Changes in Dental Fluorosis and Dental Caries in Newburgh and Kingston, New York

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ABSTRACT

Objectives. This study sought to determine whether the prevalence of dental fluorosis and dental caries had changed in a fluoridated community and a nonfluoridated community since an earlier study conducted in 1986.

Methods. Dental fluorosis and dental caries data were collected on 7- to 14-year-old lifelong residents (n = 1493) of Newburgh and Kingston, NY.

Results. Estimated dental fluorosis prevalence rates were 19.6% in Newburgh and 11.7% in Kingston. The greatest disparity in caries scores was observed between poor and nonpoor children in nonfluoridated Kingston.

Conclusions. The prevalence of dental fluorosis has not declined in Newburgh and Kingston, whereas the prevalence of dental caries has continued to decline. (*Am J Public Health.* 1998;88:1866–1870)

The use of fluoride has long been the cornerstone of public health programs designed to reduce the problem of dental caries in the United States. More than 144 million people in the United States live in areas with access to fluoridated water.[1] Unlike the situation that existed before the 1960s, when food and drinking water were the principal sources of ingested fluoride, today fluoride is available from fluoride supplements, dentifrices, rinses, gels, fruit juices, and carbonated beverages.[2–16] This increased availability has raised concerns about total intakes of fluoride.[3,4]

It is generally acknowledged that the prevalence of dental fluorosis, an indicator of excessive fluoride intake, has increased over the last 40 years and that the increase has been more pronounced in nonfluoridated communities.[10,17–24] In the United States, several recommendations were made in the 1980s to reduce fluoride ingestion from ready-to-feed infant formulas, fluoride supplements, and other fluoride products.[25–27]

As a means of determining whether the prevalence of fluorosis and caries has changed among children born after 1980, a study was undertaken in the cities of Newburgh and Kingston, NY. The city of Newburgh was fluoridated in 1945, and records indicate that fluoride in the water was maintained at 1 ± 0.2 ppm except for a 3-year interruption between 1978 and 1981. Kingston's water has a fluoride content of less than 0.3 ppm.[28]

These cities were chosen in 1945 for a community clinical trial of water fluoridation because of their similarities.[29] Since 1945, however, the availability of fluoride from sources other than water in Kingston has increased, and the communities have become less similar in their population characteristics.[19] Census data reveal that, in comparison with Kingston, Newburgh has a higher level of poverty (26% vs 12%), a lower percentage of persons with a college-level education (29% vs 43%), a lower percentage of Whites in the population (51% vs 87%), a higher rate of unemployment (12% vs 6%), and a different occupational distribution.[30]

Methods

Study Population

The design of the study was similar to that of the previous studies conducted in Newburgh and Kingston.[19,29] Children in grades 1 through 8 attending 10 schools in Newburgh and 7 schools in Kingston were invited to participate in the study; the final sample of 3226 children represented approximately 37% and 39% of all children in these schools, respectively.

Data Collection Procedures

The examination criteria for diagnosis of dental fluorosis were similar to those used in the previous studies.[19,29] Dental fluorosis and caries were determined according to Dean's classification and the National Institute of Dental Research criteria, respectively.[31–33] A pretested questionnaire was used for collecting residential and fluoride history data. A 6-month follow-up of 199 parents showed that the percentage agreement rates on residential history, daily fluoride supplement use, and early brushing were 94.7%, 78.4%, and 68.2%, respectively.

Four dentists conducted the clinical examinations in schools and recorded the data using Epi Info.[34] Reliability estimates for dental fluorosis obtained from 166 replicate examinations showed agreement levels exceeding 81% for Dean's Community Fluorosis Index (with κ statistics of 0.65, 0.76, and 1.0 for 3 of the examiners relative to the fourth). For dental caries examinations, the interclass correlation coefficient exceeded 0.87.

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Statistical Analysis

The analysis was limited to 1493 children 7 to 14 years old who had been lifelong residents of Newburgh and Kingston. Weighted estimates of the prevalence of fluorosis, Dean's Community Fluorosis Index, and their respective standard errors were calculated with SUDAAN.[35] Weights were based on the 8 grade levels and on 4 racial/ethnic strata within each city. Unweighted fluorosis prevalence and the Community Fluorosis Index were computed for comparisons between the surveys. A random assignment method[36] was used to impute missing values for fluoride exposure, education, breast-feeding, and school lunch variables.

Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for 3 variables associated with fluorosis in the bivariate analyses ($P < .1$) and 4 other variables of interest via logistic regression procedures.[37,38] The fluoride exposure categories were (1) water fluoridation alone; (2) water fluoridation in addition to either the use of daily fluoride supplements during the first 8 years (fluoride supplements) or brushing before the age of 2 years (early brushing) or both; (3) early brushing alone; (4) use of daily fluoride supplements alone; (5) combined use of fluoride supplements and early brushing; and (6) a reference group consisting of the remaining children who reported none of these exposures.

Changes in dental caries prevalence within each city were determined by computing age-standardized decayed/missing/filled surface (DMFS) indices using the 1990 New York State population as the standard. The criterion of participation in the free-lunch program in schools was used in performing analyses of covariance to determine the differences in mean DMFS between poor and nonpoor children in Newburgh and Kingston. Fluoride supplement use, early brushing, age, and number of dental sealants were also included in the model. As a means of satisfying the assumptions required for analysis of covariance, the dependent variable was transformed by adding a value of 1 to the DMFS score and then raising the result to the power of −0.2.

TABLE 1—Characteristics of 7- to 14-Year-Old Lifelong Residents of Fluoridated Newburgh and Nonfluoridated Kingston: Newburgh–Kingston Study, 1995

	Newburgh (n = 847), %	Kingston (n = 646), %
Age group, y		
7–10	59.6	59.3
11–14	40.4	40.7
Sex		
Male	49.0	50.8
Female	51.0	49.2
Race		
White	22.7	65.5
African American	41.1	19.2
Hispanic	33.6	11.6
Other	2.6	3.7
Education of head of household		
Some college	32.8	49.4
Other	55.1	44.1
Unknown	12.0	6.5
School lunch participation		
Free	61.6	47.2
Other	16.9	52.0
Unknown	21.5	0.8
Breast-fed		
Yes	25.6	31.1
No	62.8	58.1
Unknown	11.6	10.8
Family dentist		
Yes	28.5	40.7
No	34.2	12.1
Unknown	37.3	47.2
Dental insurance		
Yes[a]	55.6	61.2
No	26.2	23.2
Unknown	18.2	15.6
Fluoride supplement use		
About every day	6.1	29.1
3 times a week	1.4	6.0
Occasionally	5.6	20.4
None	75.0	33.8
Unknown	11.9	10.7
Brushing		
Before the age of 2 years	40.1	49.5
After 2 years	46.2	39.6
Not sure	3.1	3.3
Unknown	10.6	7.6
Dean's Index of Fluorosis[b]		
Questionable	19.4	6.9
Very mild	13.2	8.3
Mild	5.7	3.1
Moderate–severe	0.7	0.3

[a]Includes Medicaid.
[b]Prevalence rates of fluorosis, based on very mild to severe categories of dental fluorosis derived from weighted estimates, were 19.6 (SE = 1.5) and 11.7 (SE = 1.4) in Newburgh and Kingston, respectively.

Results

Table 1 shows the characteristics of the participants and the differences between the cities with respect to race, participation in the free-lunch program, education of the head of the household, and reported history of fluoride use, family dentist, and dental insurance.

The estimated prevalence rates of dental fluorosis classified as very mild or greater (according to the Community Fluorosis Index) were 11.7% in Kingston and 19.6% in Newburgh (Table 1). Between-survey comparisons of both fluorosis prevalence and Dean's index revealed an increase in dental fluorosis from the previous survey conducted in 1986 (Table 2), and the increase was relatively higher among African Americans.

Table 3 shows that the prevalence of fluorosis was higher for those children who received fluoride from a combination of water and supplements or early brushing (19.2%), water alone (17.9%), supplements in combination with early brushing (20.8%), and early brushing alone (11.6%) than for the group of children in nonfluoridated Kingston who had the least amount of known fluoride exposure (6.1%). The logis-

TABLE 2—Comparison of Dental Fluorosis and Community Fluorosis Indices Among Samples of 7- to 14-Year-Old Lifelong Residents, by City, Race, and Year of Examination: Newburgh–Kingston 1986 and 1995 Studies

	Fluorosis Prevalence					Community Fluorosis Index		
	1986		1995					
Population	No.	% (SE)	No.	% (SE)	Difference, % (95% CI)	1986, Mean (SE)	1995, Mean (SE)	Difference (95% CI)
All subjects								
Newburgh	459	7.8 (2.0)	847	18.5 (1.0)	10.7 (7.1, 14.3)	0.19 (0.02)	0.34 (0.02)	0.15 (0.10, 0.20)
Kingston	425	7.3 (2.0)	646	11.2 (1.0)	3.9 (0.4, 7.3)	0.16 (0.02)	0.19 (0.02)	0.03 (−0.04, 0.08)
African Americans								
Newburgh	237	9.3 (1.9)	348	25.6 (2.3)	16.3 (10.4, 22.2)	0.23 (0.04)	0.46 (0.03)	0.23 (0.12, 0.32)
Kingston	68	2.9 (2.0)	124	16.9 (3.4)	14.0 (6.3, 21.7)	0.08 (0.03)	0.29 (0.05)	0.21 (0.10, 0.33)
All others								
Newburgh	222	6.3 (1.6)	499	13.6 (1.5)	7.3 (2.9, 11.7)	0.14 (0.02)	0.26 (0.02)	0.12 (0.07, 0.19)
Kingston	357	8.1 (1.4)	522	9.8 (1.3)	1.7 (−2.1, 5.5)	0.18 (0.03)	0.16 (0.02)	0.02 (−0.08, 0.04)

Note. CI = confidence interval.

TABLE 3—Prevalence of Very Mild to Severe Dental Fluorosis and Logistic Regression Analysis for Prevalence Odds Ratios, by Selected Characteristics: Newburgh–Kingston Study, 1995 (n = 1493)

	Prevalence Rate, %	Adjusted Odds Ratio (95% Confidence Interval)
Fluoride exposure		
Fluoridation and brushing or supplements[a]	19.2	3.0 (1.64, 5.49)
Fluoridation alone[b]	17.9	2.7 (1.45, 4.91)
Fluoride supplements and brushing[c]	20.8	4.1 (2.90, 8.30)
Fluoride supplements alone[d]	8.8	1.6 (0.59, 4.42)
Early brushing alone[e]	11.6	1.8 (0.91, 3.57)
Other[f]	6.1	1.0 ...
Race		
African American	23.3	2.2 (1.62, 3.00)
Other	11.7	1.0 ...
Breast-fed		
Yes	17.0	1.4 (1.00, 1.88)
No	14.6	1.0 ...
Age group, y		
7–10	15.9	1.1 (0.79, 1.40)
11–14	14.6	1.0 ...
Sex		
Male	15.5	1.1 (0.81, 1.45)
Female	15.2	1.0 ...
Education		
Some college	16.7	1.3 (0.93, 1.69)
Other	14.3	1.0 ...
School lunch participation		
Free lunch	16.9	1.2 (0.86, 1.75)
Other	12.4	1.0 ...

Note. χ^2 = 65.46 (P = .0001), goodness-of-fit statistic = 7.66 (P = .47). Odds ratios were adjusted for all other variables in the model.
[a]Lifelong residents of Newburgh who started brushing before 2 years of age; also includes 52 children who reported taking fluoride supplements daily.
[b]Remaining lifelong residents of Newburgh.
[c]Lifelong residents of Kingston who reported everyday fluoride supplement use and started brushing before 2 years of age.
[d]Lifelong residents of Kingston who reported everyday use of fluoride supplements alone.
[e]Lifelong residents of Kingston who started brushing before 2 years of age.
[f]Remaining children from Kingston who had the least amount of exposure to fluoride.

tic regression procedures suggested that African Americans and those who received fluoride from water alone or from multiple sources were more likely to have dental fluorosis (Table 3). The higher prevalence of dental fluorosis among African Americans was confirmed in the multivariate model (OR = 2.2, 95% CI = 1.6, 3.0).

Between-survey comparisons of the age-standardized mean DMFS index showed declines from 2.2 to 1.7 and 2.8 to 1.5 in Newburgh and Kingston, respectively. Analysis of covariance showed that while the adjusted mean DMFS was approximately 50% higher among poor children than among nonpoor children in Kingston, no such differences were observed in Newburgh (Table 4). This analysis also showed that regular use of fluoride tablets and introduction to early brushing reduced DMFS scores.

Discussion

This study shows that the prevalence of dental fluorosis has not declined in either the fluoridated or the nonfluoridated community since 1986. In Newburgh and Kingston, an earlier study of the fluoride content of infant foods found that the amount of fluoride available from foods and beverages was within the acceptable range.[39] Therefore, it appears that the other recommendations made in the early 1980s to reduce fluoride exposure in both fluoridated and nonfluoridated communities were either not sufficient or not properly implemented.

Although the prevalence of dental fluorosis has increased in Newburgh and among African-American children in Kingston, the extent and severity of dental fluorosis were within the acceptable range (as specified by Dean[40]). Unlike their cohorts in the earlier study, Newburgh residents in the current study had uninterrupted access to fluoride in water continuously from birth. This increased fluoride exposure relative to the 1986 study may have resulted in a higher prevalence of dental fluorosis.

The results indicate that the risk for fluorosis is greater when children are exposed to multiple sources of fluoride than when exposure is restricted to a single source. Previous studies have consistently reported an

TABLE 4—Crude and Covariate-Adjusted DMFS and Transformed DMFS for 7- to 14-Year-Old Lifelong Residents of Newburgh and Kingston, by Poverty Status, Fluoride Supplement Use, and Early Brushing: Newburgh–Kingston Study, 1995

Group	Crude Mean DMFS (SE)	Covariate-Adjusted Mean DMFS (SE)	Covariate-Adjusted Mean Transformed DMFS	*P*
Newburgh poor	1.28 (0.10)	1.16 (0.12)	0.50	.795
Newburgh nonpoor	1.35 (0.19)	1.13 (0.19)	0.48	
Kingston poor	1.55 (0.15)	1.51 (0.14)	0.62	
Kingston nonpoor	0.80 (0.14)	0.76 (0.13)	0.32	.0001
Fluoride supplement	0.80 (0.16)	1.00 (0.16)	0.43	
Others	1.32 (0.07)	1.28 (0.08)	0.52	.046
Early brushing	1.07 (0.09)	1.05 (0.10)	0.40	
Others	1.39 (0.09)	1.23 (0.11)	0.55	.022

Note. DMFS = decayed/missing/filled surface. Transformed DMFS $R^2 = 0.154$. Covariates used in the model included age and number of sealants. Transformed DMFS refers to rescaled transformed variable DMFS: 1 – Transformed $DMFS^5$/Transformed $DMFS^5$. The fluoride supplement group consisted of children with a history of daily fluoride tablet/drop use. "Poor" refers to children who were participating in the free school lunch program. All others were categorized as nonpoor.

increased risk of dental fluorosis with regular use of daily fluoride supplements.[10,17,41–43] However, children in the present study were more likely to have been exposed to a lower dose of fluoride supplements than the children studied earlier. Also, this analysis may have lacked sufficient power to detect statistical significance when differences were small. Because the risk of fluorosis increased when daily supplement use was combined with early brushing, and because a large proportion (64.8%) of fluoride tablet users also reported early brushing, further studies are required to determine whether the downward adjustment in the fluoride dosage schedule recommended in 1994 is adequate to reduce dental fluorosis prevalence.

Many investigators have suggested that inappropriate use of fluoride dentifrices results in dental fluorosis because young children cannot control the swallowing reflex.[41–45] In our study, the odds ratio was higher for those children who initiated brushing before the age of 2 years in both the fluoridated and nonfluoridated areas, although the effect of early brushing alone was not statistically significant. While a detailed history regarding the time, duration, and amount of fluoride exposure is desirable, the quality of such data is often questionable. Therefore, drawing definitive conclusions regarding the risk imposed by fluoride dentifrices using cross-sectional or retrospective study designs may be unwise. While early brushing appeared to increase the risk of fluorosis, there was a slight but statistically significant benefit in caries reduction.

The higher prevalence of fluorosis observed among African Americans could not be explained by any of the fluoride-related factors studied. Whether dental fluorosis is more apparent among African Americans because of the color of the teeth or because of differences in fluoride exposure or metabolism needs further study. Because the fluoride exposure measurements in this study were crude and may not reflect actual fluoride intake by individuals, we may not have accounted for all fluoride exposures.

Dental caries has continued to decline in both Newburgh and Kingston. Although the differences between these 2 cities with respect to socioeconomic and demographic characteristics and access to dental care do not permit a direct comparison at present, the narrowing in the difference between fluoridated and fluoride-deficient communities has been observed in the previous decade in numerous other studies.[46–48]

It has been observed that fluoridation may be particularly beneficial to groups of low socioeconomic status.[49–51] A significant disparity in caries prevalence between poor and nonpoor groups was apparent in Kingston but not in fluoridated Newburgh. These data appear to support a fundamental premise of water fluoridation, namely, that benefits accrue to all residents. Other modalities of fluoride delivery may not be readily available to disadvantaged groups. Although it is tempting to attribute the absence of a difference in caries scores between poor and nonpoor children in Newburgh to fluoridation, it must be noted that variations in treatment patterns, differing definitions of poor and nonpoor status, and other unknown factors may have played a role.

Before these results may be generalized to other communities, additional studies are required; interpretations should take into consideration methodological issues concerning cross-sectional studies conducted over time. Although the participation rate of older children appears to have been lower, the impact of this lower participation rate on the study may have been minimal. First, many children from neighboring towns who attend schools in Newburgh and Kingston did not see a need to participate in the survey. Second, when the analysis was limited to 7- and 8-year-olds (participation rate: 52%), the results remained virtually unchanged. Third, an analysis of 601 nonrespondents showed that the primary reason they declined to take part was that they already had a family dentist (59%). Among participants, however, having a family dentist was not a predictor of dental fluorosis. Finally, if this participation rate resulted in an underestimate or overestimate, it also occurred in 1986 and in both Newburgh and Kingston. □

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