

Dental fluorosis in salt fluoridation schemes

Summary

The prevalences of fluoride-associated opacities (FOP) and non-fluoride-associated opacities (non-FOP) were assessed in two cantons of Switzerland with different salt fluoridation schemes. In the Canton of Zurich 305 schoolchildren from eight communities (age 9–10) were examined in 1995 and 900 children from one community (age 8–16) in 2002. In the Canton of Glarus 144 schoolchildren from 14 communities (age 9–10) were examined in 1996. In the Canton of Zurich 84% of the children used fluoridated domestic salt (250 ppm F) in the first five years of their life (questionnaire for parents 1995). In the Canton of Glarus, the corresponding value was 87%. In addition, about half of the bread samples in the Canton of Glarus showed an increased fluoride content (> 3 ppm F). Standardized photographs were taken of incisors dried with compressed air (15 seconds) and assessed using the Thylstrup Fejerskov index.

The prevalence of FOP was 21% in eight communities of the Canton of Zurich (1995) and 22% in 14 communities of the Canton of Glarus (1996). No differences were found between these two locations, although fluoride intake was higher in the Canton of Glarus due to fluoridated salt used by bakeries. A recent examination in one community of the Canton of Zurich (2002) showed a lower prevalence of 11%. The prevalences of non-FOP in all locations were between 17% and 23%.

The prevalences of FOP were at a low level in Switzerland compared to international studies using the same index. The most plausible explanation for this difference is the widespread use of low fluoride toothpastes (250 ppm F) by children under six. These toothpastes were introduced in 1986 and the consumption increased continuously until 1992. The low FOP prevalence cannot be considered a public health problem and is not perceived as such by the population. It is concluded that the Swiss fluoridation policy of the past two decades was appropriate, with caries prevalence in permanent teeth of Swiss schoolchildren being among the lowest globally.

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Introduction

Domestic salt containing 90 ppm fluoride was first introduced in the Canton of Zurich in 1955. In the following years, this salt was made available in most cantons of Switzerland. In 1983, the fluoride content of the domestic salt was increased to 250 ppm fluoride. Fluoridated salt is now voluntarily used by more than 80% of households.

In the cantons of Glarus and Vaud practically only fluoridated domestic salt containing 250 ppm fluoride has been available since 1974 and 1970 respectively. In addition, salt for bakeries also contains 250 ppm fluoride.

Fluoridated toothpastes with up to 1,500 ppm fluoride quickly spread in Switzerland from the 1960s on. In 1985, low fluoride toothpastes containing 250 ppm fluoride were introduced for children under six in the whole country.

The aim of the present paper was to assess prevalences of enamel fluorosis in a location with a free choice of salt (taking the Canton of Zurich as an example for the normal Swiss situation) and a location where only fluoridated salt is available (Canton of Glarus).

Materials and methods

Opacities due to fluoride are hereafter referred to as fluoride opacities (FOP) and those not due to fluoride as non-fluoride opacities (non-FOP). In eight communities of the Canton of Zurich (ZH) and 14 communities of the Canton of Glarus (GL), schoolchildren between seven and 16 years were randomly selected for a caries epidemiological survey. In addition, the anterior teeth of the third and fourth grade children (9- and 10-year olds) were photographed in order to assess enamel opacities. The participation rates and inclusion criteria have been previously described (WEBER 1997).

In 2002, all 1,252 schoolchildren at Volketswil between the ages eight and 16 years were chosen for a survey to assess opacities clinically and photographically. Due to nonparticipation (refusal, absenteeism, excursion), missing questionnaires and unassessable cases, complete data for 900 children were available (BARMAN 2004). In addition, one hundred children were randomly selected for a second photograph and examination. Prior to the clinical examination, the children cleaned their teeth in groups under the supervision of a school dental assistant. All examinations were conducted on school premises using mobile units comprising chairs with headrests, adjustable fibre optic halogen lamps and compressed air. Lip and cheek retractors were used to obtain an unobstructed view of the anterior teeth. Two Nikonmat cameras and a Nikon F camera with medical lens ($f=200$ mm) and built-in flash were used to take the photographs. An additional lens was needed to obtain a reduction ratio of 2/3. Exposure time was 1/60th of a second and the aperture value 22. Kodak color slide film Ektachrome EPR 64 ASA from the same batches were used in 1995/96 and 2002 respectively (for further details please refer to WEBER [1997] and BARMAN [2004]).

After insertion of the lip retractors, the children were instructed to move the incisors to an edge-to-edge position. The teeth were dried with compressed air for 15 seconds, whereafter children were asked to neither swallow nor press the tongue against the front teeth. The buccal surfaces of anterior teeth were then photo-

graphed, ensuring that the lens was placed orthogonally to the labial surfaces of the incisors (DE CROUSAZ 1982). Slides were assessed on a lightbox with the aid of a freestanding loupe with double magnification, and interference from surrounding light was kept to a minimum. Taking into consideration the 2/3 reduction ratio employed at the outset, a final magnification of 1.33 was obtained. The eight incisors were individually assessed for enamel opacities using the Thylstrup and Fejerskov index (FEJERSKOV et al. 1988). Non-fluoride associated opacities were also recorded. Opacities that did not conform to the description provided by FEJERSKOV et al. (1988) were regarded as non-FOP. Only opacities of at least 1 mm in diameter were recorded. When both conditions were present on the same tooth, then FOP were given priority ahead of non-FOP.

Data recorded for the eight permanent incisors was converted into an overall assessment for each individual. Children classified as having FOP had at least one tooth with a fluoride opacity. They received the highest observed FOP score. Children with non-FOP had at least one tooth affected. The unit of analysis was the individual.

All slides obtained in the eight communities of Zurich and 14 communities of Glarus were mixed and assessed blindly by two experienced and one less-experienced examiner. Equally, all slides from Volketswil were assessed by the same experienced and another less-experienced examiner. The examiners were calibrated beforehand. The Kappa statistic was used to ascertain intra- and inter-rater reliability (HUNT 1986). The Kappa values were interpreted in accordance with FLEISS (1981) as follows: ≤ 0.40 = poor; 0.40 to 0.75 = fair to good; ≥ 0.75 = excellent. A Kappa value of ≥ 0.60 denotes a good level of agreement. Agreement levels were based on the diagnosis "FOP yes or no" without considering the degree of severity.

The prevalence data presented for the communities in Zurich and Glarus were achieved through a consensus of three examiners. The prevalence data for Volketswil corresponds to a mean of three examiners.

In Volketswil, parents and children were asked whether they had noticed any white or yellow stains or discolorations on the anterior teeth and whether they viewed them as unaesthetic (details see BARMAN 2004).

Results

In the cantons of Zurich (1995) and Glarus (1996), slides of 449 children (305 and 144 respectively) were available for the evaluation. In Volketswil, it was 900. In addition, of 70 children two slides were available for repeat examination. In Table I (column

Tab. I Reliability (FOP = fluoride opacities; non-FOP = non-fluoride opacities)

Year	Location	Number of children	Age	Kappa value, intra-rater (1 slide)		Kappa value, inter-rater (1 slide)	
				FOP	non-FOP	FOP	non-FOP
1995	ZH, 8 communities	449	9–10	0.93	0.87	0.65 ¹	0.60 ¹
1996	GL, 14 communities						
2002	ZH, Volketswil	900	8–16			0.62 ¹	0.58 ¹
				Kappa value, intra-rater (2 slides)			
2002	ZH, Volketswil	70	8–16	0.75 ²	0.69 ²		

¹ Mean of three comparisons (3 examiner pairs)

² Mean of three examiners

second from right) intra-rater reliability is shown. One examiner assessed 449 slides twice in an interval of two weeks. The Kappa value was 0.93 for FOP and 0.87 for non-FOP. In Volketswil, the average Kappa value for three examiners was 0.75 for FOP and 0.69 for non-FOP. In this case two slides for each of the 70 children were compared. In Table I (extreme right column) inter-rater reliability is shown. The average Kappa values were 0.65 for FOP and 0.60 for non-FOP in the communities of Zurich and Glarus. The corresponding values for Volketswil were 0.62 and 0.58.

The prevalences of enamel opacities are presented in Table II. In eight communities of the Canton of Zurich, the prevalence of FOP was 21%, almost equal to the 22% in the 14 communities of the Canton of Glarus. In Volketswil, a distinctly lower prevalence (11%) was found. The most affected children in all locations had mild fluorosis (TF grade 1). Only between 1% and 4% had TF grades 2 or 3. Higher grades were not observed. The prevalence of non-FOP varied between 17% and 23%.

In Volketswil, the parents of 27% of the schoolchildren had noticed white or yellow stains or discolorations on their children's anterior teeth. Of the schoolchildren 16% had noticed stains. Fifty parents and two schoolchildren considered these stains to be unaesthetic.

Discussion

The high Kappa value for the intra-rater reliability (0.93) shows that a high consistency in diagnosis within the same examiner can be achieved. The Kappa value for the intra-rater reliability – by taking two pictures (slides) – was 0.75. This value is influenced by 1) differences between the two pictures and 2) the inconsistency of the raters. The nevertheless excellent result indicates that both factors do not greatly affect reliability.

The Kappa value for the inter-rater reliability was lower (between 0.62 and 0.65). It seems more difficult to achieve a good level of agreement between examiners. An in-depth analysis of data showed that examiners who had worked many years in co-operation had a higher agreement (Kappa values of 0.76 [WEBER 1997] and 0.82 [BARMAN 2004]).

Consequently comparisons of prevalences obtained by different, uncalibrated examiners may be somewhat problematic when prevalences of different countries with different examiners have to be compared. More trustworthy are comparisons of different locations, when grading was performed by the same examiners. This holds true for the comparison of Zurich (1995) and Glarus (1996).

The prevalence of FOP was virtually equal in the children from the Canton of Zurich (21%) and the Canton of Glarus (22%). This is remarkable because the corresponding salt fluoridation schemes were different. In fact, analyses of bread samples obtained from 197 children in 1983 and 1987 showed that approximately half of the samples had fluoride concentrations

above 3.0 ppm, while almost all of the remaining samples had less than 1.0 ppm F (MENGHINI et al. 1995); the low fluoride samples were due to bread imported from large bread factories in other cantons. This observation indicates that the Glarus scheme could be implemented throughout Switzerland without increasing the risk of fluorosis.

The difference in FOP prevalence between the eight communities of Zurich (20%) and the Zurich community of Volketswil (11%) is noticeable. One possible reason is an examiner drift. A more conservative assessment of FOP has been introduced to our staff in recent years in order to achieve a high specificity of diagnosis. This is underlined by the reevaluation of earlier slides for FOP prevalence in the community of Volketswil in the year 1982 (STEINER & MENGHINI 1984). This reevaluation resulted in a FOP prevalence of 8% (KATUMBA-GSELL 2004). The same examiners estimated the prevalence to be 21% in 1984. Other possible reasons for the difference between FOP prevalence of the eight communities of Zurich and the Zurich community of Volketswil are a decrease in the consumption of fluoride tablets and an increase in the use of low fluoride toothpastes (MENGHINI et al. 2003) as well as the different ages of the school populations investigated.

Some comparisons can be made with international studies using the same index (TF index) to assess incisor teeth. No studies from areas with salt fluoridation using TF index could be found. The following comparisons relate to studies from areas without water fluoridation. COCHRAN et al. (2004a) found FOP prevalences of between 51% and 82% in six EU states. All prevalences were determined by the same investigator. Other authors observed prevalences between 15% and 36% (HOLT et al. 1994, RIORDAN & BANKS 1991, TABARI et al. 2000, WANG et al. 1997) from surveys conducted in Great Britain, Norway and Australia. The latter studies show somewhat higher prevalences compared to Switzerland. In the study by COCHRAN et al. (2004a) much higher prevalences were observed. The big difference in comparison to Swiss findings could be influenced by both the raters and methodological details (drying period 105 seconds/camera angle 45° [COCHRAN et al. 2004b]).

In summary, the prevalences of FOP are at a very low level in Switzerland. The most plausible explanation for this is the widespread use of low fluoride toothpastes (250 ppm F) by children under six. This view is supported by HOLT et al. (1994) and RIORDAN (2002). The existing low FOP prevalence cannot be considered a serious cosmetic and even less a public health problem. This view is supported by the responses of the parents of 900 children from Volketswil. Parents of only 50 children found the stains on their children's teeth unaesthetic. It is noteworthy that in only six of these cases, the examiners had detected FOP. In conclusion, the Swiss fluoridation scheme of the past two decades seems adequate. In addition to a low FOP prevalence, a low caries experience in permanent teeth of schoolchildren (MENGHINI et al. 2003) was achieved.

Tab. II Prevalences of FOP and non-FOP

Year	Location	Number of children	Age	% with FOP grades					% with non-FOP
				0	1	2	3	≥1	
1995	ZH, 8 communities ¹	305	9–10	79	17	4	0	21	20
1996	GL, 14 communities ¹	144	9–10	78	20	1	1	22	23
2002	ZH, Volketswil ²	900	8–16	89	9	2	1	11	17

¹ Consensus of three examiners

² Mean of the percentages of three examiners

Zusammenfassung

In zwei Kantonen der Schweiz mit unterschiedlicher Fluoridsalz-Versorgung wurde die Prävalenz der fluoridbedingten (FOP) und nicht fluoridbedingten Schmelzopazitäten (non-FOP) ermittelt. Im Kanton Zürich wurden im Jahr 1995 305 Schüler (Alter 9–10) aus acht Gemeinden und im Jahr 2002 900 Schüler (Alter 8–16) aus einer Gemeinde untersucht. Im Kanton Glarus wurden im Jahr 1996 144 Kinder (Alter 9–10) aus 14 Gemeinden untersucht. Im Kanton Zürich verwendeten 84% der Eltern (Angaben 1995) fluoridiertes Salz (250 ppm F) während der ersten fünf Lebensjahre ihres Kindes. Im Kanton Glarus betrug der entsprechende Wert 87%; dazu wiesen rund die Hälfte der Brotproben einen erhöhten Fluoridgehalt (>3 ppm F) auf.

Standardisierte Fotos wurden von den mit Druckluft getrockneten Inzisiven (15 Sekunden) hergestellt und mit dem Thylstrup-Fejerskov-Index bewertet. Die Prävalenz der FOP betrug 21% in den acht Gemeinden des Kantons Zürich (1995) und 22% in den 14 Gemeinden des Kantons Glarus (1996). Zwischen den beiden Kantonen bestand kein Unterschied, obwohl die Fluorideinnahme im Kanton Glarus wegen des fluoridierten Salzes für die Bäckereien höher war. Eine neuerliche Untersuchung in einer Gemeinde des Kantons Zürich (2002) zeigte eine tiefere Prävalenz von 11%. Die Prävalenzen der non-FOP betrugen zwischen 17% und 23%.

Im Vergleich mit internationalen Studien, die den gleichen Index benützten, lagen die Prävalenzen der FOP in der Schweiz auf einem sehr tiefen Niveau. Die plausibelste Erklärung für diesen Unterschied ist der weitverbreitete Gebrauch von Kinderzahnpasten mit niedrigem Fluoridgehalt (250 ppm F) durch Kinder unter sechs Jahren. Diese Zahnpasten wurden im Jahr 1986 eingeführt, und der Verbrauch stieg bis 1992 kontinuierlich an.

Die niedrige Prävalenz der FOP kann nicht als Problem der öffentlichen Gesundheit betrachtet werden und wurde auch von der Bevölkerung nicht als solches wahrgenommen. Es kann daraus geschlossen werden, dass sich die Schweizer Fluoridierungspolitik der zwei letzten Jahrzehnte bewährt hat, dies auch deshalb, weil die Kariesprävalenz im bleibenden Gebiss von Schulkindern weltweit zu den tiefsten gehört.

Résumé

Les prévalences respectives des opacités associées aux fluorures (FOP, *fluoride associated opacities*) et non associées aux fluorures (non-FOP) ont été évaluées dans deux cantons suisses avec des schémas différents de fluoration du sel. Dans le canton de Zurich, 305 enfants en âge de scolarité (9 à 10 ans) de huit communes ont été examinés en 1995; dans une seconde étude, 900 enfants âgés entre 8 et 16 ans ont été examinés dans une commune en 2002. Dans le canton de Glaris, 144 enfants (également âgés de 9 à 10 ans) ont été examinés en 1996 dans 14 communes. Dans le canton de Zurich, 84% des parents (données de 1995) utilisaient du sel de cuisine fluoré (250 ppm F) durant les cinq premières années de vie de leurs enfants. Dans le canton de Glaris, la proportion respective était de 87%; en outre, environ la moitié des échantillons de pain analysés présentait une concentration élevée de fluorure (>3 ppm F).

Ces études ont été réalisées sur la base de photographies standardisées des incisives séchées à l'air comprimé pendant 15 secondes et par l'évaluation des clichés à l'aide de l'indice de Thylstrup-Fejerskov. Les prévalences respectives des FOP ont été de 21% dans les huit communes du canton de Zurich (1995) et de 22% dans les 14 communes du canton de Glaris (1996).

Aucune différence n'a été observée entre ces deux régions, en dépit du fait que l'absorption de fluorure a été plus importante dans le canton de Glaris en raison de l'utilisation de sel fluoré dans les boulangeries locales. Dans toutes les communes considérées, les prévalences des non-FOP se situaient entre 17% et 23%.

En comparaison avec des études internationales ayant utilisé le même indice, ces données indiquent que les prévalences des FOP se situaient à un niveau très bas en Suisse. L'explication la plus plausible de cette différence serait la très large utilisation de dentifrices pour enfants à concentration réduite de fluorure (250 ppm F) chez les enfants âgés de moins de six ans. Ces dentifrices ont été introduits en 1986 et la consommation en a augmenté continuellement jusqu'en 1992.

La faible prévalence des FOP ne peut pas être considérée comme un problème de santé publique et n'est pas perçue comme tel par la population. Ces données permettent de conclure que la politique de fluoration en vigueur depuis deux décennies en Suisse a fait ses preuves, ce d'autant que la prévalence des caries des dents permanentes chez les enfants en âge de scolarité se situe à l'un des niveaux les plus bas sur le plan mondial.

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