Has the Level of Dental Fluorosis Among Toronto Children Changed?

• **James Leake,** DDS, DDPH, MSc •
• **Fred Goettler,** BMath, MASc, MSc •
• **Brenda Stahl-Quinlan** •
• **Hazel Stewart,** DDS, DDPH •

Abstract

We conducted a survey during the 1999–2000 school year to obtain valid estimates of the oral health status of a probability sample of children in the 4 regions of the newly amalgamated city of Toronto. The results will be used in developing recommendations for programs to address the oral health problems identified. The Dental Indices System is the Ontario protocol whereby information on the oral health status and treatment needs of children can be obtained by direct assessment of the children. One of 2 specially trained dental hygienists examined each child's teeth and periodontal tissues using sterilized mouth mirrors and blunt probes with a standard light source. Overall, there were 3657 participants in the survey, of whom 2435 were aged 7 or 13 years; these 2 age groups formed the basis for the analysis. Forty percent of those aged 7 or 13 had had one or more decayed teeth. Approximately 7% of children in the younger age group had at least one condition requiring urgent care. Dental fluorosis of moderate severity (Tooth Surface Index of Fluorosis ≥ 2) was found among 14.0% of 7-year-olds, 12.3% of 13-year-olds and 13.2% of the 2 age groups combined. The prevalence of fluorosis was of the same order as all but one of the more recent studies performed in Toronto. The prevalence may fall as the recently imposed reduction in concentration of fluorides in city water takes effect. On the basis of these findings of fluorosis, Toronto Public Health should continue to monitor levels of dental fluorosis and caries and should continue its efforts to inform parents of very young children about the safe use of fluoridated dentifrice.

MeSH Key Words: *Canada; child; dental health surveys; fluorosis, dental/epidemiology*

© J Can Dent Assoc 2002; 68(1):21-5
This article has been peer reviewed.

We report partial findings of a dental survey conducted in Toronto during the 1999–2000 school year. The purpose of the survey was to obtain valid estimates of the oral health status of children in the 4 regions of the recently amalgamated city. These estimates will be used in developing recommendations for programs to address any needs identified.

The city is served by a common water system that has been fluoridated since 1963. In the fall of 1999, the concentration was reduced in 2 stages (from 1.2 ppm to 1.0 ppm and then to 0.8 ppm), to meet revised Canadian water standards[1]. A continuing oral health issue relates to the concentration of fluoride in the public water supply needed to balance the prevalence and severity of dental caries and the prevalence and severity of dental fluorosis. This paper reports recent findings on oral health status and compares fluorosis findings with those reported in earlier studies.

Previous Studies of Fluorosis

Interest in the prevalence and severity of dental fluorosis is reflected in the number of surveys that have been conducted. Starting with the most recent study, prevalence for children has been variously estimated for parts of the new city at the following levels:

- 13.9% for 7-year-olds in the former East York;[2]
- 13% for 8- to 10-year-olds, again in the former East York;[3]
- 19.9% in the former Scarborough for children 7, 9, 11 and 13 years of age;[4]

- 36% of children in grades 2 and 6 (ages about 7 and 12 years) with uninterrupted residence in a small area of the former Toronto and East York where the children were potentially exposed to airborne fluoride emissions;[5]
- declining from 9.4% in 1971 to 2.4% in 1975 for 7-year-olds in the former Toronto.[6]

None of the previous studies covered the entire new city, and 3 different indices were used. The Toronto[6] and Scarborough[4] studies also used several different examiners, whereas the others used limited numbers of "calibrated" examiners. Thus, a valid and reliable estimate of the prevalence and severity of fluorosis was needed to support public health policy decisions in this area.

Methods

The Office of Research Services of the University of Toronto, the Research and Education section, Policy and Programs Division of Toronto Public Health, and both the Toronto District Board of Education and the Toronto Catholic District School Board approved the methods.

Sampling Scheme

The sample size was determined by the desire to obtain relatively precise prevalence estimates of dental caries for 3 age groups (5, 7 and 13 years), for high-risk, medium-risk and low-risk schools in each of the 4 health regions (3 x 3 x 4 = 36 cells in total). According to Ontario standards, a school is at medium risk if between 9.5% and 14.0% of junior and senior kindergarten children have decay on 2 or more teeth. The risk categorization of schools, while not necessarily applying to children in more senior grades, is used in the program guidelines issued by the provincial Ministry of Health to guide dental staff in Ontario health units in determining when to allocate resources for further screening and group preventive services for children in those schools.

On the basis of partial data obtained in 1994, estimates of the precision for the percentage of children who were caries-free and mean DMFT scores were examined for sample sizes of 75, 100 and 200 children. Because of limited resources, we elected to include 100 children for each of the 3 age groups (5, 7 and 13 years), in each of the 4 new health regions and the 3 risk categories, for a total of 3600 children. We decided to survey children from 6 schools only for each cell, so as to limit the travel required.

From screening results obtained in 1998–1999, a database of all elementary schools in the Toronto public and Catholic school boards was prepared. The database contained information on the school name, address, health region, numbers of children enrolled in senior kindergarten (age 5), grade 2 (age 7) and grade 8 (age 13), plus the school's risk category (high, medium or low). A 2-stage sampling process was used. During the first stage we selected 6 schools for each cell (age, risk category and region). Then we used a random start and cell-specific sampling ratio (age-specific enrolment in the 6 schools divided by 100) to select the children to be included in each cell.

Enrolment of Participants

Principals and staff were contacted and informed of the survey and their cooperation was obtained. A letter was sent to the parents of children in the target grades to allow the parents to refuse their child's participation. Children without parental refusal were selected according to the sampling ratio for that school and invited to participate. Substitutes were obtained in the same fashion for selected children who, on their own, stated that they did not wish to participate.

Examination and Recording

The survey examination followed the protocol issued by the Ontario Ministry of Health[7] and used in previous dental health surveys in Ontario. The protocol states that only dentinal caries is to be scored at the level of the tooth, i.e., surface scores are not recorded. The protocol also calls for examiners to indicate whether the child has urgent treatment needs that would meet the eligibility criteria for the provincial Children in Need of Treatment program. Dental eligibility criteria include presence of pain, infection, hemorrhage, trauma, large open lesions and acute periodontal conditions.

Fluorosis was measured on the maxillary permanent anterior teeth of children aged 7 and 13 according to the Tooth Surface Index of Fluorosis (TSIF).[8] The ministry protocol states that TSIF be scored, in terms of the highest score on bilateral pairs of teeth, as none (TSIF = 0); parchment white patches visible on less than one-third of the tooth surface (TSIF = 1); parchment white colour visible on at least one-third but less than two-thirds of the tooth surface (TSIF = 2); parchment white colour visible on two-thirds or more of the tooth surface (TSIF = 3); and staining or pitting (or both) in conjunction with a TSIF score of 1, 2 or 3 (TSIF = 4).

Under the protocol, information on possible health determinants is limited to birthplace (obtained from school records or by questioning the child). One of 2 specially trained dental hygienists examined each child's teeth and periodontal tissues using sterilized mouth mirrors and blunt probes with a standard light source. Assistants using number codes recorded the findings in a computer program or on paper for later entry. The examination of each child took no more than 5 minutes and was conducted in a private area of the school.

Parents and participants were informed of any key findings (to be shared with the family dentist), and parents of children with urgent dental conditions were given a

notification form that they could use to obtain care for the child if they could not afford it.

Training of Examiners

Two examiners were trained during separate, day-long sessions by the senior investigator (J.L.L.). The training sessions consisted of a review of the criteria outlined in the manual, illustrated with projected clinical slides, followed by examinations of children. Compliance with the criteria in the protocol was rechecked approximately biweekly by the senior investigator, who independently examined children enrolled in the study and compared his results with those of the 2 examiners. The examiners remained consistent with the examination protocol in virtually all cases.

Analysis and Reporting

The data were transferred to SPSS for analysis (SPSS Inc., Chicago, Ill.). The descriptive findings were weighted according to the city's population in each age group. Tests for associations with potential determinants were conducted on the unweighted data. Basic findings are reported according to the O'Keefe template.[2] For fluorosis, the reporting cut-off, a score of 2 or more, reflects the untested hypothesis that most parents and children would not be aware of a condition scoring 1. For scores of 1, the lesion is often not prominent, having indistinct borders and flecks of white in a lattice-like appearance on less than one-third of the tooth surface. The focus of this paper is on the prevalence and severity of fluorosis on maxillary permanent anterior teeth and, accordingly, no findings are reported for 5-year-olds.

Results

The data file contained the results of 3657 examinations. One hygienist examined 90% of the children. Controlling for age and risk level in the region where they overlapped, there were no statistical differences in the major indicators of health: mean deft + DMFT, percentage with 2 or more decayed teeth and percentage with fluorosis as determined by the examiner. This report is limited to the findings of fluorosis on maxillary permanent anterior teeth and its relationship to the prevalence and severity of dental caries.

Table 1 shows the major dental health indicators for 7- and 13-year-olds in the weighted sample. Approximately 40% of children had had one or more cavities. The percentage of children needing urgent care and needing 2 or more teeth restored was highest for the 7-year-olds. The mean number of teeth decayed, missing or filled among deciduous (deft) and permanent (DMFT) teeth for children 7 years of age was 1.59 and among permanent teeth only (DMFT) for children 13 years of age was 1.13.

Table 1 **Caries and fluorosis in Toronto children (weighted findings of the 2000 Dental Indices System survey)**

Indicator	Age group; weighted % of subjects[a]	
	7-year-olds (weighted *n* = 2792)	13-year-olds weighted *n* = 2493)
Previous caries experience	41.3	39.3
Urgent treatment needs	7.4	1.7
With 2 or more decayed teeth	7.0	2.0
Mean deft + DMFT (and SD)	1.59 (2.7)	
Mean DMFT (and SD)		1.13 (2.0)
With moderate fluorosis (TSIF ≥ 2)	14.0	12.3

[a]*Except where indicated otherwise.*
SD = standard deviation, TSIF = Tooth Surface Index of Fluorosis.

Table 2 **Distribution of TSIF scores (weighted findings of the 2000 Dental Indices System survey)**

TSIF score	Age group; weighted % of subject	
	7-year-olds (weighted *n* = 2792)	13-year-olds weighted *n* = 2493)
0 (no fluorosis)	73.2	79.6
1 (fluorosis on less than one-third of the tooth)	12.8	8.2
2 (fluorosis on at least one-third but less than two-thirds of the tooth)	9.2	6.6
3 (fluorosis on two-thirds or more of the tooth)	4.5	3.9
4 (staining, pitting or both, in conjunction with TSIF score of 1, 2 or 3)	0.3	1.8

TSIF = Tooth Surface Index of Fluorosis.

The prevalence of dental fluorosis, defined as TSIF of at least 2, was not statistically different between the 2 age groups: 14.0% for the 7-year-olds, 12.3% for the 13-year-olds, and 13.2% for the 2 groups combined.

Table 2 shows the distribution of the 4 degrees of severity of fluorosis for the 2 age groups weighted according to the population. A score of 1 (which occurred in 12.8% of 7-year-olds and 8.2% of 13-year-olds) is by convention assumed to be esthetically unimportant. Roughly 5% of children had scores of 3 or 4; this degree of fluorosis is likely noticeable by most, if not all, affected children and their parents.

For Tables 3 and 4, only the unweighted data were used. There was no significant difference in the prevalence or severity of fluorosis between the 2 age groups, so they were combined for the analysis presented in Table 3. Table 3

Table 3 **TSIF scores by birthplace among 7- and 13-year-old participants (weighted findings of the 2000 Dental Indices System survey)**

TSIF score	Birthplace; % of subjects: Toronto, Ontario (*n* = 1265)	Elsewhere in Canada (*n* = 61)	Outside Canada (*n* = 800)	Not stated (*n* = 309)	Total (*n* = 2435)	*p* value[a]
0	73.4	85.2	86.9	63.8	76.9	
≥ 1	26.6	14.8	13.1	36.2	23.1	< 0.001
≥ 2	15.4	8.2	4.9	23.0	12.7	< 0.001

[a]*Chi-square test.*
TSIF = Tooth Surface Index of Fluorosis.

Table 4 **Relationship between severity of fluorosis and caries experience among 7-year-olds (weighted findings of the 2000 Dental Indices System survey)**

Caries experience	TSIF = 0 (*n* = 902)	TSIF = 1 (*n* = 146)	TSIF ≥ 2 (*n* = 162)	All scores (*n* = 1210)	*p* value
% of children with caries experience (deft + DMFT ≥ 1)	42.4	30.1	37.0	40.2	0.014[a]
Mean deft + DMFT	1.69	1.36	1.23	1.59	0.067[b]

[a]*Chi-square test, 2 degrees of freedom.*
[b]*Analysis of variance (ANOVA).*

shows the distribution of 7- and 13-year-old children with any fluorosis at all (TSIF ≥ 1) and with fluorosis scores of at least 2 (TSIF ≥ 2) by birthplace. The differences by place of birth are significant, no matter what cut-off is used to identify the condition. By either criterion, the proportion of children with the condition is about 3 percentage points higher for children born in Toronto than for the sample as a whole but is much higher than the others for whom we had birthplace information. Children born outside Canada had the least fluorosis, and those born elsewhere in Canada had the next lowest level of fluorosis. Among those for whom we had no information on birthplace, the proportion with the condition was highest: for the clinically important levels of fluorosis (TSIF ≥ 2), the proportion was 1.5 times that for the children born in Toronto.

Although not presented in the table, separate analysis has shown that the children for whom birthplace was unknown were atypical: they had both high prevalence and severity of caries and the highest fluorosis scores.

The mean numbers of decayed, missing and filled teeth (deft + DMFT for 7-year-olds and DMFT for 13-year-olds) were significantly different between the 2 age groups, so the examination of the relationship between the prevalence and severity of caries and the fluorosis scores was limited to the 7-year-olds. The prevalence of children with caries (deft + DMFT > 0) was highest among children with no fluorosis (Table 4). Similarly, there was a trend for the mean caries scores to be lower among those with higher levels of fluorosis, but these differences were not statistically significant.

Discussion and Implications

The findings of this study are limited in the first instance by the DIS protocol, according to which only place of birth and age are available as possible explanatory variables for levels of fluorosis. We were unable to obtain birthplace information for all of the children, and even where it was available, the information might mis-specify the exposure to fluoridated water during the susceptible period for the permanent anterior teeth, depending on family mobility. Such mis-specification would lessen any effect observed. Second, the relationship between greater fluorosis and fewer dental caries (Table 4) might have been enhanced by examiner bias: examiners may under-report caries in children they have previously identified as having fluorosis, since fluorosis is recorded before dental caries in the protocol.

Given these limitations, the first findings of note are that caries continues to be found in about 40% of children and that both the proportion of children with untreated decay and the need for urgent care were greatest in the younger age group. These levels of disease and urgent needs seem sufficiently high to warrant continued public health efforts to reduce them.

Moderate fluorosis, defined as TSIF of at least 2, was evident among 14.0% of children 7 years of age. For this age group, the criteria, cut-offs and results were consistent with those of O'Keefe.[2] Osuji and others[3] and Lewis and others[5] used the Thylstrup and Fejerskov[9] index and reported prevalence as any score of at least 1. If we recalculate prevalence using a cut-off value of 1, our results (23.8% of the 2 age groups, weighted) are intermediate between the finding of Lewis and others[5] (36%) and that of Osuji and others[3] (13%). Lewis,[6] while not specific, presumably reported any level of at least 0.5 on Dean's index.[10] Johnston and Shosenberg[4] also used Dean's index and reported the prevalence as "some evidence of fluorosis" (Dean's index ≥ 0.5). Johnston and Shosenberg[4] stated that

they examined life-long residents of the region. Lewis and others[5] appear to have reported on only those who were life-long residents within 1 mile (1.6 km) of a known source of airborne fluoride, which perhaps accounts for the higher prevalence than either we or Osuji and others[3] found. Because earlier studies covered only parts of the newly amalgamated city, used different indices and were influenced by various mixes of exposure because of immigration patterns, trends are hard to identify. Nonetheless, the prevalence and severity of dental fluorosis among those we could identify as having been born in Toronto support the August 1999 decision to reduce Toronto's water fluoride concentration to 0.8 ppm from the former 1.2 ppm.

The levels of fluoride exposure at the time of crown formation, as demonstrated by the TSIF scores, continue to be related to the prevalence of caries among 7-year-olds (Table 4). This finding can be explained by either a systemic effect of fluoride or the stability of exposure to topical fluorides over the childhood years, factors not examined in this study. In this survey we did not collect data on the amount of toothpaste swallowed during the years of formation of crowns on the permanent anterior teeth, but other studies have shown that this is a risk factor for dental fluorosis in fluoridated communities.[3,11] Thus, on the basis of the prevalence and severity of fluorosis among those born in the city, Toronto Public Health should continue its efforts to inform parents of very young children about the safe use of fluoride dentifrices. ◆

Acknowledgments: We acknowledge and thank Ms. Penny Liozou and Ms. Rose Greco, who examined the participants. We also thank their several assistants who recorded the results, the principals and staff of the schools they visited, and the parents and children who agreed to participate.

Dr. Leake is professor and head, community dentistry, department of biological and diagnostic sciences, faculty of dentistry, University of Toronto, Toronto, Ontario.

Mr. Goettler is biostatistician, planning and policy, Toronto Public Health, Community and Neighbourhood Services, City of Toronto, Ontario.

Ms. Stahl-Quinlan is dental coordinator, dental and oral health services, Toronto Public Health, Community and Neighbourhood Services, City of Toronto.

Dr. Stewart is director, dental and oral health services, Toronto Public Health, Community and Neighbourhood Services, City of Toronto.

Correspondence to: Dr. James L. Leake, Community Dentistry, Faculty of Dentistry, University of Toronto, Toronto, ON M5G 1G6. E-mail: james.leake@utoronto.ca.

References

1. Health Canada. Guidelines for Canadian Drinking Water Quality — Supporting Documents. 1996; Ottawa, Canada. P. 12. Available from: URL: http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/dwgsup_doc/fluoride.pdf.

2. O'Keefe JP. A template dental health status report for Ontario public health units. *Can J Community Dent* 1995; 10(1):18-24.

3. Osuji OO, Leake JL, Chipman ML, Nikiforuk G, Locker D, Levine N. Risk factors for dental fluorosis in a fluoridated community. *J Dent Res* 1988; 67(12):1488-92.

4. Johnston DW, Shosenberg JW. Prevalence and severity of dental fluorosis in a fluoridated community. IADR Combined Section Meeting; 1986 Oct; Niagara-on-the-Lake, Ontario.

5. Lewis DW, Ondrack C, Mayhall JT, Hunt AM. Dental fluorosis survey relative to brick plant fluoride emissions in Toronto and Brampton, Ontario. Toronto, Canada; Faculty of Dentistry, University of Toronto; 1982 January.

6. Lewis DW. An evaluation of the dental effects of water fluoridation, City of Toronto, 1963-1975. Toronto, Canada; Department of Public Health; 1976 June.

7. Ontario Ministry of Health. Dental index system. Toronto, Canada; Public Health Branch; 1998.

8. Horowitz HS, Driscoll WS, Meyers RJ, Heifetz SB, Kingman A. A new method for assessing the prevalence of dental fluorosis — the Tooth Surface Index of Fluorosis. *J Am Dent Assoc* 1984; 109(1):37-41.

9. Thylstrup A, Fejerskov O. Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. *Community Dent Oral Epidemiol* 1978; 6(6):315-28.

10. Dean HT. Classification of mottled enamel diagnosis. *J Am Dent Assoc* 1934; 21:1421-6.

11. Pendrys DG. Risk of enamel fluorosis in nonfluoridated and optimally fluoridated populations: considerations for the dental professional. *J Am Dent Assoc* 2000; 131(6):746-55.

CDA Resource Centre

For additional information on dental fluorosis, CDA members can contact the Resource Centre at tel.: **1-800-267-6354** or **(613) 523-1770**, ext. 2223; fax: **(613) 523-6574**; e-mail: **info@cda-adc.ca**.