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Caries and Fluorosis Prevalence in Communities with Different Concentrations of Fluoride in the Water

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48.4% of children in low fluoride area report no cavities. 46.8% in high fluoride area had no cavities. The fluorsis index was 8x lower, however, in the low-fluoride area. Socio-economic status, sweet consumption + oral habits affect cavities not more fluoride in the water.

Key Words

Dental caries · Fluorosis · Italy · Public health dentistry · Water fluoridation

Abstract

The need to defluoridate and fluoridate the water supplies in areas with drinking water naturally containing above-optimal (≥2.5 mg/l) and suboptimal (≤0.3 mg/l) fluoride concentration and caries and fluorosis prevalence of 12-year-old schoolchildren were assessed in Italy. In the low-fluoride area, 48.4% children were caries-free (DMFT = 0) and the DMFT and DMFS were 1.5 and 2.6; in the high-fluoride area, 46.8% had a DMFT = 0 and the values of the indices were 1.4 and 1.6, respectively. Multiple logistic regression analysis showed a significant association in the caries-free status according to parents' employment status (OR = 1.2, 95% CI = 1.1–1.3) and children's sweets consumption, since children who consumed sweets at least once a day had an adjusted odds ratio of 1.8 (95% CI = 1.4–2.3) compared to those with a lower consumption. Multiple linear regression analysis showed that DMFT and DMFS were significantly higher in children with a lower socioeconomic status and in those who consumed sweets at least once a day, with the DMFS significantly associated also with the area of residence. DT and FT scores were higher in the high- and low-fluoride areas, respectively. No evidence of fluorosis was reported in 94.5 and 55.3% of children in the low- and high-fluoride areas, respectively. The Community Fluorosis Index (CFI) for all permanent teeth was significantly higher in the high-fluoride area, 0.8, than the value, 0.1, found in the low-fluoride community. Our results substantiate the difficulties in defining universal guidelines for the fluoridation or defluoridation of drinking water and the need for an epidemiological approach to the decision as to fluoridate and defluoridate the water supply.

By the 1990s it became apparent that the current range of optimal concentration of fluoride in drinking water (0.7–1.2 mg/l) was not appropriate for all parts of the world. Even in the United States, where this range of concentration was developed [US Public Service, 1962], the advent of air-conditioning, the increased consumption of processed soft drinks and foods, and the widespread availability of fluoride in many forms were rendering obsolete the assumptions upon which the recommended fluoridation range was based. In other parts of the world, in particular the tropical and subtropical parts of Asia and Africa, the recommended fluoridation range had probably never been appropriate, and the unsuitability of international guidelines for fluoride in drinking water had already been established [Manji et al., 1986a, b; Brouwer et al., 1988; Evans, 1989; Warnakula-

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suriya et al., 1992; Irigoyen et al., 1995; Lo and Bagramian, 1996; Villa and Guerrero, 1996]. Moreover, the WHO Expert Committee on Oral Health Status and Fluoride Use [1994] has also recently recommended a more conservative range of 0.5–1 mg/l.

Determining of the most appropriate levels of fluoride in drinking water is crucial both for communities which intend to start water fluoridation and for those with excessive natural fluoride which require partial defluoridation. In these cases, the definitions of explicit criteria appear even more controversial. The European Community Regulations [Direttiva n. 80/778, 1980] do not differentiate between optimal value and maximum allowable concentration and have established a range of 0.7–1.5 mg/l. United States guidelines appear to be more permissive and recommend a water fluoride concentration of 0.7–1.2 mg/l and a maximum allowable value of 4 mg/l [Environmental Protection Agency, 1985, 1986]. Recently, the National Research Council [1993] in the United States has reexamined this limit and concluded that there was no evidence that would necessitate any change, but urged that the situation be constantly reviewed.

The decision to fluoridate or defluoridate the water is complicated, and some have argued that the recommended fluoride concentration should be based on the evaluation of caries and fluorosis prevalence, exposure to other sources of fluoride and the availability of dental care [Ismail, 1995]. The purposes of this study were to determine the need to defluoridate and fluoridate the water supplies of two areas of Italy with drinking water naturally containing above-optimal (≥2.5 mg/l) and suboptimal (≤0.3 mg/l) fluoride concentrations and to report the results of a survey of caries and fluorosis prevalence.

Materials and Methods

The population for this study consisted of schoolchildren 12 years of age who, according to questionnaires, had lived continuously since birth in their respective communities located in the southern part of Italy, and who had always used the community water supply as their primary source of drinking water. The children from low-fluoride (≤0.3 mg/l) communities resided in Catanzaro. The high-fluoride (≥2.5 mg/l) communities were located in the area around Naples.

Random sampling was used to select the primary public schools, from each school, classes were randomly selected and all children in the selected classes were asked to participate in the study, if eligible. Parents of sampled children were notified about the study by the school and invited to participate. The clinical examination took place during the period January to May 1997.

The children were examined in the schools. The 2 examiners had previously been trained and calibrated. Only the permanent teeth were examined. A surface had to be fully erupted to be examined or, if restored, sufficient tooth structure (more than 75%) had to remain. Teeth were not included if they were banded orthodontically or were partially erupted.

The examination of dental caries was carried with portable equipment, using a mirror and probe; no radiographs were taken. The DMFT and DMFS indices were used to record caries experience [World Health Organization, 1987]. The presence of natural teeth was recorded according to the WHO criteria [1987]. The dental information reported included the teeth present and whether these teeth required treatment according to WHO criteria [1987]. Enamel fluorosis was determined for each child using Dean's [1942] index. Each child was classified on the basis of the two teeth in the mouth showing the most advanced signs of fluorosis. Wherever two teeth were not affected to the same degree, the child was assigned the score of the lesser affected tooth. The examiners used criteria described by Russell [1961] for differentiating fluorosis from nonfluoride enamel opacities. According to Dean et al. [1942], only scores of 1–4 were considered definitive for fluorosis and, therefore, for the computation of fluorosis prevalence the category of questionable was not included. The Community Fluorosis Index (CFI), as described by Dean [1942], was also calculated to determine if community differences in the severity of fluorosis existed. The questionable category was included in the calculation of the CFI score.

Before the dental examination, all children completed a pretested, structured questionnaire, under the supervision of a parent/guardian, that sought information on: sociodemographics, consumption of sweets, frequency of oral hygiene habits, use of fluoride vehicles, and utilization of dental services. The sociodemographic variables were sex, age, child's residential history, and parent(s)/guardian(s) employment status. When a child had two working parents/guardians, the highest occupation was considered. The questions concerning frequency of consumption of sweets used the four following categories: (a) never, (b) less than once a day, (c) each day, (d) several times a day. The frequency of toothbrushing was evaluated as following: (a) less than once a day, (b) once a day, (c) more than once a day. The questions concerning the use of fluoride vehicles included information regarding whether or not fluoride dentifrices or fluoride supplement drops or tablets were used during each of the first 6 years of life and at the time of the investigation. The questions on the use of dental services asked whether the child had ever had a dental visit, and the reason for these dental visits.

The data were analyzed using the Stata software program [Stata Corp., 1993]. Multiple logistic regression and multiple linear regression analyses were performed to identify the variables that affect the following dental caries and fluorosis outcomes: caries-free status, DMFT, DMFS, DT, FT, and CFI. In all models the explanatory variables included were the following: area of residence (low fluoride water level = 0, high fluoride water level = 1), sex (male = 0, female = 1), parent(s)/guardian(s) employment status (five categories: high professional and managerial = 1, lower managerial = 2, senior clerical, small commercial operators = 3, skilled artisans, farmers = 4, others = 5), and toothbrushing habits (less than once a day = 0, at least once a day = 1). In caries models, the variables dental visit (never or for a dental problem = 0, routine checkup = 1) and frequency of consumption of sweets (less than once a day = 0, at least once a day = 1) were included. The model building strategy included the following steps: (1) univariate analysis of each variable considered, using the appropriate test statistic (chi-square test, t test or one-way analysis of variance); (2) inclusion of any variable whose univariate test has a p value lower than 0.25; (3) backward elimination of any variable which does not contribute to the model on the ground of the Likeli-

Table 1. Caries experience according to various explanatory variables in children from areas with different levels of fluoride in their water

	Low-fluoride area									
	n	caries-free %	DMFT	DT	MT	FT	DMFS	DS	MS	FS
Sex	(461)									
Men	233	49.8	1.5	0.5	0.1	0.9	2.4	0.9	0.4	1.1
Women	228	46.9	1.6	0.6	0.1	0.9	2.7	2.2	0.3	0.2
Parents' employment status	(455)									
High professional and managerial	127	57.5	1.2	0.2	0.1	0.9	2.1	0.4	0.6	1.1
Lower managerial	171	45.0	1.5	0.5	0.0	1.0	2.2	0.8	0.1	1.3
Senior clerical, small commercial operators	44	47.7	1.4	0.7	0.0	0.7	2.7	1.7	0.0	1.0
Artisans, farmers	90	41.1	1.8	0.8	0.1	0.9	3.4	1.8	0.5	1.1
Others	23	52.2	1.5	0.8	0.2	0.5	3.0	1.5	0.9	0.6
Toothbrushing habits	(458)									
Less than once a day	37	59.5	1.1	0.6	0.0	0.5	2.2	1.4	0.0	0.8
At least once a day	421	47.3	1.5	0.5	0.1	0.9	2.6	1.0	0.4	1.2
Dental visit	(453)									
Never or only when trouble	217	43.3	1.6	0.7	0.1	0.8	2.9	1.5	0.3	1.1
Routine checkup	236	53.8	1.4	0.4	0.1	0.9	2.2	0.7	0.4	1.1
Sweets consumption	(452)									
Less than once a day	276	54.0	1.3	0.4	0.1	0.8	1.9	0.6	0.3	1.0
At least once a day	176	39.2	1.9	0.8	0.1	1.0	3.5	1.6	0.5	1.4

In parentheses the number of children responding to the question is given.

hood Ratio Test (logistic regression) and the F test statistic (linear regression), using a cutoff of 0.05 level significance; variables whose exclusion alters the coefficient of the remaining variables are kept in the model; (4) testing of interaction terms using a cutoff of 0.15 level significance [Kleinbaum et al., 1988; Hosmer and Lemeshow, 1989]. The outcome caries-free status was dichotomized into 'caries-free' (DMFT = 0) and 'caries' (DMFT ≥ 1). Adjusted odds ratio (OR) and 95% confidence intervals (CI) were calculated.

Results

A total of 462 children participated in the low-fluoride group and 553 children participated in the high-fluoride group for response rates of 81.3 and 90.5%, respectively. Almost all children (99.2%) used fluoride toothpastes and the large majority of them (98.7%) were using dentifrices with standard fluoride concentration (<1,000 ppm) since the early years of life. Use of fluoride supplements between birth and 6 years of age was not common, since in the low- and in high-fluoride areas only 3 and 1% of children, respectively, reported a regular use of supplements in that period; a greater proportion of children reported a regular use of supplements at the time of the investigation (23 and 11%, respectively). Therefore, the information collected on the use of fluoride vehicles clearly indicated that this factor is very unlikely to contribute to the differences in fluorosis and caries prevalence in the two areas surveyed.

There were no significant differences between the children living in the low- and high-fluoride areas with regard to sex (chi-square = 0.01, 1 d.f., p = 0.91) and utilization of dental services (chi-square = 1.07, 1 d.f., p = 0.3), while children in the low-fluoride area had higher socioeconomic status (chi-square = 68.31, 4 d.f., p<0.0001), better toothbrushing habits (chi-square = 40.06, 1 d.f., p<0.0001) and consumed sweets less frequently (chi-square = 12.49, 1 d.f., p<0.0001) than those in the high-fluoride area.

In the children living in the area with a low fluoride water concentration the prevalence of caries-free status (DMFT = 0) was 48.4% and the DMFT and DMFS scores were 1.5±1.9 (SD) and 2.6±3.9 (SD), while 46.8% of the children in the area with high fluoride level had a DMFT = 0 and the mean (± SD) values of the indices were 1.4±1.7 and 1.6±1.9, respectively. However, at univariate analysis, only differences in DMFS turned out to be statistically significant (t = 4.46, 1,012 d.f., p<0.0001). Children living in the low-fluoride area had a significantly lower DT score

High-fluoride area									
n	caries-free %	DMFT	DT	MT	FT	DMFS	DS	MS	FS
(553)									
277	47.3	1.4	1.2	0.0	0.2	1.5	1.3	0.0	0.2
276	46.0	1.5	1.3	0.0	0.2	1.8	1.4	0.1	0.3
(553)									
52	50.0	1.1	0.9	0.0	0.2	1.2	1.0	0.0	0.2
208	53.9	1.2	0.9	0.0	0.3	1.5	1.1	0.0	0.4
89	44.9	1.4	1.3	0.0	0.1	1.6	1.5	0.0	0.1
153	41.2	1.6	1.5	0.0	0.1	1.9	1.7	0.0	0.2
51	33.3	1.6	1.6	0.0	0.0	2.1	2.0	0.1	0.0
(553)									
126	39.7	1.5	1.4	0.0	0.1	1.7	1.6	0.0	0.1
427	48.7	1.4	1.2	0.0	0.2	1.6	1.3	0.0	0.3
(553)									
283	47.7	1.5	1.3	0.0	0.2	1.8	1.5	0.0	0.3
270	45.6	1.3	1.2	0.0	0.1	1.5	1.3	0.0	0.2
(553)									
276	54.4	1.1	1.0	0.0	0.1	1.2	1.1	0.0	0.1
277	39.0	1.7	1.4	0.0	0.3	2.0	1.7	0.0	0.3

Table 2. Results of the logistic regression model (1) and linear regression models (2–6) for estimates of associations of caries experience and fluorosis with potential risk factors

Variable	OR	SE	95% CI	p value
Model 1: Outcome: Caries-free status				
log-likelihood = –676.94, chi-square = 32.48 (2 d.f.), p<0.0001				
Sweets consumption	1.81	0.23	1.40–2.33	<0.001
Parents' employment status	1.17	0.06	1.05–1.30	0.003

Variable	Coeff.	SE	t	p value
Model 2: Outcome: DMFT				
$F(2,994) = 15.46$, $p<0.0001$, $R^2 = 3.02\%$, adjusted $R^2 = 2.88\%$				
Parents' employment status	0.11	0.05	2.24	0.026
Sweets consumption	0.58	0.12	4.85	<0.001
Constant	0.89			
Model 3: Outcome: DMFS				
$F(3,993) = 20.44$, $p<0.0001$, $R^2 = 5.82\%$, adjusted $R^2 = 5.53\%$				
Parents' employment status	0.27	0.08	3.23	0.001
Residence	–1.14	0.21	–5.52	<0.001
Sweets consumption	1.08	0.20	5.36	<0.001
Constant	1.45			

Variable	Coeff.	SE	t	p value
Model 4: Outcome: DT				
$F(3,993) = 35.75$, $p<0.0001$, $R^2 = 9.75\%$, adjusted $R^2 = 9.47\%$				
Parents' employment status	0.19	0.04	5.04	<0.001
Residence	0.55	0.09	5.99	<0.001
Sweets consumption	0.38	0.09	4.27	<0.001
Constant	–0.06			
Model 5: Outcome: FT				
$F(2,1005) = 42.28$, $p<0.0001$, $R^2 = 7.76\%$, adjusted $R^2 = 7.58\%$				
Parents' employment status	–0.07	0.03	–2.05	0.041
Residence	–0.66	0.08	–8.31	<0.001
Constant	1.04			
Model 6: Outcome: CFI				
$F(1,1006) = 256.35$, $p<0.0001$, $R^2 = 20.31\%$, adjusted $R^2 = 20.23\%$				
Residence	0.63	0.03	16.01	<0.001
Constant	0.14			

Table 3. Prevalence of Dean's fluorosis index scores (%) and CFI according to various explanatory variables in children from areas with different levels of fluoride in their water

	Dean's fluorosis score, %							
	Low-fluoride area							
	n	normal	questionable	very mild	mild	moderate	severe	CFI (SD)
Sex	(461)							
Men	233	81.6	13.7	3.9	0.4	–	0.4	0.13(0.36)
Women	228	82.5	11.0	5.7	0.4	–	0.4	0.14(0.37)
Parents' employment status	(455)							
High professional and managerial	127	81.1	14.2	4.7	–	–	–	0.12(0.26)
Lower managerial	171	78.4	13.4	6.4	0.6	1.2	–	0.18(0.48)
Senior clerical, small commercial operators	44	84.1	6.8	6.8	2.3	–	–	0.15(0.40)
Artisans, farmers	90	87.8	11.1	1.1	–	–	–	0.07(0.19)
Others	23	82.6	13.0	4.4	–	–	–	0.11(0.26)
Toothbrushing habits	(458)							
Less than once a day	37	78.4	13.5	8.1	–	–	–	0.15(0.31)
At least once a day	421	82.2	12.3	4.5	0.5	0.5	–	0.13(0.37)
Dental visit	(453)							
Never or only when trouble	217	83.4	14.3	1.8	0.5	–	–	0.11(0.32)
Routine checkup	236	80.1	11.0	7.6	0.9	0.4	–	0.16(0.40)
Sweets consumption	(452)							
Less than once a day	276	81.5	12.7	4.4	0.7	0.7	–	0.15(0.41)
At least once a day	176	82.4	11.9	5.7	–	–	–	0.12(0.27)

In parentheses the number of children responding to the question is given.

($t = -7.52$, 1,012 d.f., $p<0.0001$) and higher FT score ($t = 9.01$, 1,012 d.f., $p<0.0001$) compared to those in the high-fluoride communities. Other factors, besides residence, found significantly associated to caries experience were parents' employment status and sweets consumption. In particular, no caries-free status, DMFT and DMFS indices appeared to be higher in lower socioeconomic classes ($p<0.0001$) and tended to increase with the increase of frequency of sweets consumption ($p<0.0001$).

Table 1 presents the percentage of children who were caries-free and the mean DMFT and DMFS scores according to various explanatory variables and by water fluoride status. The effects on caries experience of parents' employment status and sugar consumption were evident both in low- and high-fluoride areas. Indeed, DMFT increased from 1.2 to 1.8 and from 1.1 to 1.6 as the parents' employment status decreased in the low- and high-fluoride areas, respectively, whereas DMFS increased from 2.1 to 3.4 and from 1.2 to 1.9. DMFT and DMFS were approximately 50 and 80% higher both in low- and high-fluoride areas in children consuming sweets at least once a day. Multivariate analyses substantially confirmed the results of univariate analysis. In particular, the results of multiple logistic regression analysis showed a significant association in the caries-free status according to parents' employment status (OR = 1.2, 95% CI = 1.1–1.3) and children's sweets consumption, since children who consumed sweets at least once a day had an adjusted OR of 1.8 (95% CI = 1.4–2.3) compared to those with a lower consumption (model 1 in table 2). The results of multiple linear regression analysis showed that DMFT and DMFS were significantly higher in children with a lower socioeconomic status and in those who consumed sweets at least once a day, with the DMFS significantly associated also with the area of residence (models 2 and 3 in table 2). The effect of the area of residence was significant also on DT and FT scores, since they were higher in the high- and low-fluoride areas, respectively (models 4 and 5 in table 2). No significant interactions among the variables at 0.15 level were detected, and therefore they were not included in the final models. In all fitted models, graphs of residuals did not show any clear evidence of curvilinearity, heteroscedasticity and outliers.

High-fluoride area							
n	normal	questionable	very mild	mild	moderate	severe	CFI (SD)
(553)							
30.3	30.3	22.0	31.0	14.1	2.2	0.4	0.78(0.75)
34.4	34.4	23.9	24.3	14.5	2.5	0.4	0.74(0.78)
(553)							
52	28.8	23.1	32.7	13.5	1.9	–	0.77(0.72)
208	37.0	23.6	24.0	13.9	1.0	0.5	0.68(0.73)
89	28.1	21.4	39.3	10.1	1.1	–	0.74(0.64)
153	32.0	22.9	24.2	16.3	3.9	0.7	0.82(0.84)
51	25.5	23.5	27.5	17.6	5.9	–	0.92(0.86)
(553)							
126	27.8	29.4	26.9	15.9	–	–	0.73(0.67)
427	33.7	21.1	27.9	13.8	3.0	0.5	0.77(0.79)
(553)							
283	31.8	25.1	26.9	13.8	2.1	0.3	0.75(0.75)
270	33.0	20.7	28.5	14.8	2.6	0.4	0.78(0.78)
(553)							
276	32.2	21.7	28.6	14.9	2.2	0.4	0.77(0.76)
277	32.5	24.2	26.7	13.7	2.5	0.4	0.75(0.77)

Table 3 shows the percentage distribution of Dean's fluorosis score in the examined children according to various explanatory variables and by water fluoride status. The prevalence of dental fluorosis (score of 1 and higher) was related to the water fluoride level of the community. Indeed, 94.5% of the children had no evidence of fluorosis in the area with low fluoride concentration in the water supply as compared to 55.3% of the children in the high-fluoride area. In the remaining, a relatively small proportion of children showed definite signs of fluorosis in the high-fluoride area: only 2.7% of the teeth affected had a score of 3 (moderate) and no evidence of severe degree was observed. The mean (± SD) score using the CFI for all permanent teeth was 0.1±0.3 and 0.8±0.8 in children living in low- and high-fluoride communities, respectively. The results of multiple linear regression analysis indicated that the mean CFI score was significantly higher in children living in the area with high fluoride concentration in the water supply compared to those in the low-fluoride area (model 6 in table 2). Again, no evidence of curvilinearity, heteroscedasticity and outliers was found at the graph of residuals.

Discussion

The debate about the relationship between the concentration of fluoride in drinking water and dental caries and fluorosis began with Dean's [1942] 21-city study in the United States. A resurgence of interest has occurred during the past two decades, with a large body of literature published in several countries; comparisons with these studies must be interpreted cautiously because of different climatic conditions, patterns of water and dentifrice ingestion, dietary habits, fluoride supplement exposition, use of different criteria and indices, and a lack of uniformity of collected information. We agree with Nowjack-Raymer et al. [1995] that limits of any retrospective study exist mainly because of the possible inaccuracy of a parent to recall information about a child's fluoride intake. However, our results suggest that, apart from the possibly misclassified child, all children ingested similar quantities of fluoride. Comparison with the most recent international figures on caries at age 12 shows that children in our study had better dentition than those reported in most other industrialized countries of comparable life-style supplied with similar water fluoride concentrations. Indeed, in low-fluoride areas our caries-free prevalence, 48.4%, and DMFS index, 2.6, were better than the values reported in the United States by Grobler et al. [1986] (36.4% and 4.9), Ismail et al. [1990] (8.4% and 8.63), and Jackson et al. [1995], who reported a DMFS of 6.65. Treasure and Dever [1994] in New Zealand found that 22% were caries-free and had a DMFS of 6.2. Moreover, our DMFT, 1.5, was lower than the 1.91 observed by one of us in children living in an area with 0.3 ppm fluoride water concentration [Angelillo et al., 1990]. In high-fluoride areas, the percentage of caries-free children, 46.8%, and the DMFS score, 1.6, were lower that the values found in the United States by Driscoll et al. [1983] with a DMFS of 2.59, Grobler et al. [1986] with values of 23.5% and 8.63, and Jackson et al. [1995], who found a DMFS of 4.47. Data from recent studies in European countries showed that declines of DMFT averages to 1.0 seem to be attainable. This is particularly borne out by the averages from England and Wales as well as Finland, with a DMFT of 1.2, and from the Netherlands and Switzerland, where averages as low as 0.8–1.1 have been reported [Marthaler et al., 1996]. The reasons for this very encouraging and continuing decline in caries prevalence among the populations of many areas of the developed world may be attributed to the introduction of fluoride into a number of oral health care products and in particular the increased use of fluoride toothpastes. (97% of Europe has no added fluoride in the water).

The employment status of parents, an indicator of socioeconomic status, and children's sweets consumption were shown in this study to be associated with caries prevalence. Indeed, children from lower socioeconomic status and those who consumed sweets at least once a day had a significantly greater level of dental caries experience in terms of the absolute number of subjects affected and caries indices. These findings have confirmed several previous studies [Serra Majem et al., 1993; Kalsbeek and Verrips, 1994; Grindefjord et al., 1996; Petridou et al., 1996; Angelillo et al., 1998]. Moreover, in the current investigation the beneficial effect of water fluoride on caries experience was observed when comparing children from the low- to those from the high-fluoride community. Indeed, the DMFS value in the low-fluoride area was significantly higher, and our result indicates that water fluoride may continue to provide protection even in the presence of a low prevalence of dental caries. This finding is in accordance with results from previous studies that have shown an additional benefit in caries reduction when comparing a low- to a high-fluoride community [Driscoll et al., 1983, 1986; Angelillo et al., 1990; Ismail et al., 1993; Jackson et al., 1995].

At the low fluoride level, 4.7% of the children had dental fluorosis with a Dean's score of 0.1, and these results offer support for the finding reported in children who were lifetime residents of a low-fluoride community in the United States. Indeed, fluorosis was almost absent with only 2.9% of the children examined showing any definite signs of the condition and a Dean's index of 0.1 [Driscoll et al., 1986]. Moreover, Leverett [1986] found a prevalence of 10.1% and Kumar et al. [1989] a value of 9.4% and a Dean's score of 0.23. Present data on the prevalence and severity of dental fluorosis recorded in the high-fluoride area were lower than in most studies carried out in other countries. Prevalence recorded in the permanent dentition of US schoolchildren with a fluoride concentration in the drinking water of 3.48–4.07 ppm was 87.5% [Driscoll et al., 1983]. More recently, data from children in Mexico, who were exposed to water fluoride concentrations of about 2.8 ppm, showed a prevalence of fluorosis of 97.8%, with more than two thirds of the children classified in the moderate and severe categories, and a Dean's index of 2.9 [Irigoyen et al., 1995]. Jackson et al. [1995], in children living in an area with water containing 4 ppm of fluoride, found that 89.7% had evidence of fluorosis and almost half of the children received a Dean's score of 3 or greater. This extreme heterogeneity in findings, across various countries, makes the definition of universal guidelines on water fluoride concentration especially difficult, and suggests the need for a more pragmatic approach. In our survey, it was obvious that the higher water fluoride concentration led to an increased fluorosis prevalence, but it should be pointed out that the pattern of severity seems to be the same, and almost all subjects have less than moderate fluorosis. According to Dean [1942], the CFI score of 0.1 for the low-fluoride area warrants no public health concern, while the score of 0.8 in the high-fluoride area constituted a slight problem. Both scores, although significantly different, show that the prevalence of fluorosis in the two communities might not be considered a public health problem by Dean's criterion. This finding is consistent with past and present findings [Driscoll et al., 1986; Leverett, 1986; Ismail et al., 1993; Jackson et al., 1995].

The ultimate goal of this survey was to collect epidemiological data that could support the decision-making process about the choice for implementing a water treatment program (fluoridation or defluoridation) in the areas surveyed. In the low-fluoride community, fluorosis and caries prevalence results indicated that a critical level of fluoride exposure in this population had not been reached, and that water fluoridation was very likely to be an effective caries-preventive measure. However, caries prevalence appears to be very low and it is well known that the cost-effectiveness of water fluoridation programs depends to a great extent on the underlying levels of caries in the target population [White et al., 1989; Birch, 1990]. Therefore, from a cost-effectiveness point of view, water fluoridation needs to be assessed with other alternative programs, in order to efficiently use resources aimed at the promotion of dental health.

In the above-optimal fluoride area a decision to not implement a defluoridation program appears more straightforward. Unfortunately, current Italian regulations mandate that the high-fluoride area that has been studied is required to defluoridate its water supply or to shift to alternative water sources with lower fluoride concentration. These actions are not supported by our results and, although we did not assess the community acceptance of fluorosis, according to the findings of recent epidemiologic studies, fluorosis is perceived as a minor aesthetic problem and is not a concern for the public at large [Ismail et al., 1990, 1993; Williams and Zwemer, 1990; Clark et al., 1993; Riordan, 1993]. The benefits of water fluoride, in terms of protection against dental caries, appears to be substantiated, particularly because the availability of dental care, given the high contribution to the DMFT score of active decay, does not appear satisfactory. Previous studies have shown that discontinuation of water fluoridation or defluoridation of naturally fluoridated water supplies result in a significant increase in dental caries and a doubling of the cost of restorative care [Stephen et al., 1987; Attwood and Blinkhorn, 1989].

In conclusion, the results of our study document the difficulties in defining universal guidelines for the fluoridation or defluoridation of drinking water. Water treatment programs considering fluoridation or defluoridation cannot rely solely upon international standards, but must add epidemiological considerations to the decision as to fluoridate and defluoridate the water supply. Information on caries and fluorosis prevalence, exposure to other fluoride products and availability of dental care are fundamental in order to make rational choices, implement cost-effective interventions and thus to realize the considerable savings inherent in avoiding unnecessary and costly water treatment programs.

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