Community Fluoridation Status and Caries Experience in Children

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Abstract

Objective: *This study compares dental caries experience in fluoridated and nonfluoridated communities.* ***Methods:*** *A dental health survey designed to collect data on caries experience and treatment needs for community-specific public health planning purposes was conducted in public elementary schools during the 1996–97 school year. Oral examinations of 17,256 children were completed, representing 93 percent of children residing in 62 East Tennessee communities.* ***Results:*** *The analysis showed that water fluoridation was significantly related to caries experience in the primary (dfs) and permanent (DMFS) dentitions and to the proportion of caries-free children in the primary and permanent dentitions. When the data were adjusted for socioeconomic status, race, and age, caries levels were 21 percent lower in the primary dentition and 25 percent lower in the permanent dentition in fluoridated communities than in nonfluoridated communities. In addition, the proportion of children who were caries free was larger in fluoridated as compared with nonfluoridated communities by 19 percent in the primary dentition and 6 percent in the permanent dentition.* ***Conclusion:*** *Although the design of the study prevented the collection of individual fluoride and residency histories, findings suggest there was substantially lower caries experience in fluoridated communities than in nonfluoridated communities. [J Public Health Dent 2001;61(3):168-71]*

Key Words: caries experience, water fluoridation, oral health survey.

Water fluoridation has been hailed as one of the 10 great public health achievements in the United States during the last century (1). In 1945, Grand Rapids, Michigan, became the first city in the world to adjust the level of fluoride ion in its drinking water to one part fluoride per 1 million parts water (1 ppm) (2). Since that historic moment, fluoridation of public water systems has been beneficial in controlling dental caries (2,3). It also has shown advantages over other forms of fluoride in regard to cost, delivery, safety, efficacy, and equity in the United States and elsewhere (4). By the end of 1992, over 144 million Americans were served fluoridated water, including 62 percent of those on public water systems (5).

Evidence suggests that the effectiveness, not efficacy, of communal water fluoridation has diminished over time. Early reviews of fluoridation studies reported between 1956 and 1979 showed modal caries reductions due to fluoridation of 50–60 percent in permanent teeth and 40–50 percent in primary teeth (3,6). Reports published between 1979 and 1989 showed modal caries reduction of 30–40 percent in permanent teeth (3,7). It is surmised that the narrowing differences in caries experience between optimally fluoridated and nonfluoridated communities are attributable to both the "diffusion" effect of water fluoridation and the "dilution" effects of other topical and systemic sources of fluoride (4,8).

Tennessee began fluoridation of public water supplies on March 12, 1951, when Milan became the first city in the state to fluoridate its water supply (9). A five-year study compared the caries experience of 6-year-old Milan children in 1956 with the same age cohort in 1951 (9). The reduction in permanent caries experience in 1956 was 57 percent. The study also compared dental caries in 6-year-old Milan children in 1956 with the same age cohorts in two neighboring nonfluoridated Tennessee cities, Humbolt and Trenton. The reductions in dental caries experienced in permanent teeth among Milan children were 62 percent and 70 percent, respectively, compared to Humbolt and Trenton. The caries reduction in primary teeth (def) in Milan 6-year-olds as compared with Humbolt and Trenton 6-year-olds was 36 percent and 47 percent, respectively.

Today, 96 percent of Tennesseans on community water systems have access to optimally fluoridated water. At present, 362 water systems in the state supply fluoridated water to an estimated 4.7 million residents (10). Prefluoridation surveys conducted in nine Tennessee communities during 1953 and the early part of 1954 and postfluoridation surveys conducted in 1974, 1979, and 1988 indicate that there had been a dramatic and continuous decline in dental caries among children. In the 34-year period from 1954 through 1988, a 75 percent decline in dental caries (as measured by mean DMFT scores) in children 6–14 years of age occurred and has been attributed primarily to exposure of individuals to fluorides in various forms both topical and systemic (11-13).

During the 1996–97 school year, dental staff of the Oral Health Services Section of the Tennessee Department of Health conducted a cross-sectional survey to determine caries experience, dental treatment needs, sealant prevalence, and incisor trauma among schoolchildren residing in 62 communities in East Tennessee. Two previous

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TABLE 1
Demographic Profile of East Tennessee Communities by Fluoridation Status

Fluoridation Status	Number of Communities	Number of Children	Free & Reduced Lunch Participation*	Sealant on Permanent Dentition	Caucasian*	Male	Age* (Years)
Fluoridated	31	10,495	54.5%	22.6%	96.3%	52.0%	8.0
Nonfluoridated	31	6,761	71.1%	23.0%	99.1%	52.3%	8.2

*$P<.05$.

papers have reported findings from this survey (14,15). This paper compares dental caries experience in nonfluoridated communities (<0.3 ppm) with that of optimally fluoridated (1 ppm) communities.

Methods

This geographic region of Tennessee encompassed 15 counties and included 119 communities (i.e., a population living in an area served by a public elementary school). Communities were stratified by geographic region, fluoridation status of the public water supply (if present), socioeconomic status (SES) of the community measured by the proportion of children participating in the federally subsidized school lunch program, urbanization, and school enrollment. Based on these criteria, 62 communities were selected. The 31 communities classified as "optimally fluoridated" received water from public water systems that began adjusting fluoride levels prior to 1986. The data collection phase of the survey began in November 1996 and ended in May 1997. Therefore, the fluoridated communities had been optimally fluoridated for at least 11 years.

The demographics of this region of Tennessee indicate that the communities surveyed have had relatively stable population bases in recent years and during the course of the survey with no appreciable fluctuations in populations besides random family migration into or out of the communities. Between 1990 and 1996 there was less than a 3 percent increase in the 5–11-year-old population in this geographic area of the state (16). In these communities, practically all resident children attended the community school.

In an effort to achieve the highest possible response rate, children participated in the dental survey as in a health screening, without individual parental consent. Instead, school officials were asked to provide written notification in advance of the survey, giving parents the prerogative to exclude their children. Very few children were excluded due to parental objection, absence from school, or lack of cooperation. Oral examinations were conducted on 17,256 children aged 5–11 years, representing approximately 93 percent of the children in selected schools. This survey was considered to be a census of 5–11-year-old children residing in each community.

One public health dentist, experienced in conducting oral epidemiologic surveys, examined all 17,256 children. This examiner had been trained and calibrated in a previous statewide oral survey that used similar diagnostic criteria. Intraexaminer reliability was not measured in the current study. Children were examined at school using a portable A-dec® dental chair and Rolux® fiber optic light. Instruments were limited to #4 front-surface dental mirrors. No radiographs were made. The diagnostic criteria were comparable to those used in the 1988 oral health survey of schoolchildren in Tennessee (13) and to those originally adopted by the Caries Measurement Task Group, Conference on Clinical Testing of Cariostatic Agents, sponsored by the American Dental Association in 1968 (17). The main departure from these criteria is that coronal caries in this survey was diagnosed by visual examination only. An explorer was not used in the detection of caries (18,19).

Measures of dental health included average community caries experience in the primary (dfs) and permanent (DMFS) dentitions and the proportion of children in the community without caries in the primary and permanent dentitions. Assessment of primary teeth included children aged 5–9 years and assessment of permanent teeth was conducted among children aged

FIGURE 1
Adjusted Means for Caries Experience by Fluoridation Status ($P<.05$)

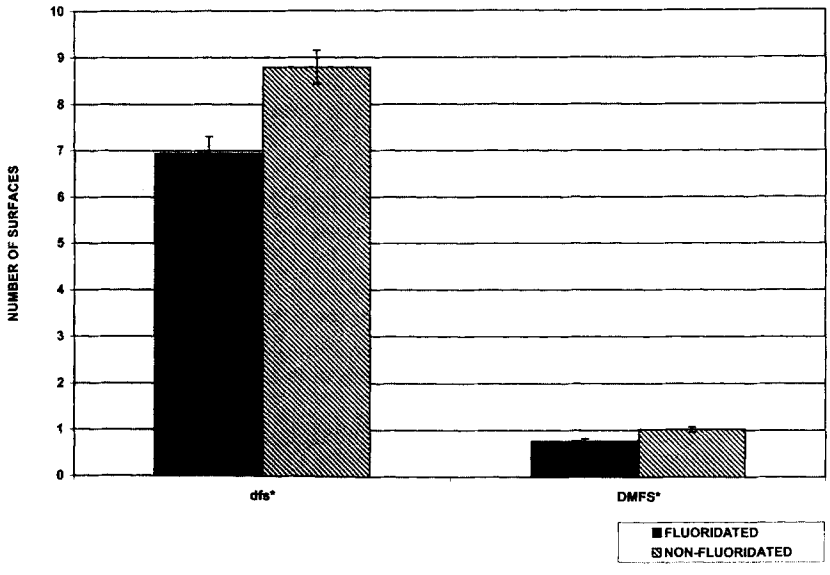
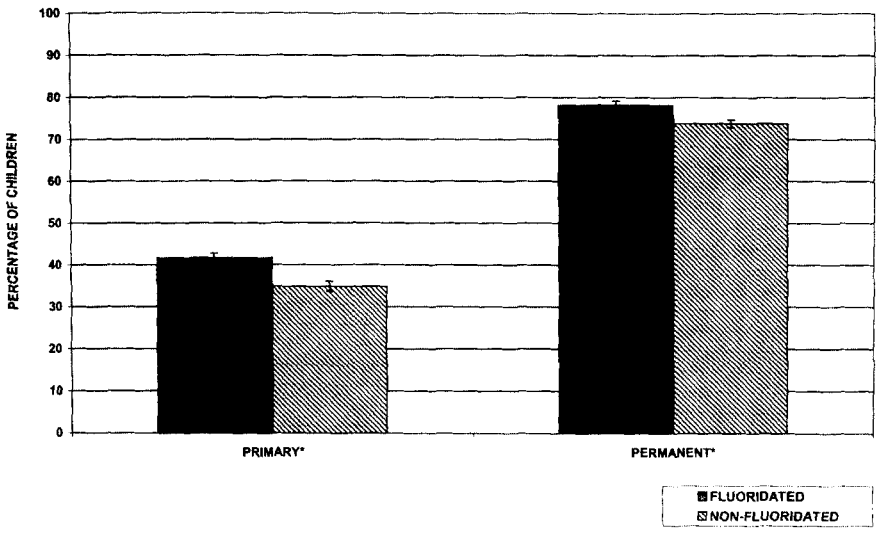


FIGURE 2
Adjusted Percentage of Caries-free Children by Fluoridation Status ($P<.05$)



5–11 years. Further details regarding sampling, consent procedures, measures, and protocols have been reported elsewhere (14,15).

Data were aggregated at the community level to represent the 62 communities. Analyses of covariance were used to determine the relationship between community fluoridation and caries experience, controlling for effects of community SES, race, and age. The LSMEANS procedure in SAS was used to compute adjusted means. For all analyses an alpha=.05 was used to test for statistical significance. Ninety-five percent confidence intervals are provided for all means. Because the analysis was at the community level, for all statistical tests the sample size was the number of communities (n=62), rather than the number of examinees.

Results

Descriptive information provided in Table 1 indicates significant differences in community socioeconomic status, race, and age by fluoridation status. There were no significant differences by sex or sealant prevalence.

Community fluoridation status was significantly related to dfs, DMFS, and the proportion of children who were caries free in their primary or permanent dentition. Figure 1 shows that caries experience was greater in primary and permanent teeth in nonfluoridated communities. Nonfluoridated communities had an average dfs score of 8.79 (95% CI=8.06, 9.52) compared to 6.94 (95% CI=6.21, 7.67) in fluoridated communities. DMFS scores averaged 1.02 (95% CI=0.90, 1.13) and 0.77 (95% CI=0.65, 0.88), respectively. Caries levels in fluoridated communities were 21 percent lower in primary teeth and 25 percent lower in permanent teeth compared to caries levels in nonfluoridated communities.

Community fluoridation status was also associated with the presence or absence of caries in both the primary and permanent dentitions. Figure 2 reveals that percentage of children in fluoridated communities with a caries-free dentition was 19 percent higher in the primary dentition and 6 percent higher in the permanent dentition compared to nonfluoridated communities. The percentage of children in fluoridated communities with a caries-free primary dentition was 42 percent (95% CI=39–44%) compared to 35 percent (95% CI=32–37%) in nonfluoridated communities. For the permanent dentition, 78 percent (95% CI=76–80%) of children in fluoridated communities had no caries compared with 74 percent (95% CI=72–76%) in nonfluoridated communities. In summary, communities with optimally fluoridated water supplies had lower caries levels and higher percentages of caries-free children, even when effects of SES, age, and race were controlled.

Discussion

Marked reductions in caries experience among US children in recent decades have made it difficult to establish statistically significant reductions in caries due to water fluoridation alone. Widespread exposure to other types of fluoride in dentifrices, dietary fluoride supplements, professionally applied topical fluoride products, school-based fluoride mouthrinses, over-the-counter individual home rinses, as well as in foods and beverages also make it difficult to isolate the protective effect of water fluoridation (7,20).

By design, this survey precluded individual fluoride histories or continuous residency histories. Participation in the survey was based upon parental notification rather than individual consent. The consent procedure resulted in a sample that was a census of the target population. An advantage to this method was that a higher response rate was achieved, which resulted in a more representative estimate of caries experience. A limitation of the study was that individual information such as fluoride history and length of residency could not be obtained.

The accuracy of individual fluoride histories—which rely upon parents' recall of their child's exposure to topical or systemic fluoride products at home, school, or the dental office—is suspect. It becomes even more ambiguous when one factors in family migration into or out of fluoridated and nonfluoridated communities. Nevertheless, oral health surveys that attempt to determine the efficacy of water fluoridation should include, if possible, a record of continuous or long-term residency and a history of fluoride therapy to control for confounding factors that can affect study findings.

This study presents findings at the community level that suggest water fluoridation continues to have substantial dental benefits. Marked differences in caries experience between fluoridated and nonfluoridated communities were observed in both primary and permanent dentitions. Because questions have been raised recently regarding the differences in caries levels one might expect between fluoridated and nonfluoridated communities, the authors thought it was important to report more recent estimations.

Although these findings do not imply causality, they do indicate that water fluoridation is still a very important public health measure. Informa-

tion gleaned from this study and others comparing caries experience in fluoridated and nonfluoridated communities will be used to promote, defend, and maintain national, state, and local fluoridation initiatives.

References

1. Centers for Disease Control and Prevention. Ten great public health achievements—United States, 1900-1999. MMWR Morb Mortal Wkly Rep 1999;48: 241-2.
2. McClure FJ. Water fluoridation—the search and the victory. Bethesda, MD: US Department of Health, Education and Welfare, National Institutes of Health, National Institute of Dental Research, 1970:109-42.
3. Ripa LW. A half-century of community water fluoridation in the United States: review and commentary. J Public Health Dent 1993;53:17-44.
4. Horowitz HS. The effectiveness of community water fluoridation in the United States. J Public Health Dent 1996;56(Spec Iss):253-8.
5. Centers for Disease Control and Prevention. Achievements in public health, 1900-1999. Fluoridation of drinking water to prevent dental caries. MMWR Morb Mortal Wkly Rep 1999;48:933-40.
6. Murray JJ, Rugg-Gunn AJ. Water fluoridation and child dental health, water fluoridation and adult dental health, community fluoridation schemes throughout the world. In: Fluorides in caries prevention. Dental practitioner handbook no 20. 2nd ed. Boston, MA: Wright PSG, 1982:31-73.
7. Newbrun E. Effectiveness of water fluoridation. J Public Health Dent 1989; 49:279-89.
8. Brunelle JA, Carlos JP. Recent trends in dental caries in US children and the effect of water fluoridation. J Dent Res 1990; 69(Spec Iss):723-7.
9. Trithart AH, Denny RP. Study of caries experience rates of six-year-old children of Milan, Tennessee, after five years of fluoridation. J Tenn Dent Assoc 1956;36: 156-9.
10. Tennessee Department of Environment and Conservation. Fluoridated community water systems in Tennessee. Nashville, TN: Tennessee Department of Environment and Conservation, Division of Water Supply, 2000.
11. Gunter BF. Data of prefluoridation surveys made in nine Tennessee communities. J Tenn S Dent Assoc 1954;39:138-47.
12. Bryan ET, Collier DR, Howard WR, Van Cleave ML. Dental health status of schoolchildren in Tennessee—a 25-year comparison. J Tenn Dent Assoc 1982; 2:31-3.
13. Gillcrist JA, Collier DR, Wade GA. Dental caries and sealant prevalences in schoolchildren in Tennessee. J Public Health Dent 1992;52:69-74.
14. Brumley DE, Hawks RW, Gillcrist JA, Blackford JU, Wells WW. Successful implementation of community water fluoridation via the community diagnosis process. J Public Health Dent 2001;61:28-33.
15. Gillcrist JA, Brumley DE, Blackford JU. Community socioeconomic status and children's dental health. J Am Dent Assoc 2001;132:216-22.
16. Health Information Tennessee. Available at: http://web.utk.edu/~chrg/hit/. Accessed September 15, 2000.
17. Radike AW. Criteria for diagnosis of dental caries. In: Proceedings of the conference on the clinical testing of cariostatic agents, 1968. Chicago: American Dental Association, 1972:87-8.
18. Pitts NB. Current methods and criteria for caries diagnosis in Europe. J Dent Educ 1993;57:409-14.
19. Wenzel A. New caries diagnostic methods. J Dent Educ 1993;57:428-32.
20. Horowitz HS. The future of water fluoridation and other systemic fluorides. J Dent Res 1990;69(Spec Iss):760-4.