National Health and ~~Nutrition Examination~~ Survey

Not used entirely age between 6 ans 29

2015-2016 Data Documentation, Codebook, and Frequencies

Fluorosis - Clinical (FLXCLN_I)

Data File: FLXCLN_I.xpt

First Published: April 2019

Last Revised: NA

> ***Note: The quality assessment findings in the Analytic Notes Section below should be strongly considered when determining whether the NHANES clinical fluorosis assessment data are appropriate for analytic objectives.***

Component Description

Dental fluorosis clinical assessment was included in the NHANES oral health examination to monitor fluorosis in the population for selected age groups. Fluoride exposure, from any source, during the period of tooth development is associated with increased risk of developing dental (or enamel) fluorosis. Dental fluorosis is characterized by an increasing porosity or hypomineralization of the tooth enamel that leads to visual changes of the enamel that appear once a tooth erupts (Dean, 1934; Fejerskov et al., 1990). The severity of dental fluorosis depends on the dose and duration of fluoride ingestion during tooth development (Dean, 1942; Fejerskov et al., 1990).

In the United States, dental fluorosis is generally considered a cosmetic effect with no negative functional effect (Kaminsky et al., 1990; Fluoride Recommendation Work Group, 2001; US Department of Health and Human Services, 2015). The severe form of dental fluorosis, however, may have adverse dental effects because the pitting can compromise the protective function of the enamel and the affected area can break away (Clark and Slayton, 2014; Fejerskov, et al., 1990; National Research Council, 2006; US Department of Health and Human Services, 2015). But the severe form is rare in the U.S. (Beltran 2010; National Research Council, 2006).

Eligible Sample

A dental fluorosis clinical assessment was conducted on survey participants aged 6-29 years who received the Oral Health Examination (exam status code, OHDEXSTS, is complete or partial).

Protocol and Procedure

The 2015-2016 dental fluorosis clinical assessment followed the same protocols as conducted in 1999-2004 and 2011-2014.

The dental fluorosis clinical assessment was conducted at the NHANES mobile examination center (MEC) by dental examiners, who were dentists (D.D.S. or D.M.D.) licensed in at least one U.S. state. A health technician assisted in entering all examiner observations directly into a computerized data collection system at the MEC. Examiners used a surface reflecting mirror

for the assessment. Teeth were not dried with air before assessment.

All fully erupted, permanent teeth (excluding third molars) were evaluated. The dental fluorosis clinical assessment proceeded tooth-by-tooth in a similar manner as the dental caries assessment, beginning with the maxillary right central incisor and proceeding posteriorly to the upper second molar. Then, the same sequence was repeated for the upper left, lower left, and lower right quadrants of the mouth.

Each tooth was scored according to the Dean's Fluorosis Index (DFI) and assigned one of the DFI disease severity categories (Table 1), based on the area of the tooth surface with visible fluorosis and presence of pitting: normal (DFI=0), questionable (5), very mild (1), mild (2), moderate (3), or severe (4) (Dean, 1934; Dean, 1942). Missing teeth, deciduous (primary) teeth, permanent teeth not fully erupted, and teeth in which more than one-half of the visible surface area was obscured by a restoration, caries, or orthodontic appliance were not assessed. These teeth were coded as cannot be assessed (9). A tooth having a non-fluoride opacity was coded as 8. The NHANES Oral Health Examiners Manual provides detail on assessing a tooth for fluorosis.

Table 1. Dean's Fluorosis Index (DFI) criteria and scoring on the NHANES dental fluorosis clinical assessment

NHANES DFI Value	Fluorosis Severity Level	Description
0	Normal	No fluorosis detected
1	Very mild	Opaque, paperwhite areas involving less than ¼ of the tooth surface
2	Mild	Opaque, paperwhite areas involving ¼ to less than ½ of the tooth surface
3	Moderate	Opaque paperwhite areas involving ½ or more of the tooth surface
4	Severe	Discrete or confluent pitting in involved areas
5	Questionable	Slight aberration of normal enamel appearance, including white flecks
8	Non-fluoride opacity	Coded if non-fluoride opacity
9	Cannot be assessed	Coded if the tooth was missing, not fully erupted, one-half or more of the tooth was replaced with a restoration, covered with orthodontic band, or destroyed by caries.

Quality Assurance & Quality Control

The specific QA practices for the dental fluorosis clinical assessment are documented in detail in the NHANES Oral Health Examiners Manual.

All dental examiners received an initial training which consisted of lecture, model review, practice simulations and standardization sessions. Following successful initial training, examiners received field training at the MEC consisting of more practice simulations, standardizations, and calibration sessions.

During data collection, the reference examiner visited each dental examiner 2-3 times a year to conduct a random number of replicate examinations during each visit. The reference examiner determined if retraining and future monitoring of the dental examiner was needed. The reference examiner also conducted an annual retraining session for all dental examiners to

reinforce existing protocols and to introduce protocol updates as needed.

Since 1999, data for the oral health examination have been recorded directly onto a computerized data collection system at the MEC. The system is integrated centrally and allows for ongoing monitoring of much of the data. As part of the quality control practice, all data are reviewed systematically for logical inconsistencies. Before data release, the collected data are further reviewed.

Data Processing and Editing

While the dental examiners assess the teeth in quadrants, starting from the central incisor and moving to the molars, the data files are produced with the teeth numbered using the Universal or ADA Dental Numbering System. Note that there is no data for tooth numbers 1, 16, 17, and 32. Third molars were not assessed in this clinical examination.

Analytic Notes

1999-2004 and 2011-2016 DATA QUALITY ASSESSMENT CONCLUSIONS

NHANES is currently the only survey providing national estimates on dental fluorosis. Two-year estimates of fluorosis prevalence by DFI category demonstrated variability within and across the six year time periods. Inter-examiner reliability statistics found that agreement ranged from 0.51-0.98 for the nine primary dental examiners in 1999-2016. These values indicate moderate (0.41-0.60) to almost perfect (0.81-0.99) agreement based on Landis and Koch, and mostly adequate agreement (33 out 36 kappas >=0.6) based on McHugh. There was also high percent agreement in defining very mild or greater fluorosis. The proportion of the total number of examinations for which a gold standard examination was conducted was, however, low and the DFI scoring method has high examiner subjectivity. The observed increase in dental fluorosis prevalence with age between 2001-2004 and 2011-2014, based on the analysis of the synthetic cohort, is not biologically plausible. This suggests that there may have been some change in the way the examiners evaluated the level of fluorosis over time.

The quality assessment findings in this document should be strongly considered when determining whether these data are appropriate for the user's analytic objectives, including studies of prevalence and trends. An NCHS Vital and Health Statistics Series 2 Report on the data quality for the NHANES 1999-2004 and 2011-2016 dental fluorosis clinical assessment data is available at NCHS website (National Center for Health Statistics and National Center for Chronic Disease Prevention and Health Promotion, 2019).

DATA EVALUATION OF 1999-2004 AND 2011-2016 FLUOROSIS CLINICAL ASSESSMENT DATA

As described previously, several QA processes were implemented during the dental fluorosis clinical assessment. In addition, evaluation of rater variability and reliability was assessed on the final data. The summary of the data evaluation of the dental fluorosis clinical assessment data from 1999-2004 and 2011-2016 for participants aged 6-19 years (the common age range across all survey years) is provided below.

For these analyses, a person was assigned a dental fluorosis severity value based on the lesser of the two most affected tooth-level DFI values. For all analyses, tooth-level DFI value of cannot be assessed (code 9) and non-fluoride opacity (code 8) were recoded to missing and questionable recoded to 0.5. Only youth with at least two teeth with a non-missing DFI value were assigned a person-level DFI and included in further analyses. Qualitative interpretation of numeric kappa statistic value ranges are: less than chance agreement (<0), slight agreement (0.00-0.20), fair agreement (0.21-0.40), moderate agreement (0.41-0.60), substantial agreement (0.61-0.80), and almost perfect (0.81-0.99) (Landis and Koch, 1977). Kappa <0.60 may also be used as a general indicator of inadequate agreement among raters (McHugh 2012).

Intra-Examiner Reliability: Evaluation of Replicate Examinations from 1999–2001

During 1999–2001, approximately 10% of examined participants aged 6-49 had a repeat second fluorosis examination. Details on these replicate examinations were previously published (Dye et al. 2007) and are summarized here. The weighted kappa statistics comparing the DFI values for the same participant by the same examiner ranged from 0.56 – 0.72, across the three main dental examiners who conducted examinations from 1999 through 2001. These kappa values are considered moderate to substantial agreement. The difference in DFI values for the same teeth assessed in the same way days apart, however, indicates the subjective nature of the DFI scoring method.

Inter-Examiner Reliability: Evaluation of Gold Standard Examinations from 1999–2004 and 2011–2016

Gold standard examinations were conducted by a reference examiner on 3.6% (n=356) and 2.8% (n=210) of participants aged 6-19 years in 1999–2004 and 2011–2016, respectively. Complete data for analysis (i.e., at least two teeth with valid DFI values for both examiner and reference) were available for 339 participants aged 6-19 years in 1999-2004 and 198 in 2011-2016. These analyses did not use the survey examination weights.

Weighted kappa statistics were computed using different weighting schemes (explained below) which assigned specific values to the various possible levels of disagreement between dental examiner and reference examiner on the DFI scale (i.e., difference in one category, two categories, etc.).

Unweighted kappa (Cohen et al. 1960) assigns a weight of 1 for perfect agreement (e.g., examiner DFI = 1 and reference DFI =1) and 0 for no agreement (e.g., examiner DFI = 1 and reference DFI =2); Custom #1 weights assigned 1 for perfect agreement, 0.667 for 1 category difference, 0.333 for a 2 category difference, and 0 for more than 2 categories; Custom #2 (based on Kumar et al. 2000) assigned 1 for perfect agreement, 0.5 for 1 category difference, and 0 for all others; the other two weighting schemes were based on Cicchetti and Allison (1971) and Fleiss and Cohen (1973). Unweighted kappa values for examiners ranged from 0.35 to 0.78, with five of nine examiners having values below 0.60 during the two 6-year time periods (Table 2). When considering the results across all four weighting schemes, the agreement between the dental examiners and reference examiner ranged from 0.51 through 0.87 for the five primary dental examiners who conducted examinations in 1999-2004 and from 0.60 through 0.98 for the four primary examiners during 2011-2016. For both time periods, these reliability statistics would be considered moderate to almost perfect agreement based on the Landis and Koch interpretation of kappa values. When McHugh's requirement of a kappa value of at least 0.60 for adequate agreement is applied, the majority of the kappa values indicate adequate agreement (i.e., 33 out of 36 kappa values (computed for 9 examiners for 4 different weighting schemes) were at or above 0.60).

Table 2. Percent agreement and kappa statistics on person-level Dean's Fluorosis Index values assigned by dental examiner and reference examiner for participants aged 6-19 years with available gold standard observations by 6-year survey period: National Health and Nutrition Examination Survey, 1999-2004 and 2011-2016

Survey Years	Examiner	n	Agreement (%)	Unweighted kappa	Weighted Cicchetti-Allison	Weighted Fleiss-Cohen	Weighted Custom #1	Weighted Custom #2
1999-2004	A	62	58.1	0.45	0.62	0.77	0.60	0.54
1999-2004	B	53	73.6	0.64	0.77	0.87	0.78	0.76
1999-2004	C	48	72.9	0.61	0.70	0.81	0.70	0.69
1999-2004	D	97	62.9	0.51	0.71	0.86	0.68	0.64
1999-2004	E	38	47.4	0.35	0.62	0.80	0.57	0.51
2011-2016	F	66	63.6	0.53	0.70	0.82	0.69	0.65
2011-2016	G	26	84.6	0.78	0.93	0.98	0.87	0.84
2011-2016	H	60	66.7	0.48	0.64	0.77	0.62	0.60
2011-2016	I	25	80.0	0.69	0.81	0.90	0.73	0.71

NOTES: All kappa statistics were computed using the following Dean's Fluorosis Index values:
0 = Normal, 0.5 = Questionable (recoded from collected value of 5), 1 = Very mild; 2 = Mild,
3 = Moderate, 4 = Severe. All values of 8 (non-fluoride opacity) and 9 (could not assess) were
set to missing.

Percent agreement between dental and reference examiners in categorizing fluorosis

When DFI categories are collapsed into broader categories and fluorosis is defined as mild or
greater severity, the examiner and reference agreed on 88.8% of cases in 1999-2004;
agreement was 89.4% in 2011-2016. When fluorosis is defined as moderate or severe,
agreement is 97.1% in 1999-2004 and 94.4% in 2011-2016. It is expected that agreement
would improve when broader categories are assessed since agreement is achieved as long as
both examiners rate the same DFI category or higher.

As a means of detecting systematic scoring biases, differences between the dental examiner
and reference examiner were further explored by examining the direction of the disagreement
between the dental examiner's and the reference examiner's person-level DFI values (Table 3).
Among the cases where there was disagreement between the examiner and reference, in
1999–2004, the examiner scored higher than the reference examiner on 48.8% of these
cases, while the reference examiner scored higher than the dental examiner on 51.2%. In
2011–2016, the examiner scored higher than the reference examiner on 54.8% of cases,
whereas the reference examiner scored higher than the examiner on 45.2%. The majority of
the disagreement was by one DFI level: 82.7% in 1999–2004 and 88.7% in 2011–2016.

Table 3. Disagreement on person-level Dean's Fluorosis Index values assigned by dental
examiner and reference examiner for participants aged 6-19 years with available gold standard
observations, by 6-year survey period: National Health and Nutrition Examination Survey,
1999-2004 and 2011-2016

Survey Years	# Gold Standard Exams	Disagree [1]		Examiner > Reference	Reference > Examiner	Differ by 1 level	Differ by 2 levels	Differ by 3 levels	Differ by 4 levels	Differ by 5 levels
		n	%	%	%	%	%	%	%	%
1999-2004	339	127	37.5	48.8	51.2	82.7	15.0	2.4	0	0
2011-2016	198	62	31.3	54.8	45.2	88.7	11.3	0	0	0

[1]Disagreements are based on differences in person-level Dean's Fluorosis Index values: 0 = Normal, 0.5 = Questionable (recoded from collected value of 5), 1 = Very mild; 2 = Mild, 3 = Moderate, 4 = Severe. For example, examiner score = questionable and reference score = very mild is reported in this table as differing by 1 level.

Overall, for the two 6-year survey periods, there was similarity between the dental examiner and reference examiners in the person-level DFI values (Table 4). In 1999-2004, 48.7% were classified by the dental examiner and 49.8% by the reference examiner with DFI values of very mild or greater. In 2011-2016, the percentages were 74.2% and 73.7%, respectively.

Table 4. Percent of survey participants aged 6-19 years with gold standard observations classified at each person-level Dean's Fluorosis Index value: National Health and Nutrition Examination Surveys, 1999-2004 and 2011-2016

	1999-2004 (n=339)		2011-2016 (n=198)	
Dean's Fluorosis Index level	Dental Examiners (%)	Reference Examiner (%)	Dental Examiners (%)	Reference Examiner (%)
Normal	26.0	30.1	13.1	11.6
Questionable	25.4	20.1	12.6	14.6
Very mild	29.8	26.8	34.9	39.9
Mild	13.0	15.3	23.7	17.7
Moderate	5.0	5.6	13.1	13.1
Severe	0.9	2.1	2.5	3.0

Prevalence of Dental Fluorosis Severity Among Youth

Weighted 2- and 6-year estimates of dental fluorosis severity were computed on children 6-19 years (the common age range across all years) who had at least 2 teeth with a non-missing DFI value (1999-2004, n=9395; 2011-2016, n=7158). These analyses used the examination sample weights.

During 1999-2004, 25.3% (SE=1.5) of youth 6–19 years were estimated to have very mild fluorosis, 7.7% (SE=0.5) mild, 3.2% (SE=0.4) moderate, and 0.4% (SE=0.1) severe (Table 5, Figure 1). In 2011–2016, 35.6% (SE=2.5) of youth 6–19 years were estimated to have very mild fluorosis, 21.5% (SE=2.2) mild, 13.4% (SE=1.5) moderate, and 1.0% (SE=0.2) severe (Table 5, Figure 2). In 1999–2004, 3.6% of youth 6–19 years had moderate or severe fluorosis; whereas, in 2011–2016 the percent increased to 14.4%.

Variability in the prevalence of different dental fluorosis severity levels was seen within each 6-year time period, as well as across the two time periods (Table 5, Figures 1 and 2). For example, during 1999-2004, questionable fluorosis ranged from 0.4% to 34.6%. During 2011-2016, mild fluorosis prevalence ranged from 9.1% to 40.4% and moderate fluorosis prevalence ranged from 1.3% to 20.6%.

Table 5. Percentage (weighted) dental fluorosis severity levels, based on person-level Dean's Fluorosis Index, among youth 6-19 years: National Health and Nutrition Examination Surveys 1999-2004 and 2011-2016

Survey Years	n	Normal Percent (SE)	Questionable Percent (SE)	Very Mild Percent (SE)	Mild Percent (SE)	Moderate Percent (SE)	Severe Percent (SE)
1999-2004	**9,395**	**44.3 (2.8)**	**19.2 (1.6)**	**25.3 (1.5)**	**7.7 (0.5)**	**3.2 (0.4)**	**0.4 (0.1)**
1999-2000	3,103	65.9 (4.6)	0.4 (0.2)	22.3 (3.1)	7.0 (0.9)	3.9 (1.1)	0.5 (0.2)
2001-2002	3,326	48.8 (5.4)	20.6 (3.6)	21.8 (2.1)	6.4 (0.8)	2.1 (0.3)	0.2 (0.1)
2003-2004	2,966	20.0 (2.8)	34.6 (1.8)	31.9 (2.6)	9.5 (1.0)	3.5 (0.7)	0.5 (0.2)
2011-2016	**7,158**	**18.1 (1.6)**	**10.4 (1.1)**	**35.6 (2.5)**	**21.5 (2.2)**	**13.4 (1.5)**	**1.0 (0.2)**
2011-2012	2,304	34.1 (4.0)	8.8 (0.9)	19.5 (2.1)	14.9 (1.6)	20.6 (3.7)	2.0 (0.5)
2013-2014	2,502	6.1 (1.2)	5.7 (1.3)	28.7 (4.2)	40.4 (5.2)	18.4 (2.1)	0.8 (0.3)
2015-2016	2,352	14.3 (2.9)	16.8 (3)	58.4 (4.9)	9.1 (2.2)	1.3 (0.4)	0.1 (0.1)

SE=standard error

Figure 1. Percent (weighted) dental fluorosis severity levels, based on person-level Dean's Fluorosis Index (DFI), among youth 6-19 years, National Health and Nutrition Examination Surveys 1999-2004
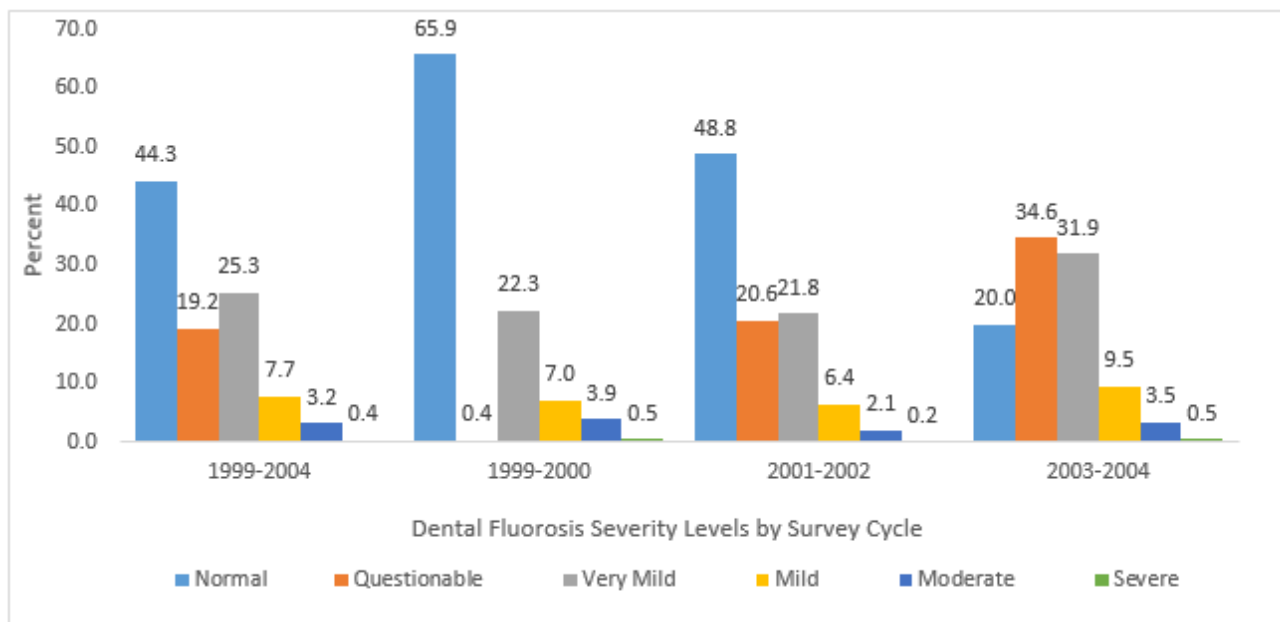
Figure 2. Percent (weighted) dental fluorosis severity levels, based on person-level Dean's Fluorosis Index (DFI), among youth 6-19 years, National Health and Nutrition Examination Surveys 2011-2016
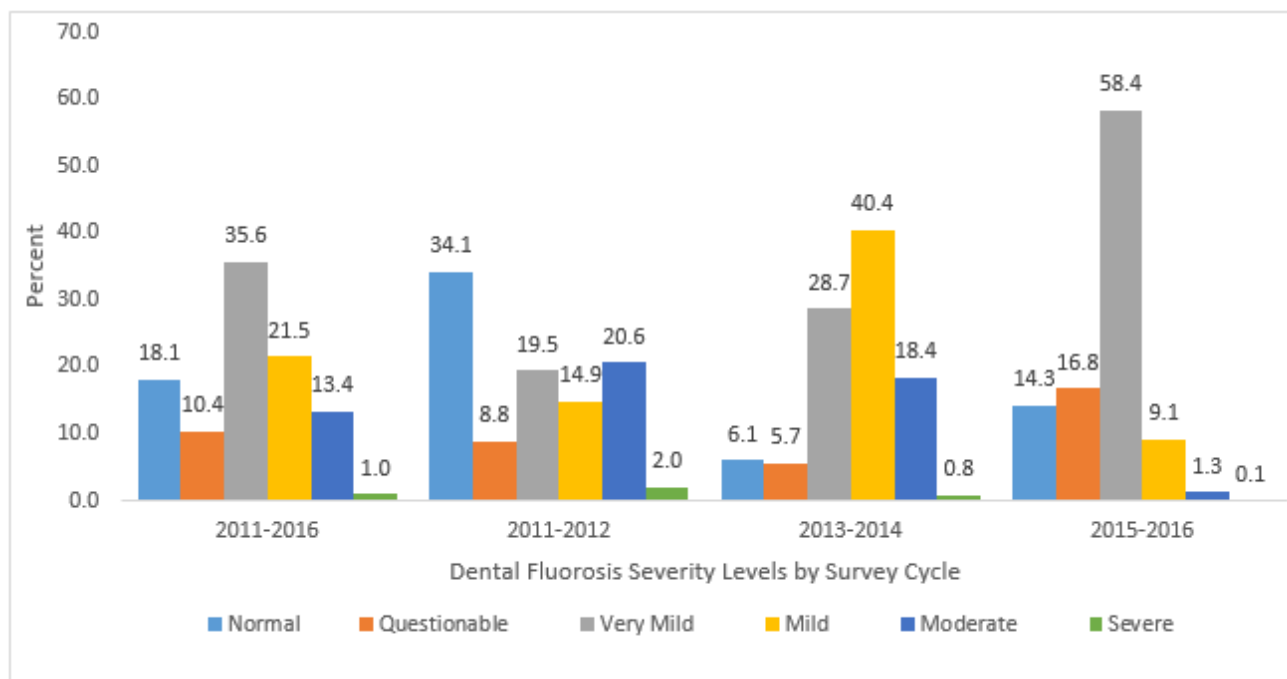
Dental Fluorosis Severity Levels by Survey Cycle

Assessing Biological Plausibility of Prevalence Estimates

Further evaluation was conducted on the NHANES 1999-2004 and 2011-2016 dental fluorosis clinical assessment data to determine whether the prevalence estimates presented above could be consistent with the known etiology of fluorosis.

Fluoride ingestion prior to tooth eruption is the only known cause of fluorosis (Fejerskov et al., 1990); therefore, there should be no change in fluorosis prevalence among erupted permanent teeth of the same tooth type in the same birth cohort over time. For this analysis, a synthetic birth cohort that included youth aged 6-9 years in 2001-2004 (born 1992–1998; n=1097) and youth aged 16-19 years in 2011-2014 (born 1992–1998; n=1193) was constructed to determine if the percent with fluorosis, for a given tooth type (specifically first permanent molars, which usually appear between 6-7 years; ADA, 2006) was constant with age, as would be expected given that fluorosis develops before teeth erupt. Logistic regression and computed predictive marginals were used to estimate the prevalence of mild or greater and moderate or severe dental fluorosis in the first permanent molars (identified in the data file as tooth numbers 3, 14, 19, 30) among youth aged 6-9 years in 2001-2004 and 16-19 years in 2011-2014. Adjusted models, which included sex and race and Hispanic origin, were run to control for possible population changes over the time period.

Prevalence (adjusted for age and race and Hispanic origin) of mild or greater fluorosis in the first permanent molars of youth aged 6-9 years in 2001–2004 was 9.5% (standard error (SE) = 0.01) and among youth aged 16-19 years in 2011–2014 was 46.9% (SE = 0.04, p<.001). This increase between surveys was unexpected, because the prevalence of fluorosis in the first permanent molar should not change over time among a similar birth cohort given that tooth eruption has already occurred by 6-9 years of age. Similarly, adjusted prevalence of moderate and severe fluorosis in the first permanent molars of the birth cohort increased from 2.8% (SE = 0.01) in 2001–2004 to 17.7% (SE = 0.3) in 2011–2014 (p<.001). Estimates were similar in unadjusted models.

Impact of Oversampling in NHANES

During 1999–2016, there were changes in the racial and ethnic composition of the U.S. population. Also, in 2011–2016, NHANES started oversampling Asian American persons and continued the oversampling of Hispanic persons, which began in 2007. The oversampling of adolescents was also discontinued in 2007. It may be possible that underlying changes in the

population composition of the U.S. or NHANES sample design changes affected the overall prevalence estimates of dental fluorosis and contributed to some of the observed differences in estimates between 1999-2004 and 2011–2016.

Closer examination of the race and Hispanic origin estimates from 2011–2016, however, showed no differences in the prevalence of dental fluorosis for the specific severity categories across the different race and Hispanic origin groups. In 1999–2004, the race and Hispanic origin groups (specifically, non-Hispanic white, non-Hispanic black, and Mexican-American) follow a similar pattern to 2011–2016 (data not shown).

Impact of Geographic Variation in Water Fluoridation Levels

Determining the water fluoridation level in a given NHANES location is not straightforward given that a county may include multiple water systems. For example, in 2013, there were 345 total public water systems (PWSs) for seven of the NHANES locations visited that year. Nine of the 345 PWSs had levels higher than 1.2 mg/L. These nine were all from a location with a substantial number of PWSs.

As stated earlier, dental fluorosis typically occurs from fluoride exposure during early tooth development before eruption, typically. Therefore, water fluoride levels many years before the NHANES examination would need to be assessed to determine exposure levels rather than levels for participants at the time of examination. For example, fluoride exposure for a 19-year-old participant examined in 1999 would have occurred during 1980–1986. Determining actual fluoride exposure during childhood, however, is further complicated by the uncertainty of migration patterns among families (i.e., if they ever moved, taking them from one PWS to another).

1999-2004 and 2011-2016 DATA QUALITY ASSESSMENT SUMMARY

There are potential sources of error in the measurement of fluorosis in general, and specifically in sample surveys, such as NHANES. For time-varying factors, these may include intra-subject (within subject) variation and intra- or inter-examiner (within or between examiner) variations in measurement. Within-subject variation could occur if there were changes in the underlying disease process between assessments. However, dental fluorosis is the result of exposure to fluoride from when a child is born up to about 8 years of age. Therefore, intra-subject variability due to physiological or biological reasons is unlikely. Intra- or inter-examiner error, however, may occur due to lack of adherence to the protocol by examiners and changes in quality control procedures over time. During 1999–2004 and 2011–2016, there were only minor changes to the dental fluorosis assessment protocol (no dental explorer used for assessment in 2011–2016) and the QA procedures (repeat examinations by the same examiner only occurred in 1999–2001). There was no change to the measurement scale (DFI). This index is, however, known for its subjective nature, which leads to potential variability, especially at the low end of the index where distinguishing between very mild (i.e., less than 25% of the tooth) and mild (25% to less than 50%) can be difficult. Evaluation of gold standard examinations found that agreement (across 4 different weighting schemes) ranged from 0.51 to 0.98 for the 9 primary dental examiners in 1999-2016. These values indicate moderate (0.41-0.60) to almost perfect (0.81-0.99) agreement based on Landis and Koch, and mostly adequate agreement (33 out 36 kappas >=0.6) based on McHugh. It is possible, however, that the quantity of repeats as a percentage of the total examined persons (2.8%–3.6%) was inadequate for making conclusions on the reliability of a tool with such subjective variability. Additionally, the assessment of intra-examiner reliability from 1999–2001, as published by Dye et al. (2007), did not show perfect agreement in scoring of the same person only a few days later (weighted kappa statistics comparing person-level scores for the same participant by the same examiner ranged from 0.56 to 0.72). This demonstrates the substantial subjectivity and variability of this scoring method. There was no assessment of intra-examiner reliability in 2011–2016, and procedures to ensure calibration of the reference examiner over time are not available. Therefore, the possibility of a shift in how the examiners assessed dental fluorosis over time cannot be ruled out.

The impact of the complex sampling scheme of NHANES and geographic variability in the presence of fluoride in drinking water on the results were also evaluated. While there were significant sample design changes between 1999–2004 and 2011–2016, and specifically with

the oversampled groups, when proper weighting procedures are used, the final estimates produced should still be reflective of the civilian noninstitutionalized U.S. population of youth aged 6–19 years, and estimates from the different survey periods should be comparable. There were no changes to the inclusion and exclusion criteria for the examination for youth aged 6–19 years specifically and no differences in the percentage of the sample who completed the fluorosis assessment.

Variability in the prevalence of different dental fluorosis severity levels was seen within each 6-year time period, as well as across the two time periods. For example, during 1999-2004, questionable fluorosis ranged from 0.4% to 34.6% and during 2011–2016, mild fluorosis prevalence ranged from 9.1% to 40.4%. The reasons for this variability cannot be determined but likely include random error, true change in prevalence, or changes in the application of measurement processes. There may be other factors outside of these that could also contribute to the variability in 2-year prevalence estimates.

Further analyses of the synthetic birth cohort born in 1992-1998, revealed that the prevalence of mild or greater fluorosis in the first permanent molars was 9.5% in youth aged 6–9 years in 2001–2004, but was 46.9% in youth aged 16–19 years in 2011–2014. This increase does not seem biologically plausible since fluorosis develops before teeth erupt and therefore prevalence in erupted teeth for the same birth cohort should not change over time. The analysis of the synthetic cohort with adjustment for possible changes in the demographic characteristics of the population over time, suggests that the observed increase in fluorosis prevalence does not reflect the genuine amount of change within the U.S. population.

For general information on analyzing NHANES data and the use of examination sample weights refer to the NHANES Analytic Guidelines and the on-line NHANES Tutorial.

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Codebook and Frequencies

SEQN - Respondent sequence number

Variable Name:	SEQN
SAS Label:	Respondent sequence number
English Text:	Respondent sequence number.
Target:	Both males and females 6 YEARS - 29 YEARS

FCX02DI - Fluorosis DI: #2

Variable Name: FCX02DI

SAS Label: Fluorosis DI: #2

English Text: Fluorosis Deans Index: Upper right 2nd molar (2M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	365	365	
1	Very mild	1105	1470	
2	Mild	154	1624	
3	Moderate	17	1641	
4	Severe	2	1643	
5	Questionable	315	1958	
8	Non-fluoride opacities	6	1964	
9	Cannot be assessed	1470	3434	
.	Missing	44	3478	

FCX03DI - Fluorosis DI: #3

Variable Name: FCX03DI

SAS Label: Fluorosis DI: #3

English Text: Fluorosis Deans Index: Upper right 1st molar (1M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	563	563	
1	Very mild	1593	2156	
2	Mild	187	2343	
3	Moderate	19	2362	
4	Severe	3	2365	
5	Questionable	552	2917	
8	Non-fluoride opacities	18	2935	
9	Cannot be assessed	499	3434	
.	Missing	44	3478	

FCX04DI - Fluorosis DI: #4

Variable Name:	FCX04DI
SAS Label:	Fluorosis DI: #4
English Text:	Fluorosis Deans Index: Upper right 2nd bicuspid/2nd primary molar (2B)
Target:	Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	729	729	
1	Very mild	405	1134	
2	Mild	82	1216	
3	Moderate	15	1231	
4	Severe	1	1232	
5	Questionable	994	2226	
8	Non-fluoride opacities	8	2234	
9	Cannot be assessed	1200	3434	
.	Missing	44	3478	

FCX05DI - Fluorosis DI: #5

Variable Name: FCX05DI

SAS Label: Fluorosis DI: #5

English Text: Fluorosis Deans Index: Upper right 1st bicuspid/1st primary molar (1B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	760	760	
1	Very mild	413	1173	
2	Mild	77	1250	
3	Moderate	13	1263	
4	Severe	1	1264	
5	Questionable	976	2240	
8	Non-fluoride opacities	17	2257	
9	Cannot be assessed	1177	3434	
.	Missing	44	3478	

FCX06DI - Fluorosis DI: #6

Variable Name: FCX06DI

SAS Label: Fluorosis DI: #6

English Text: Fluorosis Deans Index: Upper right cuspid (C)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1052	1052	
1	Very mild	292	1344	
2	Mild	40	1384	
3	Moderate	3	1387	
4	Severe	1	1388	
5	Questionable	752	2140	
8	Non-fluoride opacities	24	2164	
9	Cannot be assessed	1270	3434	
.	Missing	44	3478	

FCX07DI - Fluorosis DI: #7

Variable Name: FCX07DI

SAS Label: Fluorosis DI: #7

English Text: Fluorosis Deans Index: Upper right lateral incisor (LI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1242	1242	
1	Very mild	384	1626	
2	Mild	58	1684	
3	Moderate	11	1695	
4	Severe	1	1696	
5	Questionable	840	2536	
8	Non-fluoride opacities	39	2575	
9	Cannot be assessed	859	3434	
.	Missing	44	3478	

FCX08DI - Fluorosis DI: #8

Variable Name: FCX08DI

SAS Label: Fluorosis DI: #8

English Text: Fluorosis Deans Index: Upper right central incisor (CI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1374	1374	
1	Very mild	398	1772	
2	Mild	90	1862	
3	Moderate	24	1886	
4	Severe	1	1887	
5	Questionable	989	2876	
8	Non-fluoride opacities	59	2935	
9	Cannot be assessed	499	3434	
.	Missing	44	3478	

FCX09DI - Fluorosis DI: #9

Variable Name: FCX09DI

SAS Label: Fluorosis DI: #9

English Text: Fluorosis Deans Index: Upper left central incisor (CI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1347	1347	
1	Very mild	421	1768	
2	Mild	97	1865	
3	Moderate	23	1888	
4	Severe	1	1889	
5	Questionable	987	2876	
8	Non-fluoride opacities	56	2932	
9	Cannot be assessed	502	3434	
.	Missing	44	3478	

FCX10DI - Fluorosis DI: #10

Variable Name: FCX10DI

SAS Label: Fluorosis DI: #10

English Text: Fluorosis Deans Index: Upper left lateral incisor (LI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1189	1189	
1	Very mild	401	1590	
2	Mild	63	1653	
3	Moderate	9	1662	
4	Severe	2	1664	
5	Questionable	875	2539	
8	Non-fluoride opacities	37	2576	
9	Cannot be assessed	858	3434	
.	Missing	44	3478	

FCX11DI - Fluorosis DI: #11

Variable Name: FCX11DI

SAS Label: Fluorosis DI: #11

English Text: Fluorosis Deans Index: Upper left cuspid (C)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1014	1014	
1	Very mild	301	1315	
2	Mild	46	1361	
3	Moderate	4	1365	
4	Severe	1	1366	
5	Questionable	800	2166	
8	Non-fluoride opacities	15	2181	
9	Cannot be assessed	1253	3434	
.	Missing	44	3478	

FCX12DI - Fluorosis DI: #12

Variable Name: FCX12DI

SAS Label: Fluorosis DI: #12

English Text: Fluorosis Deans Index: Upper left 1st bicuspid/1st primary molar (1B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	717	717	
1	Very mild	429	1146	
2	Mild	93	1239	
3	Moderate	16	1255	
4	Severe	1	1256	
5	Questionable	1009	2265	
8	Non-fluoride opacities	6	2271	
9	Cannot be assessed	1163	3434	
.	Missing	44	3478	

FCX13DI - Fluorosis DI: #13

Variable Name: FCX13DI

SAS Label: Fluorosis DI: #13

English Text: Fluorosis Deans Index: Upper left 2nd bicuspid/2nd primary molar (2B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	662	662	
1	Very mild	429	1091	
2	Mild	111	1202	
3	Moderate	17	1219	
4	Severe	1	1220	
5	Questionable	1017	2237	
8	Non-fluoride opacities	10	2247	
9	Cannot be assessed	1187	3434	
.	Missing	44	3478	

FCX14DI - Fluorosis DI: #14

Variable Name: FCX14DI

SAS Label: Fluorosis DI: #14

English Text: Fluorosis Deans Index: Upper left 1st molar (1M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	530	530	
1	Very mild	1585	2115	
2	Mild	219	2334	
3	Moderate	31	2365	
4	Severe	5	2370	
5	Questionable	535	2905	
8	Non-fluoride opacities	21	2926	
9	Cannot be assessed	508	3434	
.	Missing	44	3478	

FCX15DI - Fluorosis DI: #15

Variable Name: FCX15DI

SAS Label: Fluorosis DI: #15

English Text: Fluorosis Deans Index: Upper left 2nd molar (2M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	328	328	
1	Very mild	1097	1425	
2	Mild	180	1605	
3	Moderate	20	1625	
4	Severe	3	1628	
5	Questionable	309	1937	
8	Non-fluoride opacities	4	1941	
9	Cannot be assessed	1493	3434	
.	Missing	44	3478	

FCX18DI - Fluorosis DI: #18

Variable Name: FCX18DI

SAS Label: Fluorosis DI: #18

English Text: Fluorosis Deans Index: Lower left 2nd molar (2M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	360	360	
1	Very mild	1073	1433	
2	Mild	146	1579	
3	Moderate	13	1592	
4	Severe	2	1594	
5	Questionable	268	1862	
8	Non-fluoride opacities	10	1872	
9	Cannot be assessed	1562	3434	
.	Missing	44	3478	

FCX19DI - Fluorosis DI: #19

Variable Name: FCX19DI

SAS Label: Fluorosis DI: #19

English Text: Fluorosis Deans Index: Lower left 1st molar (1M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	650	650	
1	Very mild	1534	2184	
2	Mild	164	2348	
3	Moderate	25	2373	
4	Severe	7	2380	
5	Questionable	462	2842	
8	Non-fluoride opacities	25	2867	
9	Cannot be assessed	567	3434	
.	Missing	44	3478	

FCX20DI - Fluorosis DI: #20

Variable Name: FCX20DI

SAS Label: Fluorosis DI: #20

English Text: Fluorosis Deans Index: Lower left 2nd bicuspid/2nd primary molar (2B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	744	744	
1	Very mild	360	1104	
2	Mild	65	1169	
3	Moderate	9	1178	
4	Severe	2	1180	
5	Questionable	1054	2234	
8	Non-fluoride opacities	12	2246	
9	Cannot be assessed	1188	3434	
.	Missing	44	3478	

FCX21DI - Fluorosis DI: #21

Variable Name: FCX21DI

SAS Label: Fluorosis DI: #21

English Text: Fluorosis Deans Index: Lower left 1st bicuspid/1st primary molar (1B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	815	815	
1	Very mild	347	1162	
2	Mild	65	1227	
3	Moderate	10	1237	
4	Severe	1	1238	
5	Questionable	1056	2294	
8	Non-fluoride opacities	16	2310	
9	Cannot be assessed	1124	3434	
.	Missing	44	3478	

FCX22DI - Fluorosis DI: #22

Variable Name: FCX22DI

SAS Label: Fluorosis DI: #22

English Text: Fluorosis Deans Index: Lower left cuspid (C)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1422	1422	
1	Very mild	193	1615	
2	Mild	33	1648	
3	Moderate	2	1650	
4	Severe	2	1652	
5	Questionable	702	2354	
8	Non-fluoride opacities	14	2368	
9	Cannot be assessed	1066	3434	
.	Missing	44	3478	

FCX23DI - Fluorosis DI: #23

Variable Name: FCX23DI

SAS Label: Fluorosis DI: #23

English Text: Fluorosis Deans Index: Lower left lateral incisor (LI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	2526	2526	
1	Very mild	85	2611	
2	Mild	14	2625	
3	Moderate	1	2626	
4	Severe	2	2628	
5	Questionable	348	2976	
8	Non-fluoride opacities	18	2994	
9	Cannot be assessed	440	3434	
.	Missing	44	3478	

FCX24DI - Fluorosis DI: #24

Variable Name: FCX24DI

SAS Label: Fluorosis DI: #24

English Text: Fluorosis Deans Index: Lower left central incisor (CI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	2711	2711	
1	Very mild	77	2788	
2	Mild	15	2803	
3	Moderate	2	2805	
4	Severe	2	2807	
5	Questionable	338	3145	
8	Non-fluoride opacities	23	3168	
9	Cannot be assessed	266	3434	
.	Missing	44	3478	

FCX25DI - Fluorosis DI: #25

Variable Name: FCX25DI

SAS Label: Fluorosis DI: #25

English Text: Fluorosis Deans Index: Lower right central incisor (CI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	2696	2696	
1	Very mild	84	2780	
2	Mild	15	2795	
3	Moderate	1	2796	
4	Severe	1	2797	
5	Questionable	336	3133	
8	Non-fluoride opacities	27	3160	
9	Cannot be assessed	274	3434	
.	Missing	44	3478	

FCX26DI - Fluorosis DI: #26

Variable Name: FCX26DI

SAS Label: Fluorosis DI: #26

English Text: Fluorosis Deans Index: Lower right lateral incisor (LI)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	2529	2529	
1	Very mild	95	2624	
2	Mild	12	2636	
3	Moderate	0	2636	
4	Severe	2	2638	
5	Questionable	329	2967	
8	Non-fluoride opacities	17	2984	
9	Cannot be assessed	450	3434	
.	Missing	44	3478	

FCX27DI - Fluorosis DI: #27

Variable Name: FCX27DI

SAS Label: Fluorosis DI: #27

English Text: Fluorosis Deans Index: Lower right cuspid (C)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	1420	1420	
1	Very mild	189	1609	
2	Mild	28	1637	
3	Moderate	2	1639	
4	Severe	2	1641	
5	Questionable	714	2355	
8	Non-fluoride opacities	15	2370	
9	Cannot be assessed	1064	3434	
.	Missing	44	3478	

FCX28DI - Fluorosis DI: #28

Variable Name: FCX28DI

SAS Label: Fluorosis DI: #28

English Text: Fluorosis Deans Index: Lower right 1st bicuspid/1st primary molar (1B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	794	794	
1	Very mild	337	1131	
2	Mild	66	1197	
3	Moderate	9	1206	
4	Severe	2	1208	
5	Questionable	1081	2289	
8	Non-fluoride opacities	17	2306	
9	Cannot be assessed	1128	3434	
.	Missing	44	3478	

FCX29DI - Fluorosis DI: #29

Variable Name: FCX29DI

SAS Label: Fluorosis DI: #29

English Text: Fluorosis Deans Index: Lower right 2nd bicuspid/2nd primary molar (2B)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	709	709	
1	Very mild	358	1067	
2	Mild	67	1134	
3	Moderate	11	1145	
4	Severe	2	1147	
5	Questionable	1075	2222	
8	Non-fluoride opacities	8	2230	
9	Cannot be assessed	1204	3434	
.	Missing	44	3478	

FCX30DI - Fluorosis DI: #30

Variable Name: FCX30DI

SAS Label: Fluorosis DI: #30

English Text: Fluorosis Deans Index: Lower right 1st molar (1M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	593	593	
1	Very mild	1540	2133	
2	Mild	184	2317	
3	Moderate	27	2344	
4	Severe	5	2349	
5	Questionable	478	2827	
8	Non-fluoride opacities	25	2852	
9	Cannot be assessed	582	3434	
.	Missing	44	3478	

FCX31DI - Fluorosis DI: #31

Variable Name: FCX31DI

SAS Label: Fluorosis DI: #31

English Text: Fluorosis Deans Index: Lower right 2nd molar (2M)

Target: Both males and females 6 YEARS - 29 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	Normal	339	339	
1	Very mild	1079	1418	
2	Mild	157	1575	
3	Moderate	8	1583	
4	Severe	2	1585	
5	Questionable	266	1851	
8	Non-fluoride opacities	8	1859	
9	Cannot be assessed	1575	3434	
.	Missing	44	3478	