models constructed using the same complete dataset. The AIC is the sum of two terms. The first term is twice the negative empirical log likelihood, a measure that reflects the fit of the model to the data. The log likelihood indicates how well the proposed covariates explain the outcome variable, and increases with improved fit. Therefore, the negative log likelihood is smaller with better model fit. The second term is a penalization which consists of twice the number of covariates included in the model. This penalty term increases in accordance with model complexity. The AIC is the sum of these two values, and lower AIC values are preferable. This helps users identify a model that provides an optimal balance between the competing objectives of parsimony and fidelity to the data.

When comparing AIC values, it is suggested that a decrease of at least 2 units indicates a meaningful improvement in penalized model fit (19, 20). Models with an AIC within 2 units of the lowest observed AIC are deemed as roughly statistically equivalent, implying that often there is no single model which represents the true phenomenon of longitudinal caries development. Therefore, the AIC for all possible models was calculated. Then, the model with the lowest AIC and all models with AIC values within 2 units of the lowest AIC were examined. There were 9 models within 2 units of the lowest AIC model.

Results

From the five questionnaires for each increment period, the average (SD) number of questionnaires returned in the two years prior to age 9 was 4.09 (1.39), 4.02 (1.41) for the two years prior to age 13, and 3.82 (1.50) for the two years prior to age 17for the 392 subjects who had caries exams at ages 9, 13, and 17.

Table 1 summarizes the subjects' demographic variables. Their ages were close to the age expected at each caries exam, and on average, each subject had a little over 4 years between each pair of exams (4.24 years between age 9 and 13 exams, and 4.26 years between age 13 and 17 exams). The sample was 46.7% male.

In 2007, the group was relatively high SES, with 68.6% of subjects belonging to families with incomes of $60,000 or more, and the mothers of 50.3% of the subjects having ≥4 years of post-secondary education in 2007. Also, compared to subjects who were recruited to the IFS but not included in this study, subjects included in this study were more likely to have white mothers and belong to higher-income households. Specifically, mothers of 98.2% of subjects included in this analysis were white, while 93.2% of recruited subjects not included in this analysis had white mothers. Among subjects in this analysis, 18.6% belonged to a household with an annual income ≥ $60,000 at subject birth, while 12.4% of subjects not included in this analysis had household income of ≥ $60,000. Based on this information, the IFS cohort could be considered a convenience sample (21).

Table 2 summarizes the dietary, fluoride, and caries outcome variables. While daily water-based beverage and SSB intake was higher at older ages, 100% juice intake was lower at older ages. Daily milk and fluoride intake as well as daily brushing frequency did not change much over time.

At the age 9 dental examinations, 76% of subjects had permanent DFS incidence of 0. From ages 9-13 and 13-17, 70% and 45% of subjects had an ADJCI of 0, respectively.

Females had marginally higher average DFS counts and ADJCI than males at the age 17 dental examination, but these differences were not significant (Table 3). Children whose families made less than $60,000 per year (in 2007) consistently had higher average DFS counts and ADJCI compared to children whose families made $60,000 or more for all three time periods. These differences were generally significant, except at age 13 for ADJCI. Children whose mothers had less than a 4-year degree had significantly higher average DFS counts and ADJCI for both the age 9-13 and 13-17 periods compared to children whose mothers had at least a 4-year degree.

Among the 392 subjects, 345 (88%) had an offset of 52 for the permanent age 9 incidence, 336 (86%) had an offset between 111 and 128 for the age 9 to 13 increment period, and 361 (92%) had an offset between 111 and 128 for the age 13 to 17 increment period.

All models within 2 units of the lowest AIC value are reported in Table 4. Each row represents a different model and blank cells within a row indicate variables not included in that model. The mean ratio estimates for the selected variables are reported, along with their respective p-values. The mean ratio estimate (computed as the exponentiated model parameter estimate) is the multiplicative factor that characterizes the change in the estimated mean ADJCI corresponding to a unit change in a covariate. Mean ratio estimates less than 1 indicate factors associated with lower ADJCI, while values greater than 1 indicate factors associated with higher ADJCI. Age, sex, mother's education, and brushing frequency were included in every model within 2 units of the lowest AIC value, indicating that they are very important in explaining variability in ADJCI. Younger age at caries exam, being male, having a mother with a 4-year degree, and brushing more often were associated with significantly lower expected ADJCI in all models. Milk was the next most represented variable, with higher milk intake associated with lower expected ADJCI. While milk intake was not significant at the 0.05 level in any model, it is a potentially important variable in explaining ADJCI. The model with the lowest AIC value of all possible models based on the explanatory variables under consideration is examined more closely in Table 5. This model included actual age at the caries exam, sex, mother's educational level, and daily brushing frequency.

Discussion

Few studies have examined factors associated with permanent tooth caries in childhood and adolescence. This longitudinal study, which has followed subjects from birth and collected detailed dietary data, helps to close this knowledge gap with extensive fluoride and beverage intake information and by identifying modifiable and non-modifiable risk factors in order to provide recommendations for the prevention of caries in children and adolescents. Although the results of this study are somewhat confirmatory, reproducibility of results is required to draw sound conclusions from observational data.

The results of this study have some important limitations, such as the study's relatively small sample size and participation mostly by healthy subjects with generally middle-to-high socioeconomic status. For instance, subjects in the IFS had relatively low DFS counts compared to the most recent NHANES report for adolescents (4). In addition, recruitment for this cohort was limited to one geographic region (Iowa) and subjects who remained active in the study from ages 7 to 17 were more likely to have higher socioeconomic status and be white than those who became inactive. The educational attainment of the subject's parents was high compared to state and national rates of educational attainment, which may be due to recruitment from relatively urban hospitals and Iowa City especially. Also, this study did not examine or control for other potentially modifiable factors, such as the presence of cariogenic bacteria or the duration or frequency of exposures to foods and beverages.

Table 3 features differences in DFS counts and ADJCI for dichotomized independent variables separately for each of the three time points/periods under study. Based on these cross-sectional results, male subjects, subjects with higher household income, and those whose mothers had more education generally had lower DFS counts and increments, although not all comparisons yielded statistically significant results.

We looked at multiple models using AIC. We cannot say with certainty that the penalized fit of the "best" model (Model Number 1 in Table 4) is superior to the penalized fit of the other nine models in Table 4 within 2 units of the lowest AIC. The variables included in the other models are important to consider when trying to determine factors associated with caries outcomes (22). When feasible, researchers should consider presenting a group of models when there are multiple models with similar fit criteria. This can provide a better picture of what variables are important, and possibly remove some of the emphasis from p-values and hypothesis testing in model selection, as recently recommended in a statement released by the American Statistical Association (23).

In the longitudinal models, all of the models with AIC values within 2 units of the minimum included the variables age, sex, mother's education, and brushing frequency. Permanent teeth generally erupt sooner in female subjects, which lead to a slightly longer exposure to cariogenic factors for these subjects (24). This explanation is consistent with the fact that later age at the caries exams is associated with significantly higher ADJCI in all of the chosen models.

As in virtually all studies, lower socioeconomic status – here in the form of lower mother's education level and lower income category – is associated with more disease (3,4,5,6,8,9). Although household income is only included in 2 out of the 10 models, in the models where it is included, lower household income is associated with more disease.

Higher brushing frequency is associated with lower ADJCI in this study. This is not surprising, because more frequent fluoride exposure from dentifrice and disrupting cariogenic biofilm mechanically are cornerstones of caries prevention. This is a modifiable behavior and frequent tooth brushing already is commonly recommended (3, 6, 25).

The effect of milk intake was modest, yet in 3 of the 10 final models, was associated with slightly lower ADJCI. For all of the beverage intakes, the mean ratio estimates were not significantly different from 1.

In the models, milk intake provides a slightly better explanation of ADJCI than other beverage intakes. Other authors have shown that milk has a caries-neutral or slightly protective effect in children. (26 - 29), but greater milk intake could also be an indicator of other healthy dietary behaviors, such as drinking less SSB. Lower overall sugar intakes, which could be represented by lower SSB intakes, are associated with fewer caries (30). This analysis is limited because it did not utilize the frequency or duration of exposure to beverages, nor does it examine the pattern of beverage intake as clustering would. Also, it has been shown that lower SES is associated with higher SSB intake (31). Therefore, income and mother's education level may explain some of the association between beverage intake and ADJCI.

Of note, fluoride exposure during late childhood and adolescence were not significantly associated with ADJCI. Although fluoride exposure generally plays an important caries preventive role (32), this cohort has relatively high fluoride exposures, low fluoride exposure variability, and compared to NHANES data, this cohort has low disease burden (4). It appears that adequate fluoride exposures resulted in low caries burden, and the low variability in fluoride exposures did not explain differences in ADJCI after adjustment for age, sex, SES, and brushing frequency. While this study focused on the permanent dentition, previously published research from the IFS which examined dfs/DFS increments at ages 5, 9, and 13 showed that higher frequency of 100% juice intake, higher tooth brushing frequency, and higher SES were associated with lower rates of new decayed and filled surfaces (12). The results are similar in this study except that 100% juice was not significantly associated with ADJCI.

Few other long-running longitudinal studies have examined the relationships between modifiable risk factors and caries increment during childhood/adolescence. The Dunedin Cohort Study has examined beliefs about the importance of widely-accepted oral health practices at ages 15, 18, and 26. Subjects who felt these practices were not important or who had inconsistent responses were likely to have worse oral health after adjustment for sex, socioeconomic status, fluoride exposure, and smoking habits (11). Later, they showed that SES early in life influences oral health beliefs and behaviors (tooth brushing) later in life, which affects caries outcomes (10).

In summary, this study used longitudinal data analysis techniques to identify the best models with similar penalized fit that indicate factors associated with caries in childhood/adolescence. This study has shown that being male, having higher socioeconomic status, and brushing more frequently are significantly associated with lower risk of caries. Higher intake of milk and higher income also could be associated with lower ADJCI in adolescence and late childhood.

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Table 1

Demographics of Iowa Fluoride Subjects

Variable	Category	Mean (SD)/N (%)
Age (years)	Age 9	9.22 (0.73) (n=376)
	Age 13	13.48 (0.62) (n=382)
	Age 17	17.74 (0.70) (n=372)
	Time Between Age 9 and 13 Visits	4.24 (0.83) (n=382)
	Time Between Age 13 and 17 Visits	4.26 (0.82) (n=372)
Sex	Male Female	183 (46.7%) 209 (53.3%)
Annual Income Category in 2007	< $60,000 $60,000 or more	123 (31.4%) 269 (68.6%)
Mother's Education in 2007	< 4-Year College Degree 4-Year College Degree or more	195 (49.7%) 197 (50.3%)

Table 2

Dietary, Behavioral, and Caries Outcome Variables of Iowa Fluoride Subjects (based on n=392)[1]

Dietary, Behavior, and Fluoride Intake Variables			
Variable	Dental Examination Visit – Mean (SD)		
	Age 9 (n=376)	**Age 13 (n=382)**	**Age 17 (n=372)**
Water and Other Sugar-Free Beverages (oz/day)	15.4 (8.7)	16.2 (10.8)	22.0 (14.8)
Milk (oz/day)	13.1 (6.5)	12.6 (7.9)	12.8 (10.0)
Sugar-Sweetened Beverages (oz/day)	5.8 (4.5)	11.1 (8.4)	12.7 (10.7)
100% Juice (oz/day)	4.5 (3.6)	2.2 (2.5)	2.1 (2.7)
Home Fluoride (ppm)	0.8 (0.4)	0.8 (0.4)	0.8 (0.4)
Fluoride Ingested (mg/day)	0.7 (0.4)	0.8 (0.4)	0.9 (0.5)
Daily Brushing Frequency	1.5 (0.5)	1.5 (0.5)	1.7 (0.5)
Caries Outcomes			
Variable	**Dental Examination Visit – Mean (SD)**		
	Age 9[2] (n=376)	**Age 13** (n=382)	**Age 17** (n=372)
Mean DFS	0.50 (1.12)	1.05 (2.10)	2.94 (4.05)
Mean Adjusted Caries Increment	0.50 (1.12)	0.65 (1.53)	1.89 (2.85)

[1]All 392 subjects had caries exams at ages 9, 13, and 17, but sample sizes in this table are slightly lower due to missing covariate information.

[2]Permanent DFS increment and incidence are the same at age 9.

Table 3

Comparisons of DFS Counts and Adjusted Caries Increments for Iowa Fluoride Subjects for Different Levels of Explanatory Variables, Stratified by Age (based on n=392)

DFS Count		Age 9[1]			Age 13			Age 17		
Variable	Description	n	Mean (SD)	p-value[2]	n	Mean (SD)	p-value[2]	n	Mean (SD)	p-value[2]
Sex	Males	177	0.38 (0.90)	0.235	179	0.79 (1.81)	0.133	177	2.49 (3.58)	0.078
	Females	199	0.60 (1.27)		203	1.28 (2.30)		195	3.35 (4.40)	
Income Category in 2007	< $60,000 per year	117	0.68 (1.26)	0.016	119	1.35 (2.17)	0.017	117	3.68 (4.58)	0.016
	>= $60,000 per year	259	0.41 (1.04)		263	0.92 (2.05)		255	2.60 (3.74)	
Mother's Education in 2007	< 4-Year College Degree	189	0.60 (1.23)	0.066	191	1.34 (2.42)	0.004	182	3.70 (4.64)	<0.001
	4-Year College Degree or More	187	0.40 (0.99)		191	0.77 (1.67)		190	2.22 (3.24)	
Adjusted Caries Increment		**Age 9[1]**			**Age 13**			**Age 17**		
Variable	**Description**	**n**	**Mean (SD)**	**p-value[2]**	**n**	**Mean (SD)**	**p-value[2]**	**n**	**Mean (SD)**	**p-value[2]**
Sex	Males	177	0.38 (0.90)	0.235	179	0.51 (1.51)	0.070	177	1.70 (2.62)	0.241
	Females	199	0.60 (1.27)		203	0.77 (1.53)		195	2.07 (3.04)	
Income Category in 2007	< $60,000 per year	117	0.68 (1.26)	0.016	119	0.80 (1.55)	0.074	117	2.21 (2.92)	0.050
	>= $60,000 per year	259	0.41 (1.04)		263	0.58 (1.51)		255	1.75 (2.81)	
Mother's Education in 2007	< 4-Year College Degree	189	0.60 (1.23)	0.066	191	0.82 (1.81)	0.018	182	2.22 (3.13)	0.012
	4-Year College Degree or More	187	0.40 (0.99)		191	0.48 (1.16)		190	1.58 (2.52)	

[1] Prevalence at age 9 is the same as the age 9 increment

[2] Wilcoxon Rank-Sum Test – tests for a difference between two groups with continuous, non-normal data

Table 4

Model Selection Using AIC to predict Adjusted Caries Increment Given Hypothesized Risk Factors in Longitudinal Analysis (Mean Ratio/p-value)[1] In Iowa Fluoride Study

Model	Age	Sex (Female)	Mother's Education (4-Yr Degree)[2]	Income (≥$60k)[2]	Water and Other Sugar-Free Beverages	Milk	Sugar-Sweetened Beverages	100% Juice	Daily Fluoride Intake	Home Fluoride Level	Brushing Frequency	Δ AIC[3]
1	1.098 <.001	1.531 0.002	0.679 0.006								0.659 0.001	Ref.
2	1.098 <.001	1.492 0.005	0.690 0.008			0.991 0.216					0.662 0.001	0.47
3	1.098 <.001	1.512 0.003	0.719 0.028	0.853 0.315							0.667 0.002	0.99
4	1.104 <.001	1.497 0.005	0.668 0.004				0.993 0.361				0.651 0.001	1.18
5	1.098 <.001	1.473 0.007	0.729 0.036	0.854 0.321		0.991 0.219					0.670 0.002	1.48
6	1.104 <.001	1.456 0.009	0.678 0.006			0.991 0.206	0.993 0.342				0.653 0.001	1.57
7	1.094 <.001	1.525 0.003	0.684 0.007					0.988 0.596			0.664 0.001	1.72
8	1.096 <.001	1.548 0.002	0.680 0.006						1.076 0.598		0.656 0.001	1.72
9	1.098 <.001	1.535 0.002	0.680 0.006							1.065 0.721	0.658 0.001	1.88
10	1.098 <.001	1.530 0.003	0.680 0.006		0.999 0.912						0.660 0.001	1.99

[1]Based on 392 subjects (Each subject contributed a mean of 2.88 time points).

[2]Mother's Education Level and Income as measured in 2007.

[3]Δ AIC represents the difference between each model's AIC value and the model with the lowest AIC (Lowest AIC value is 2859.78).

Table 5

Favored Longitudinal Model Predicting Iowa Fluoride Study Adjusted Caries Increments (based on n=392)

Effect	Mean Ratio	Confidence Interval Mean Ratio	p-value
Actual Age at Caries Exam(years)	1.098	(1.062, 1.135)	<0.001
Sex (Females)	1.531	(1.163, 2.016)	0.002
Sex (Males – reference)	1.000	-----	-----
Mother's Education (4-Year College Degree or More)	0.679	(0.517, 0.893)	0.006
Mother Education (Less than 4-Year College Degree – reference)	1.000	-----	-----
Average Daily Brushing Frequency	0.659	(0.515, 0.845)	0.001