ABSTRACT

A telephone survey was carried out in 1994, in the Québec City region, among 1006 people living in two municipalities where tap water is fluoridated and 1003 people living in two municipalities where there is no fluoridation. Knowledge of the main benefit associated with the use of fluoride (prevention of tooth decay) in drinking water was not different in fluoridated versus non-fluoridated municipalities (20.4% vs 19.4%, $p = 0.57$). Knowledge of its main disadvantage (increase of dental fluorosis) was very low and similar in both groups (3.1% vs 2.0%, $p = 0.11$). Opposition to fluoridation was slightly higher in fluoridated areas (22.0% vs 18.3%, $p = 0.04$), and the use of fluoridated supplements for children was much less important in fluoridated areas (4.4% vs 12.4%, $p = 0.001$). No changes in the measures of association (odds ratios) were found after adjustment for the different characteristics of the participants (age, family income, education). Opposition to fluoridation was lower among those who believed their tap water was fluoridated (even if not) : 19.9% vs 34.5%, $p < 0.001$. This study demonstrates that there is still need for public health education on the uses of fluorides.

ABRÉGÉ

Une enquête téléphonique a été menée en 1994, auprès d'un échantillon de personnes résidant dans la région de Québec : 1006 résidents dans deux municipalités avec fluoruration et 1003 personnes dans deux municipalités sans fluoruration. La connaissance du principale bénéfice associé à l'utilisation de fluorures dans l'eau potable (prévention de la carie dentaire) n'était pas différente dans les municipalités fluorées et non fluorées (20,4 vs 19,4 % ; $p = 0,57$). La connaissance du principal désavantage (augmentation de la fluorose dentaire) était très faible et semblable dans les deux groupes (3,1 % vs 2,0 % ; $p = 0,11$). Les mesures d'association considérées (rapports de cotes) n'étaient pas modifiées après ajustement pour les différentes caractéristiques des participants (âge, revenu familial, éducation). L'opposition à la fluoruration était plus faible chez ceux qui pensaient que leur eau était fluorée (même si elle ne l'était pas) : 19,9 % vs 34,5 % ; $p < 0,001$. Cette étude démontre qu'une éducation sanitaire sur l'usage des fluorures est encore nécessaire.

Knowledge, Perception and Behaviour of the General Public Concerning the Addition of Fluoride in Drinking Water

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Addition of fluoride to water supplies is a well-documented public health practice. It is an easy way to improve dental health in a community. Fluoridation is in fact the least expensive public health measure to fight tooth decay.¹ Nonetheless while it is an accepted practice in public health, there have always been opponents. Allegations of possible cancer risks have been refuted many times by epidemiologists, but recent experimental data lead to equivocal results that once again feed the debate around this issue.² Because of the confusion among lay people as a result of these debates, public health authorities have sometimes recommended avoiding public debates on this issue.³

In parallel, several public health dentists have noted that the efficiency of water fluoridation in preventing tooth decay is decreasing, and that minor dental fluorosis in children is more frequent in fluoridated than in non-fluoridated areas.⁴ This seems to be due to a large increase in fluoride exposure through, for instance, toothpaste ingestion or misuse of supplements.^{4,5} Findings such as these have brought the discussion back into the public health arena, this time centring on the need to redefine the optimal parameters for water fluoridation.⁶

The objectives of the present study were to evaluate the knowledge, perception and behaviour regarding the addition of fluo-

ride in drinking water among people living in fluoridated and non-fluoridated areas in the Québec City region. At the onset, we hypothesized that people drinking fluoridated water are more aware of its risks and benefits; that they reduce the exposure of their children to other sources of fluoride; and are less opposed to fluoridation.

METHOD

Four municipalities of the Québec City region were the focus of the study. Two of the municipalities add fluoride in their municipal water system (Québec since 1976 and Sillery since 1991), and two are supplied with non-fluoridated water (Sainte-Foy and Lévis). Globally, 180,000 people in these municipalities used fluoridated water and 110,000 non-fluoridated water. A random sample of informants (1 per residence), aged 18 years and older, was selected by using the telephone list of the four communities (about 500 per municipality). A final sample of 2,009 residents, 1,006 from the fluoridated areas and 1,003 from the non-fluoridated areas, participated in the study. Interviews were carried out in November 1994 by 12 experienced interviewers under the supervision of a coordinator. Ten percent (10%) of the interviews were checked by double-listening. Statistical analysis was undertaken with SAS-PC, and adjustment was made based on the 1991 census profile for age and sex for each of the four communities as well as for population size. Chi-square was used to compare proportions, and logistic regression for multivariate analysis. Prevalence Ratio (PR) and Odds Ratio (OR) are the calculated measures of association.

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RESULTS

Characteristics of the participants by study area are presented in Table I. Residents of fluoridated areas are more educated and wealthy than those of non-fluoridated areas, however the two groups are comparable in terms of age and gender distribution.

Responses of participants on knowledge of the addition of fluoride are presented in Table II. Correct awareness of addition or not of fluoride in the municipal water system is higher in fluoridated than in non-fluoridated municipalities (PR = 3.7, $p < 0.001$). Interestingly, while not shown in the table, 35% of the residents of non-fluoridated municipalities thought that their municipality had fluoridated water. Benefits of the addition of fluoride on prevention of tooth decay are known by about one fifth of the population, but awareness is not different in fluoridated municipalities than in non-fluoridated areas. Knowledge of dental fluorosis as a side effect is rare in both groups.

Table III presents results of questions on perceptions and behaviour regarding the use of fluoride for dental health. The hypothetical risk of cancer is rarely perceived as a threat by respondents, and in the same proportion in both groups. Opposition to fluoridation of drinking water is found among about one fifth of the respondents of both groups but is slightly higher among fluoridated areas (PR = 1.2, $p = 0.04$). The use of fluoridated toothpaste by children is very common and is also similar in both groups. Finally, the use of fluoridated supplements by children is rare, and even less common in fluoridated areas (PR = 0.35, $p = 0.001$). This latter difference is also greater in families with children under six years of age (PR = 0.19, $p < 0.001$).

Odds ratios, for knowledge, perception and behaviour, adjusted for sociodemographic differences between the two groups of municipalities, when comparing fluoridated versus non-fluoridated municipalities are presented in Table IV. Confounding was not found, therefore the main associations remain significant after adjustment.

The possible effect of the belief that the municipal water system is fluoridated (even

	Fluoridated Areas		Non-fluoridated Areas		p value
	n	(%)	n	(%)	
Age (years)					
18-24	116	(11.5)	131	(13.1)	0.13
25-64	748	(74.4)	759	(75.7)	
≥ 65	141	(14.0)	113	(11.3)	
Sex					
Male	417	(41.5)	399	(39.8)	0.45
Female	589	(58.5)	604	(60.2)	
Education					
Grade/High school	304	(30.4)	381	(38.3)	< 0.001
College/University	695	(69.6)	614	(61.7)	
Family Income (\$/yr)					
< 20 000	168	(19.3)	167	(19.1)	< 0.001
20 - 79,999	509	(58.6)	604	(69.2)	
≥ 80,000	192	(22.1)	102	(11.7)	

	Fluoridated Areas		Non-fluoridated Areas		p value
	n	(%)	n	(%)	
Knowledge of the fluoridation status of the municipality of residence	504	(49.7)	133	(13.4)	< 0.001
Knowledge of the main advantage of the addition of fluoride (prevention of tooth decay)	207	(20.4)	193	(19.4)	0.57
Knowledge of the main disadvantage of the addition of fluoride (dental fluorosis)	32	(3.1)	20	(2.0)	0.11
N.B.: n are the frequency weighted by 1991 census profile					

	Fluoridated Areas		Non-fluoridated Areas		p value
	n	(%)	n	(%)	
Afraid of cancer risk	45	(4.4)	42	(4.2)	0.83
Opposed to fluoridation	223	(22.0)	181	(18.3)	0.04
Use of fluoridated toothpaste by children	208	(77.9)	225	(73.9)	0.26
Use of fluoridated supplements by children (all ages)	12	(4.4)	38	(12.4)	0.001
Use of fluoridated supplements by children under 6 years	5	(3.5)	22	(18.0)	< 0.001
N.B.: n are the frequency weighted by 1991 census profile					

if it is not) was also considered. Two effects were noted (Table V): first, a significant association was found indicating that opposition to fluoridation was less frequent among people who believed that their municipality fluoridated its drinking water compared to those who believed it did not (PR = 0.58, 95% CI: 0.46-0.72); second, use of fluoride supplements was less prevalent among those who thought that their

tap water was fluoridated (PR = 0.52, 95% CI: 0.28-0.96).

Effect of drinking water patterns was also assessed (Table VI). Exclusive tap water use was not an important behaviour modifier except for the use of supplements by children, which was much lower for tap water users in fluoridated areas compared to non-fluoridated areas. It was found however that users of alternatives to tap

TABLE IV
Odds Ratios for Knowledge, Behaviour and Perception After Adjustment for Sociodemographic Characteristics

	Crude OR	Adjusted OR*
Knowledge		
Use of fluoride by the municipality	6.38†	6.09†
Tooth decay/preventive effect of fluoride	1.07	1.20
Perception and behaviour		
Cancer risk	1.05	1.12
Opposed to fluoridation	1.26†	1.29†
Use of fluoridated toothpaste by children	1.25	1.23
Use of fluoridated supplements by children	0.32†	0.26†

* adjusted for age, family income and education

† $p < 0.05$

TABLE V
Behaviour Among All Residents According to the Belief that their Tap Water is Fluoridated or Not

Behaviour	Belief (%) that the municipality water is fluoridated			p value
	Yes	No	Do Not Know	
Use of fluoridated toothpaste by children	75.6	79.5	74.0	0.58
Use of fluoridated supplements by children	7.7	14.9	6.9	0.05
Opposed to fluoridation	19.9	34.5	16.6	< 0.001

TABLE VI
Behaviour Among All Residents According to their Water Consumption Profile

Behaviour	Consumption Profile (%)					
	Tap Water Fluoridated	Non-fluoridated	p	Alternatives Fluoridated	Non-fluoridated	p
Use of fluoridated toothpaste by children	80.1	74.2	0.24	74.8	73.6	0.82
Use of fluoridated supplements by children	2.6	13.5	0.001	6.8	11.7	0.17
Opposed to fluoridation	19.3	15.3	0.09	25.9	20.7	0.06

water (e.g., bottled water or treatment device) were significantly more opposed to fluoridation than tap water users ($p = 0.01$ in fluoridated communities, and $p = 0.03$ in non-fluoridated communities).

Only minor differences were found between the two fluoridated municipalities despite differences in history of fluoridation: knowledge of the effect of fluoride in preventing tooth decay was more prevalent in the municipality having a more recent access to fluoridated water (28.6% vs 19.8%, $p < 0.001$), and use of fluoride supplements by children was also reported more often in this municipality (9.0% vs 4.0%, $p = 0.09$).

DISCUSSION

The addition of fluoride in drinking water is a public health intervention which is responsible for an important decrease in the prevalence of tooth decay. The use of

different other sources of fluoride (dental paste, topical application, use of supplement, etc.) is usually held responsible for the reduced impact of water fluoridation and also for the recent increase in the prevalence of dental fluorosis. However, the reduced use of tap water in the general population noted by different authors⁷ might also account for a reduction of the effect of water fluoridation among the population. Nevertheless, water fluoridation remains popular in North America. Dentists as well as public health officers continue, on the one hand, trying to convince more municipalities to fluoridate their water and, on the other hand, asking the public to reduce the over exposure of young children to other sources of fluoride especially for those using fluoridated water.^{8,9} The present study provides some interesting results regarding indicators of knowledge, perception and behaviour of the general population on this subject. As

opposed to our initial hypothesis, residents of municipalities fluoridating their water systems do not react very differently from people living in non-fluoridated areas in regard to the use of fluoride. They are more often aware if their municipalities add fluoride or not to their tap water than people in non-fluoridated areas. However, the difference is less important than it seems when one considers that as many as 35% of the residents from non-fluoridated areas believe their municipality uses fluoride compared to 50% in the fluoridated areas ($PR = 1.4$).

The benefits related to the use of fluoride in drinking water are slightly more known in fluoridated areas, but awareness is still surprisingly low (24%) in this population and is in fact only significantly different in the recently fluoridated municipality. Possible risk of dental fluorosis is largely unknown (2%), less so than the very hypothetical cancer belief (4%); this is not significantly different in the two areas. Opponents to fluoridation are still numerous in both areas (18-22%) but resistance is significantly lower among those who think that their municipality uses fluoridated water and those using tap water. This seems to suggest some level of acceptability by those who think they have already experienced fluoridation. Use of fluoridated toothpaste is widespread in all the municipalities. This is not surprising since nearly all dental pastes on the market in Canada contain fluoride.

Use of fluoridated supplements by children appears to be low in municipalities where tap water is not fluoridated. This is in accordance with previous research on the subject and is the main reason why supplements are not the first choice for community-based programs.^{10,11} Although we did not ask for the specific behaviour regarding each child of the respondent, we nevertheless assessed the use of supplements for all children and for those younger than six years old. The American Academy of Pediatrics and the Canadian Pediatric Society still recommend the use of fluoride supplements in children up until the age of 16, in those areas where drinking water is not fluoridated.^{10,12} Only 12% of study parents living in non-fluoridated areas told us that they provide

fluoride supplements to their children, and this level is only slightly higher among those of both areas who believe their tap water is not fluoridated (15%). This confirms that the official recommendations are not very well followed. This might be due to a number of factors, such as: the difficulty of implementing the recommendation, the number of opponents to fluoridation, the high percentage of people who believe their water is fluoridated when it is not, or the discordance between the recommendations of several dental or medical associations. For instance, both the Canadian Dental Association and the American Dental Association recommend that children stop receiving fluoride supplements at 13 years of age.^{10,13}

The finding that 4% of families with children living in fluoridated areas and that 8% of those who believed their tap water was fluoridated said they gave supplements to their children is more worrisome, since this might lead to dental fluorosis and is not recommended either by medical or dental associations.^{8,12} This problem is probably widespread since research on similar issues in the province of Québec by Payette et al.¹⁴ noted that at the age of 7-8 years old, 56% of the children had taken fluoride supplements at one time or another during their life, whereas 6% of the children had taken supplements while living in a municipality where the tap water was fluoridated. We nevertheless must recognize that the level of inadequate use of supplements was lower in families using tap water compared to those using alternatives to tap water.

CONCLUSION

Fluoridation of drinking water is still a recommended practice by public health practitioners. Even if it can have some side effects such as minor dental fluorosis, it is generally accepted that its benefits are greatly superior to its side effects. Globally,

it is striking that knowledge of its use is not high and that knowledge of its risks and benefits is not very different between residents of fluoridated and non-fluoridated municipalities. As suggested elsewhere,¹⁵ it appears that if public familiarity with water quality issues has increased over time through media coverage or public communications, popular knowledge of the technology has progressed more slowly. Resistance to technological changes can also be compounded by other factors, such as chemophobia¹⁶ or lack of trust in the competency of public authorities dealing with water quality issues.¹⁷ Use of fluoride supplements by children is low but is still present in fluoridated areas, with a possible resulting risk of minor fluorosis. Therefore there still seems to be a need for public health education on this topic, especially in fluoridated areas. This should also be extended to health personnel because previous research^{18,19} has noted that knowledge of whether or not a municipality fluoridates its water is also low among practitioners, albeit slightly higher among pediatricians. Opponents to fluoridation represent an important minority who figure more among those who believe that their water is not fluoridated, and those who use alternatives to tap water. However it is not clear whether raising the level of knowledge on actual fluoridation status will change this attitude.

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REFERENCES

1. American Association on Public Health Dentistry. Position statement on community water fluoridation. *Public Health Dent* 1993;53:61.
2. Marshall E. The fluoride debate: One more time. *Science* 1990;247:276-77.
3. Emerson B, Clark DC. The challenge of a fluoridation referendum: The results of a referendum in British Columbia. *Can J Health* 1993;84:84-87.
4. Clark DC. Trends in prevalence of dental fluorosis in North America. *Commun Dent Oral Epidemiol* 1994;22:148-52.
5. Ismail AI, Brodeur J-M, Kavanagh M, et al. Prevalence of dental caries and dental fluorosis in students, 11-17 years of age, in fluoridated and non-fluoridated cities in Québec. *Caries Res* 1990;24:290-97.
6. Ismail AI, Shoveller J, Langille D, et al. Should the drinking water of Truro, Nova Scotia, be fluoridated? Water fluoridation in the 1990s. *Commun Dent Oral Epidemiol* 1993;21:118-25.
7. Grondin J, Levallois P, Gingras S. The Influence of Demographics, Risk Perception, Knowledge, and Organoleptics on Water Consumption Patterns. Proceedings of the 1996 Annual Conference of the American Water Works Association, Toronto, Ontario, June 23-27, 1996; 537-46.
8. Pendrys DG, Morse DE. Fluoride supplement use by children in fluoridated communities. *J Public Health Dent* 1995;55:160-64.
9. Den Besten PK. Dental fluorosis: Its use as a biomarker. *Adv Dent Res* 1994;8:105-10.
10. Ismail AI. Fluoride supplements: Current effectiveness, side effects, and recommendations. *Commun Dent Oral Epidemiol* 1994;22:164-72.
11. Pollard MA, Duggal MS, Fayle SA, et al. *Caries Preventive Strategies*. Brussels: ILSI Europe, 1995.
12. Canadian Pediatric Society. The use of fluoride in infants and children. CPS Statement:N 95-02, 1995.
13. Kowalchuk I. New guidelines on fluoride supplementation for children. *CMAJ* 1996;154:1007-8.
14. Payette M, Brodeur J-M, Lepage Y, Plante R. Enquête santé dentaire Québec, 1989-1990. Portrait de la santé dentaire des jeunes québécois de 7 à 17 ans. Montréal : Centre de coordination de santé communautaire, 1991.
15. Scherer CW. Communicating water quality risk. *J Soil Water Conservation* 1990;45:198-201.
16. Slovic P, Flynn J, Mertz CK, Mullican L. Health Risk Perception in Canada. Ottawa: Health Canada, 1993.
17. AWWA. Consumer Attitude Survey on Water Quality Issues. Denver: American Water Works Association, Research Foundation, 1993.
18. Vallée J-G, Kandelman D. Connaissances, attitudes et pratiques des médecins de l'ouest de l'Île de Montréal à l'égard du fluor et de la prévention de la fluorose dentaire. *Can J Public Health* 1993;84:94-98.
19. Kuthy RA, McTigue DJ. Fluoride prescription practices of Ohio physicians. *J Public Health Dent* 1987;47:172-76.

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