Trends in Dental Fluorosis and Dental Caries Prevalences in Newburgh and Kingston, NY

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Abstract: A study was undertaken in New York State to determine the changes in dental fluorosis prevalence from 1955 to 1986 in fluoridated Newburgh and non-fluoridated Kingston children. The frequency and severity of dental fluorosis among 884 7–14-year-old children were measured by two dentists utilizing Dean's Index. Data regarding residential and fluoride history were obtained from the parents of participants. Among the Newburgh residents, the prevalence of dental fluorosis (very mild to moderate) varied from a low of 5 per cent for the 9–10-year-old group to a high of 9.4 per cent for 11–12-year-olds. Except for the 13–14-year-old group, children in non-fluoridated Kingston had the lowest dental fluorosis prevalence rates. A comparison of Dean's Community Fluorosis Indices to the 1955 baseline data obtained from studies conducted after 10 years of fluoridation in Newburgh revealed no changes of consequence among Newburgh residents. However, the changes are apparent for Kingston residents, indicating the availability of fluorides in non-fluoridated areas. The increased risk for dental fluorosis for Kingston residents appears to be from the use of fluoride tablets. An analysis of dental caries data revealed that caries prevalence declined substantially in both fluoridated and non-fluoridated areas. (*Am J Public Health* 1989; 79:565–569.)

Introduction

Oral health surveys conducted in the United States and other developed countries have demonstrated that the prevalence of dental caries in children has declined substantially in recent years.[1–8] The increased availability of fluoride in many forms appears to be the single most important factor. The use of antibiotics, improved levels of restorative care, and patterns of sugar consumption and snacking have also been thought to contribute to the secular changes.[1,9–11]

To explain changes in dental caries prevalence in non-fluoridated areas, many investigators have pointed out the effect of systemic fluorides in professionally prescribed supplements and/or the use of fluoridated dentifrices by young children.[1,12–15] The increased availability of fluorides in food has also been suggested.[13,16–21] Singer and his co-workers have indicated that the average daily fluoride intake for infants, two-year-olds, and young male adults is within the accepted range of 0.05 to 0.07 milligram per kilogram body weight and has not significantly changed over the past 30 years.[22–25] However, studies of fluoride levels of baby formulas and cereals have shown a significant increase in the fluoride content when fluoridated water was used for processing these foods.[12,19,27–29]

Additional sources of fluorides are available now that were almost nonexistent when water fluoridation standards were determined. These include fluoride rinses and fluoride dentifrices. Barnhart, *et al,*[30] reported that 2- to 4-year-old children ingested an average of 0.3 gram (gm) of dentifrice or 0.3 milligram (mg) of fluoride per brushing. Fluoride supplements are commonly prescribed for children living in non-fluoridated areas.

The availability of fluoride from multiple sources has raised questions about the potential for increases in the incidence of dental fluorosis. Aasenden and Peebles[31] found that 67 per cent of the children who ingested 0.5 mg fluoride from birth to three years of age and 1.0 mg daily thereafter had very mild to mild enamel fluorosis and 14 per cent had moderate fluorosis. In a later report, they suggested that fluorosis might become less noticeable with age.[32] Hennon and co-workers[33] reported no unacceptable levels of fluorosis among children who resided in communities with 0.6 to 0.8 ppm fluoride in the water and had taken 0.5 mg fluoride supplements from birth to age 3 years. Recently, Soparkar, *et al,*[34] reported an unexpectedly high proportion of children with enamel fluorosis and the source of fluoride was determined to be prescribed fluoride supplements. Oldak and Leverett[35] observed an increased occurrence of dental fluorosis in children residing in non-fluoridated communities. Twenty-two per cent of children ages 6–8 residing in a non-fluoridated community had fluorosis in permanent teeth. This higher than expected level of dental fluorosis was thought to be due to the prior use of dietary fluoride supplements.

Recently, Driscoll, *et al,*[36,37] and Segreto, *et al,*[38] compared data on the prevalence of fluorosis with historic data and found no important changes in the prevalence and severity of fluorosis. Although mean fluorosis indices were within the normal range in Rochester, New York, a higher than expected prevalence of very mild categories of fluorosis was reported by Leverett.[39]

Most epidemiological studies of dental fluorosis have been conducted in the Midwestern States, but baseline data on the frequency and severity of dental fluorosis in New York State are available from the 1955 Newburgh-Kingston Study.[40] Therefore, an opportunity existed to determine if the frequency and severity of dental fluorosis had changed over the last 30 years in those two cities.

Similarly, changes in dental caries prevalence could also be determined. Studies conducted between 1944 and 1955 in Newburgh indicated that dental caries prevalence declined considerably after fluoridation. In the non-fluoridated Kingston, dental caries prevalence increased during the same period. Another study of 13- and 14-year-old children in Newburgh and Kingston revealed that this trend continued into the early 1960s.[40–42]

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Methods

Between 1955 and 1986, several demographic and socioeconomic changes have occurred in both Newburgh and Kingston. Compared to Kingston, Newburgh has: a lower median income, a slightly larger proportion of low income level households, a lower median school years completed, a lower percentage of White population, a slightly higher percentage of unemployed, and a different occupational distribution.[43] The water supply records in Newburgh indicate that the level of fluoride in the water was maintained at the recommended 1 ppm established by the US Public Health Service in 1945, except for a three-year period from 1978 to 1981. This reduction in fluoride would affect the teeth of 7- to 14-year-olds differentially, depending on the stages of development of the teeth during this time. The city of Kingston has a fluoride content of 0.3 ppm in water.[44]

To obtain estimates of prevalences of dental fluorosis and dental caries in the cities of Newburgh and Kingston, children attending grades one through eight in public schools were selected to participate on the basis of a stratified random sampling of clusters. A total of 1,446 children from five elementary and two junior high schools in Newburgh and 694 children from four elementary and two junior high schools in Kingston agreed to participate in clinical examinations. The response rates were 63 per cent for Newburgh and 50 per cent for Kingston. The overall response rates were 72 per cent and 38 per cent for elementary and junior high schools, respectively.

Dental fluorosis was determined for each child according to the established classification by Dean, in which the child is classified on the basis of the two teeth in the mouth showing the most advanced signs of fluorosis.[45] In order to differentiate fluorosis from other enamel defects, the criteria developed by Russell was used.[46] Dental caries was assessed using World Health Organization (WHO) guidelines.[47] A pretested questionnaire was used to obtain residential and fluoride history from the parents of participants.

Two dentists, who were not involved in New York State fluoridation or fluoride supplement programs, independently examined approximately equal proportions of participants in Newburgh and Kingston. Examination equipment included a portable chair and a fiber optic light source. The examiners were trained by an outside consultant in applying Dean's classification and were standardized four times during the study. Further, as an attempt to incorporate blindness, children who were not continuous residents of Newburgh and Kingston were also examined. The residential and fluoride history data were not made available to the examiners.

The analysis of data is limited to groups of children between ages 7 and 14. Children under age six and over age 15 were excluded because of inadequacies in the sample size. Children with orthodontic bands or only deciduous teeth were also excluded. Estimates of community fluorosis indices and respective standard errors were calculated for comparison purposes using the methods appropriate for stratified cluster sampling.[48] Trends in dental caries prevalences were determined by comparing age-race adjusted decayed, missing, filled, teeth (DMFT) indices. The relationship between fluorosis and dental caries was determined by analysis covariance technique. The adjusted mean scores were derived by treating age as a covariate utilizing the SAS-GLM computer package.[49]

Because a large number of children attending the schools in Newburgh City were from the non-fluoridated town of New Windsor and the recently fluoridated town of Newburgh, the children were separated into distinct groups. As the amount of exposure to fluorides is of particular importance, data analysis is limited to continuous residents of Newburgh and Kingston. For the purpose of this report, 993 children who were not lifetime residents of Newburgh or Kingston cities were excluded from the analysis. Because the prevalence and severity of fluorosis did not differ significantly by ethnic group, sex, or examiners, only summary data are presented. As age-specific fluorosis rates tended to be unstable, data are presented by two-year age intervals.

Results

The characteristics of the study population by relevant variables are presented in Table 1. There are smaller proportions of White and a generally lower set of socioeconomic indicators in the Newburgh sample and somewhat fewer lifetime residents (14 per cent vs 16 per cent).

The frequency and severity of dental fluorosis for the children examined is presented for the two community groups in Table 2. Among the residents of the fluoridated Newburgh City, as well as residents of Kingston, the majority of the detectable dental fluorosis lesions observed were in the very mild category.

Among the Newburgh residents, the prevalence of dental fluorosis (very mild to moderate categories) varied from a low of 5 per cent for the 9–10-year-old group to a high of 9.4 per cent for 11–12-year-olds. Except for the 13–14-year-old group, children in the non-fluoridated Kingston had the lowest dental fluorosis prevalence rates. The relation between age and dental fluorosis prevalence was inconsistent.

When the distribution of the lesions on the worst affected tooth of each child was analyzed, the clinical manifestation of the lesions observed in Newburgh and Kingston was similar (Table 3).

A comparison of Dean's community fluorosis indices among the populations reveal that there are no differences in 1986 between Newburgh and Kingston residents (Table 4). Table 4 also compares the Dean's community fluorosis indices to the baseline data obtained from 1955 studies conducted after 10 years of fluoridation in Newburgh and Kingston. Although changes in the prevalence of dental

TABLE 1—Comparison of Demographic and Socioeconomic Characteristics in Newburgh and Kingston, NY

Characteristics	Newburgh	Kingston
Number of 7–14 year-old Children	3,209	2,611
Per Cent White	47.5	84.8
Median Family Income	$14,230	$16,573
Per Cent Unskilled (Employed)	24.1	22.0
Per Cent with 4 or More Years of College	7.7	13.0
Low Income Households in Per Cent (Yearly Income Less than $4,000)	25.1	18.2
Employed Persons 16 years and Over in Per Cent	48.1	51.5
Lifetime Residents	459	425
Per Cent Male	47.7	50.3
Per Cent White*	33.2	79.7

Source: US Bureau of the Census: 1980 Census of Populations, General Social and Economic Characteristics, New York, PC80-1-C-34NY.

*NOTE: The Black, Hispanic and Asian children were categorized as Other than White population; 78.5% and 79% of the Other than White population were Blacks in Newburgh and Kingston, respectively.

TABLE 2—Percentage Distribution of Dental Fluorosis in Newburgh and Kingston Residents by Age Group and Dean's Classification

Age	Number	Dean's Fluorosis Classification				
		Questionable	Very Mild	Mild	Moderate	Prevalence
Newburgh						
7– 8	149	11.4	4.6	2.6	2.0	9.2
9–10	135	12.5	2.2	2.9	0.0	5.1
11–12	104	12.5	7.6	0.9	0.9	9.4
13–14	71	25.3	5.6	1.4	0.0	7.0
Kingston						
7– 8	120	11.6	4.1	0.8	0.0	4.9
9–10	110	11.8	1.8	1.8	0.9	4.5
11–12	101	13.8	3.9	3.9	0.9	8.7
13–14	94	7.4	8.5	2.1	1.0	11.6

NOTE: Dental fluorosis prevalence is based on very mild to moderate categories of fluorosis. Children classified as normal or questionable are viewed as not having dental fluorosis.

TABLE 3—Distribution of Fluorosis in 7 to 14 Year-Old Children in Newburgh and Kingston According to Clinical Manifestation

Fluorosis	Newburgh %	Kingston %
Generalized Lesions	83	76
Bilateral Symmetry	96	97
Affected Areas (Cuspal Tips Only)	88	81
Degree of Tooth Affected (Less than 25% of the Tooth)	85	82

TABLE 4—Comparison of Community Fluorosis Indices Along with Standard Errors among Groups by Age and Year of Examination

Age (years)	Newburgh		Kingston	
	1955	1986	1955	1986
7– 8	0.18 (.04)	0.21 (.05)	0.00	0.16 (.04)
9–10	0.14 (.02)	0.14 (.02)	0.00	0.13 (.03)
11–12	0.11 (.03)	0.20 (.07)	0.00	0.23 (.05)
13–14	0.00*	0.20 (.05)	0.00	0.19 (.05)

*Newburgh children of this age group did not receive fluoridated water during the formation of teeth.

NOTE: The 1955 Community Fluorosis Indices for Newburgh and Kingston residents were calculated from the frequency and severity of Dental Fluorosis.[40]

fluorosis are not apparent among Newburgh residents, changes for Kingston residents were detected.

A history of the use of fluoride tablets/drops during the first eight years of life from the parental questionnaire may indicate the exposure to a known risk factor. Table 5 shows that approximately 31 per cent of the children in Kingston reported a history of regular use of fluoride tablets/drops compared to 5 per cent for the residents of Newburgh. The odds ratio calculated for the two groups indicated a greater odds of developing dental fluorosis when tablets were taken every day. Over 95 per cent of the children in both groups reportedly use fluoride dentifrices. The effect of other sources of fluoride, such as topical rinses and professional fluoride applications was not examined.

A comparison of the data gathered from studies conducted in Newburgh and Kingston reveals that caries has declined both in fluoridated and non-fluoridated areas (Figure 1). Figure 2 demonstrates the caries trends in 13- and 14-year-old children.

TABLE 5—History of Fluoride Tablets/Drops Use and the Estimated Relative Risk with Everyday Use of Tablets/Drops during the First Eight Years of Life

	N	Fluoride Tablet/Drops History			Odds Ratio*
		About Every Day	About 3 Days/Week	Occasionally	
Newburgh	459	24 (5%)	1 (0%)	47 (10%)	1.7
Kingston	425	133 (31%)	16 (4%)	46 (11%)	3.8

*Indicates the ratio of the prevalence of dental fluorosis among those who reported everyday tablet/drops use compared to those who did not report tablets/drops use.
Odds Ratio (Newburgh) = 3/24 ÷ 28/387 = 1.7 (95% CI = −0.5, +3.9)
Odds Ratio (Kingston) = 20/133 ÷ 9/230 = 3.8 (95% CI = +.07, +6.9)

A comparison of dental fluorosis and dental caries prevalence suggests an inverse relationship. Children with very mild to moderate dental fluorosis consistently had lower caries experience (Table 6). The covariate adjusted mean DMFS indices showed that children with very mild to moderate fluorosis had approximately 41 to 54 per cent fewer DMFS, respectively.

Discussion

Although demographic and socioeconomic changes over a period of four decades have resulted in population differences between Newburgh and Kingston, an analysis of trends in fluorosis prevalence should be still valid. Segreto, *et al,* have reported that the effect of gender, ethnic group, or family income in dental fluorosis is small compared with the effect of optimal fluoride level in drinking water.[38] The changes in dental caries prevalence in Kingston must be viewed in light of the effect of changes in socioeconomic characteristics and the impact of the availability of other forms of fluoride in non-fluoridated areas.

The results indicate that the extent and severity of dental fluorosis among residents in an optimally fluoridated community in a Northeastern State is within the normal range, as specified by Dean. Dean has stated that the mildest forms of dental fluorosis would occur in about 10 per cent of a population that used water containing about 1 ppm of fluoride continuously from birth.[50] Later, he suggested a method to

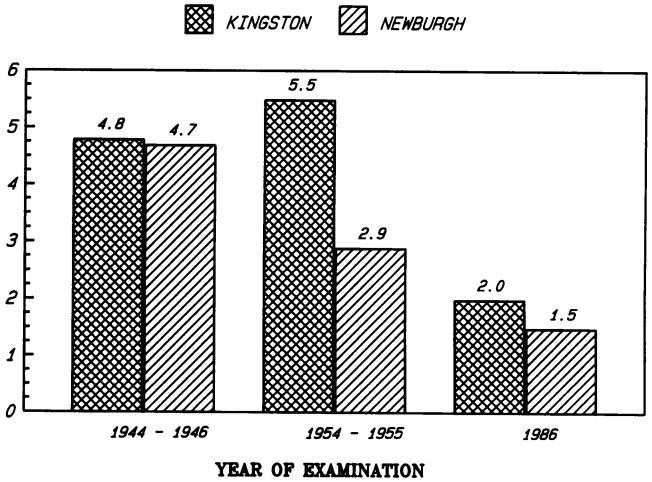

FIGURE 1—Age-Race-Adjusted Dental Caries Prevalence (DMFT) for 7–14-Year-Old Children in Newburgh and Kingston, NY, 1944–86

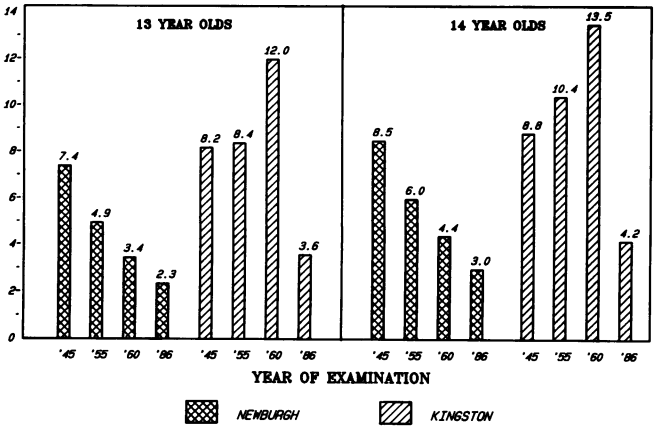

FIGURE 2—Dental Caries Prevalence for 13- and 14-Year-Olds in Newburgh and Kingston, NY, 1944–86

ascertain the public health significance of dental fluorosis utilizing the Community Fluorosis Index (CFI). According to Dean, CFI scores below 0.4 are considered as having no public health significance.[51] Because 99 per cent of the population studied had less than moderate categories of dental fluorosis and the differences over time were negligible, these data suggest that no changes have occurred in the past three decades. This observation is consistent with the recent studies conducted by Segreto, *et al,* in Texas,[39] and by Driscoll, *et al,*[36,37] in Illinois.

The lower community fluorosis indices for all age groups for Newburgh residents compared to those reported elsewhere[36–39] for residents of other fluoridated communities could be due to three years of interruption in fluoride availability from water. However, an analysis of the relation between age and fluorosis prevalence did not reveal any consistent effect of this interruption. The 13–14-year-old group that received an uninterrupted supply of fluoride from birth for seven years did not have any more fluorosis than the 7–8-year-old group that received the least amount of fluoride exposure from water. Also, the fact that 16 per cent of Newburgh resident children also reportedly received fluoride tablets may indicate that some of these children received fluoride during the period of interruption in water fluoridation. Further, compared to other indices that consider the tooth as a unit, the use of Dean's Community Fluorosis Index based on the child as a unit minimizes the underestimation resulting from interruption in fluoride availability, because any excessive exposure during the development of teeth will affect at least some teeth. This manifestation is considered as fluorosis, no matter whether the child received fluoridation during the development of some teeth or all the teeth.

Another possible explanation for the low community fluorosis indices may be due to differences in the application of the diagnostic criteria. This may have been minimized by not providing the fluoride history to examiners and by the high level of agreement among the examiners. A comparison to an earlier study in Newburgh and Kingston conducted by Russell in 1955 should take into consideration the differences that could have occurred in the application of the diagnostic criteria. The community fluorosis indices reported in 1955 for Newburgh residents were also lower compared to that of other studies.[45] However, at that time, only 7–8-year-old children had received fluoride in drinking water continuously from birth.

TABLE 6—Dental Caries Prevalence According to Dean's Fluorosis Classification

Dean's Fluorosis Classification	N	Covariate (Age) Adjusted Mean DMFS	Standard Error
Normal	704	2.2	0.11
Questionable	113	2.1	0.27
Very Mild	41	1.3	0.47
Mild	19	1.1	0.67
Moderate	7	1.0	1.11

The change in the occurrence of very mild to mild categories of dental fluorosis from the original study is noticeable in the non-fluoridated city of Kingston. This increased occurrence of fluorosis in non-fluoridated areas has been reported by other investigators.[4,34,35]

In Kingston, the increased occurrence of fluorosis may be attributed to a large extent to the use of fluoride supplements. If the use of infant formula was similar in the studied populations and the cases and controls are representative of the population, then an important factor associated with dental fluorosis is the use of fluoride tablets/drops. The fact that this group received fluoride supplements at a higher than the currently recommended dosage may have contributed to an increased risk for developing fluorosis.[52]

The higher dental fluorosis rate reported for Kingston when compared to the studies conducted in other non-fluoridated areas is consistent with the variation in the fluoride supplement use in different regions of the country.[34–39] The findings from the 1983 National Health Interview Survey indicated that the use of fluoride supplement was more frequent among White families with high incomes in the Northeastern regions.[53]

Dental caries declined substantially both in Kingston and Newburgh, a trend that is consistent with the recent findings from other studies.[1–9,13] An observation of particular interest is that between the 1940s and 1960s, dental caries increased in the non-fluoridated Kingston in contrast with the fluoridated Newburgh. As a result of this phenomenon, the caries decline between the 1960s and the 1980s in Kingston appears to be greater in Kingston compared to Newburgh. In spite of this decline in caries in the non-fluoridated area, lower caries prevalence continues to exist in the fluoridated area. However, factors such as differences in the service utilization patterns as evidenced by the comparison of the proportion of filled component of all caries surfaces, interruption in the fluoride availability for Newburgh children, and an increased availability of fluorides for Kingston children complicate the measurement of impact of fluoridation in this study.

An analysis of dental caries prevalence, according to Dean's fluorosis classification, revealed that children with very mild to moderate to dental fluorosis had 41 to 54 per cent lower caries prevalence. Driscoll, *et al,* observed similar differences among children residing in areas where the fluoride is above optimal levels.[37] The additional caries inhibitory effect for children with very mild to moderate dental fluorosis observed in the original studies appears to still exist.[51] Several researchers have suggested that the logical implication of an inverse relationship between dental caries and dental fluorosis in the development of public policy is that a slightly increased risk for dental fluorosis is preferable to a higher risk for dental caries,[57,58] since the very mild to mild categories of fluorosis are neither an adverse health effect nor esthetically objectionable, whereas dental caries results in pain, suffering, loss of esthetics, and higher costs.

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