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# Assessment of dental fluorosis prevalence in Swiss populations

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**Summary** In 1996 and 2006, recruits of the Swiss army participated in a dental survey. Similarly in 1995/96 and 2004/05, randomly selected schoolchildren from 16 rural communities of the Canton of Zurich participated in a dental survey. As part of these surveys, color slides were taken of the incisor teeth of all recruits, as well as of third and fourth grade schoolchildren. The slides (N = 2049) were examined for the presence of fluoride-associated enamel opacities (FOP), using the Thylstrup-Fejerskov (TF) index. Two examiners (A and B) assessed all slides. The examiners were blind as to the year of survey. Examiner A recorded prevalences of FOP between 18% and 27% depending on population; examiner B recorded prevalences between 7% and 12%. The examiners' influence on the estimation of the prevalence was obvious. The prevalences reported should, therefore, be considered as rough estimates. FOP of TF score 2 were only observed in approximately 1% of the participants. One examiner recorded a TF score 3 in a single individual. FOP therefore are not a cosmetic problem and certainly not a public health concern.

The prevalence of FOP decreased slightly during observation period I (recruits born 1975–77 vs 1985–87) and period II (schoolchildren born 1985–87 vs 1994–96). However, the decline was statistically supported in only one instance (Period I, Examiner B).

## Introduction

Fluoride-associated opacities (FOP) of enamel are caused by excessive fluoride intake during the phases of enamel formation and enamel maturation. This results in the formation of hypomineralised enamel. The mildest form of FOP manifests as white horizontal lines in enamel and/or "snow caps" on the incisal edges and cusps of teeth. The most severe form appears as heavily stained, friable enamel with pitting. The prevalence of FOP is dependent upon the fluoride intake in the first years of life. A population's fluoride intake and hence the prevalence of FOP can change over time. The fluoride exposure of a population can be monitored through periodic surveys of the prevalence of FOP.

In 1995/1996 and 2004/2005, the Department of Preventive Dentistry and Oral Epidemiology conducted caries epidemiological surveys in schoolchildren from 16 rural communities in the Canton of Zurich. The incisor teeth of the 9–10 year old schoolchildren were photographed to determine the prevalence of FOP. In 1996 and 2006, similar surveys were conducted on Swiss military recruits in Thun, where the incisor teeth of all recruits were also photographed.

Since the incisor teeth are most susceptible to FOP in the first three years of life (Evans & Darvell 1995, Ismail & Messer 1996, Hong et al. 2006a), it is necessary to focus on the year of birth of the participants. Recruits and schoolchildren born between 1975 and 1996 were examined.

The objective of the study was to answer the following questions: *What was the prevalence of FOP in recruits examined in 1996 (born 1975–1977) and in 2006 (born 1985–1987)? Was there any change in prevalence in this period (period I)? What was the prevalence of FOP in schoolchildren examined in 1995/1996 (born 1985–1987) and in 2004/2005 (born 1994–1996)? Was there any change in prevalence in this period (period II)?*

## Materials and Methods

### Schoolchildren

The Department of Preventive Dentistry and Oral Epidemiology regularly conducts caries epidemiological surveys on schoolchildren in the Canton of Zurich. Randomly selected schoolchildren (boys and girls) of all ages from 16 rural communities are examined (Menghini et al. 2003). In order to determine the prevalence

of FOP among schoolchildren, the incisor teeth of third and fourth graders were photographed in 1995/1996 and 2004/2005.

### Recruits

Regular caries epidemiological surveys are also conducted on military recruits in Thun (Menghini et al. 2001). The recruits in Thun come from all cantons of Switzerland. To establish the prevalence of FOP, the incisor teeth of all military recruits were photographed in 1996 and 2006.

### Examination

Schoolchildren brushed their teeth under supervision immediately prior to the examination. Each recruit independently cleaned his teeth before presenting for the examination. Both schoolchildren and recruits were examined while seated on a chair with headrest, fibre-optic light source and compressed air. A standardised method of examination was used (Marthaler 1966). After the oral examination, incisor teeth were dried with compressed air for 15 seconds and frontal photographs (color slides) were taken. The slides were assessed on a lightbox with the aid of a freestanding loupe with double magnification. The labial surfaces of maxillary and mandibular incisor teeth were inspected for opacities. Opacities recorded as fluoride-associated opacities were those that coincided with the appearance criteria described by Thylstrup & Fejerskov (1978) and Fejerskov et al. (1988). The classification according to severity is known as the Thylstrup and Fejerskov index (TF index; scores see Appendix).

Non-FOP were those opacities that did not fit the descriptions of Thylstrup and Fejerskov. They were only recorded when a lesion was at least 1 mm in diameter.

Further details relating to the materials and methods have been described by Jäger (2008), Pfister (2008) and Menghini (2005).

### Examiners

There is evidence to suggest that the estimation of the prevalence of FOP depends on the examiner (Burt et al. 2003, Barman 2004, Tavener et al. 2007). All slides were, therefore, independently assessed by 2 examiners (A and B). A proportion of the slides were reassessed for a second time after an interval of a few months. At the outset, an experienced examiner from the Department of Preventive Dentistry and Oral Epidemiology (GM) calibrated both examiners in an identical process. A preliminary assessment of slides was conducted to determine the outcome of the calibration (Tab. I).

### Mixing the slides

Slides of the schoolchildren photographed in 1995/1996 and 2004/2005 were mixed, so that the examiners were blind as to the year of survey. The slides of the recruits from 1996 and 2006 were also mixed.

### Statistical analysis

A single result for each individual was derived from the assessment of the eight permanent incisors. Individuals with FOP were those with at least two teeth with a fluoride-associated opacity. They were allocated the highest observed TF score. Individuals with non-FOP exhibited at least one tooth with a non-fluoride-associated opacity. Individuals with an unassessable maxillary central incisor or more than four unassessable incisors were excluded from the examination.

Kappa scores were calculated to ascertain the inter-rater and intra-rater reliability (Hunt 1986). Differences between the prevalences recorded by both examiners were measured by using the McNemar test. Differences in the prevalences for the various survey years were evaluated by the Chi-squared test. A difference was considered to be statistically significant if the probability value was less than five percent ($p<0.05$).

## Results

### Participating recruits and schoolchildren

The total numbers of recruits and schoolchildren examined were 962 and 1087 respectively (Tab. II). At the time of examination, the recruits ranged in age between 19 and 21 years, and the schoolchildren between 9 and 10 years. Recruits examined in 1996 were born in the mid 1970s (1975–1977). Recruits examined in 2006 and schoolchildren examined in 1995/1996 were born in the mid 1980s (1985–1987). Schoolchildren examined in 2004/2005 were born in the mid 1990s (1994–1996). The "critical years" refer to the years of life which are considered pivotal to the development of FOP on incisor teeth. Depending on the cohort, this period fell in the second half of the 1970s, 1980s or 1990s.

**Tab. I Examiner agreement in the assessment of individuals**

| | | | FOP Yes[1]/No | | non-FOP Yes/No | |
|---|---|---|---|---|---|---|
| | | Number individuals assessed | Kappa Value | McNemar Test | Kappa Value | McNemar Test |
| Preliminary Examination | | | | | | |
| Between Examiners | GM and A | 237 | 0.65 | $p<0.001$ | 0.65 | n.s. |
| Between Examiners | GM and B | 237 | 0.77 | n.s. | 0.70 | n.s. |
| Between Examiners | A and B | 237 | 0.63 | $p<0.01$ | 0.68 | n.s. |
| Main Examination | | | | | | |
| Between Examiners | A and B | 2049 | 0.45 | $p<0.001$ | 0.48 | $p<0.001$ |
| Intra-examiner | A | 108 | 0.70 | $p<0.01$ | 0.60 | n.s. |
| Intra-examiner | B | 108 | 0.71 | $p<0.05$ | 0.56 | n.s. |

GM = reference examiner
A = Examiner A
B = Examiner B
[1] FOP Yes: Individual with TF score ⩾ 1

### Examiner Agreement

Table I shows the results for the examiner agreement based on the diagnosis of whether an individual had FOP or not and whether an individual had non-FOP or not. A preliminary investigation yielded good inter-rater reliability with regard to the diagnosis of "FOP yes/no" (Kappa values between 0.63 and 0.77). However, examiner A made the diagnosis of "FOP yes" more often than the reference examiner and Examiner B ($p<0.001$ and $p<0.01$ respectively). A good agreement was also observed between the examiners with regard to non-FOP diagnosis (Kappa value between 0.65 and 0.70). There were no statistically significant differences between the examiners ($p>0.05$).

The main investigation was undertaken by Examiners A and B. They obtained only a moderate level of agreement for the diagnosis of "FOP yes/no" (Kappa = 0.45). Examiner A made more frequent diagnoses of "FOP yes" than Examiner B ($p<0.001$). When only pronounced fluoride-associated changes (TF grade $\geq 2$) were considered as FOP, a Kappa value of 0.59 was obtained (not shown in Table). There were no statistically significant differences between the examiners ($p>0.05$). In the diagnosis of "non-FOP yes/no", Examiners A and B displayed only a moderate level of agreement (Kappa = 0.48). Examiner A made the diagnosis "non-FOP yes" far less frequently than Examiner B ($p<0.001$).

Intra-rater reliability was also measured and both examiners showed a good level of agreement in the diagnosis "FOP yes/no" (Kappa values 0.70 and 0.71). However, in the second round of assessment at the end of the study, both examiners recorded "FOP yes" more frequently than in the initial evaluation ($p<0.01$ and $p<0.05$ respectively).

### Prevalences of FOP

Table III and Figure 1 give an overview of the FOP prevalence data. For all participants who were investigated, Examiner A recorded a prevalence of 22.7% (individuals with TF score $\geq 1$). Examiner B recorded a prevalence of only 9.0%. This difference was statistically significant ($p<0.001$). When only cases with distinct fluoride-associated changes (TF score $\geq 2$) were considered, Examiner A calculated a prevalence of 1.0% and Examiner B's findings measured 0.8%. This difference was not statistically significant ($p>0.05$). A FOP of TF score 3 was diagnosed in only one single schoolchild (by Examiner B).

Examiner A recorded a decrease in the prevalence by 10% ($p>0.05$) in observation period I (recruits). During observation period I, Examiner B displayed a reduction in prevalence of 33% ($p<0.05$). In period II (schoolchildren), both Examiners A and B found decreases in prevalence that were not statistically significant (18% and 26% respectively).

**Tab. II** Number examined, Age at survey, Year of birth and Critical years[1]

| | Number Examined | Age at Survey (Years) | Year of Birth | Critical Years1 | Observation Period |
|---|---|---|---|---|---|
| Recruits 1996 | 376 | 19–21 | 1975–1977 | 1975–1980 | I |
| Recruits 2006 | 586 | 19–21 | 1985–1987 | 1985–1990 | |
| Total Recruits | 962[2] | | | | |
| Schoolchildren 1995/96 | 600 | 9–10 | 1985–1987 | 1985–1990 | II |
| Schoolchildren 2004/05 | 487 | 9–10 | 1994–1996 | 1994–1999 | |
| Total Schoolchildren | 1087[3] | | | | |
| Total Examined | 2049 | | | | |

[1] Critical years for the development of FOP on incisors
[2] Of the 1033 slides available, 962 could be evaluated
[3] Of the 1142 slides available, 1087 could be evaluated

**Tab. III** Prevalences of fluoride-associated enamel opacities (FOP)

| | Number Examined | With TF score 1 N | With TF score 1 % | With TF score 2 N | With TF score 2 % | With TF score 3 N | With TF score 3 % | With TF score ≥ 1 N | With TF score ≥ 1 % | Observ. Period | Difference in prev. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Examiner A** | | | | | | | | | | | |
| Recruits 1996 | 376 | 96 | 25.5% | 7 | 1.9% | | | 103 | 27.4% | I | –10% n.s. |
| Recruits 2006 | 586 | 138 | 23.5% | 7 | 1.2% | | | 145 | 24.7% | | |
| Schoolchildren 1995/96 | 600 | 125 | 20.8% | 5 | 0.8% | | | 130 | 21.7% | II | –18% n.s. |
| Schoolchildren 2004/05 | 487 | 85 | 17.5% | 2 | 0.4% | | | 87 | 17.9% | | |
| Total | 2049 | 444 | 21.7% | 21 | 1.0% | | | 465 | 22.7% | | |
| **Examiner B** | | | | | | | | | | | |
| Recruits 1996 | 376 | 43 | 11.4% | 4 | 1.1% | | | 47 | 12.5% | I | –33%* |
| Recruits 2006 | 586 | 46 | 7.8% | 3 | 0.5% | | | 49 | 8.4% | | |
| Schoolchildren 1995/96 | 600 | 48 | 8.0% | 6 | 1.0% | 1 | 0.2% | 55 | 9.2% | II | –26% n.s. |
| Schoolchildren 2004/05 | 487 | 31 | 6.4% | 2 | 0.4% | | | 33 | 6.8% | | |
| Total | 2049 | 168 | 8.2% | 15 | 0.7% | 1 | 0.0% | 184 | 9.0% | | |

* $p<0.05$)
n.s. $p>0.05$)

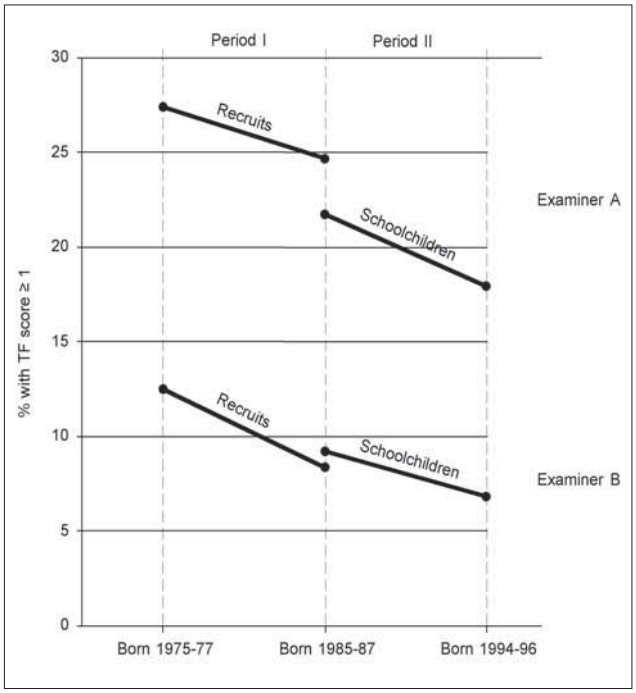


**Fig. 1** Prevalences of fluoride-associated enamel opacities (FOP)

Between boys and girls (schoolchildren) no statistically significant differences in the prevalence of FOP were found.

### Prevalences of non-FOP

The prevalences of non-FOP are summarised in Table IV. In this category, Examiner A recorded a prevalence of 6.7% for all participants who were investigated and Examiner B recorded 14.6%. The difference was statistically significant ($p<0.001$). Both Examiners A and B recorded changes in the prevalences of non-FOP for observation periods I and II that were not statistically significant.

## Discussion

### Critical years for the development of FOP

The incisor teeth are most susceptible to the formation of FOP in the first three years of life (Evans & Darvell 1995, Ismail & Messer 1996, Hong et al. 2006a). These years are referred to as the critical years. Another longitudinal study (Hong et al. 2006b) reiterated this finding. The risk of developing FOP remained low with an average fluoride intake of up to 0.04 mg (milligrams) fluoride per kilogram body weight per day in the first three years of life; at this level 12.9% of individuals exhibited FOP on the upper central incisors. This rose to 23% when fluoride intake ranged from 0.04 to 0.06 mg and in cases of higher fluoride intake, 38% were affected by FOP (Hong et al. 2006b).

### Inter-examiner reliability

There was only a moderate level of inter-rater agreement (Kappa = 0.45) although both examiners had been exposed to the same calibration exercise at the start of the study. The predominant difference between examiners was that Examiner A often diagnosed TF score 1 whereas Examiner B diagnosed "no change" (data not shown). The distinction between normal enamel and enamel affected by a very mild form of FOP proved to be the main difficulty. That probably has to do with the smooth transition between score 0 and score 1.

The examiners' influence on the estimation of the prevalence was obvious. The reported prevalence values are, therefore, to be viewed as rough estimates. Comparisons with findings from other studies should be interpreted with caution. The examiner's influence on the estimation of the fluorosis prevalence was also encountered in other studies (Burt et al. 2003, Barman 2004, Tavener et al. 2007). Tavener et al. (2007) asked 10 experienced examiners to evaluate the same 120 digital photographs of incisors. The prevalences for TF score $\geq 1$ ranged from 43% to 70%, depending on the examiner, and for TF score $\geq 3$ between 2% and 13%.

### Intra-examiner reliability

In most cases, prevalence data collected by the same examiner are better comparable. In this study, intra-examiner reliability (Kappa = 0.70 and 0.71 respectively) was of a higher level than inter-examiner reliability (Kappa = 0.45).

Even having one and the same examiner does not guarantee a consistent evaluation. When surveys are repeated after several years, there is always the risk that the same examiners will not apply the diagnostic criteria in the same manner as previously (examiner drift). This leads to uncertainty in the interpretation of results (Selwitz et al. 1995, Burt et al. 2003, Clark et al. 2006). In the present study, it has been observed that examiner drift can occur even within a period of months. In a second evaluation round at the end of the study, where a

**Tab. IV** Prevalences of non-fluoride-associated enamel opacities (Non-FOP)

| | Number Examined | With Non-FOP N | With Non-FOP % | Observation Period | Difference in Prevalence |
|---|---|---|---|---|---|
| **Examiner A** | | | | | |
| Recruits 1996 | 376 | 23 | 6.1% | I | 0% n.s. |
| Recruits 2006 | 586 | 36 | 6.1% | | |
| Schoolchildren 1995/96 | 600 | 40 | 6.7% | II | +19% n.s. |
| Schoolchildren 2004/05 | 487 | 39 | 8.0% | | |
| Total | 2049 | 138 | 6.7% | | |
| **Examiner B** | | | | | |
| Recruits 1996 | 376 | 63 | 16.8% | I | −16% n.s. |
| Recruits 2006 | 586 | 83 | 14.2% | | |
| Schoolchildren 1995/96 | 600 | 89 | 14.8% | II | −12% n.s. |
| Schoolchildren 2004/05 | 487 | 64 | 13.1% | | |
| Total | 2049 | 299 | 14.6% | | |

part of the slides were reassessed, both examiners graded the slides more strictly.

### Prevalences of FOP in Switzerland and other countries

Table V compares the current results as well as the findings from earlier studies conducted in Switzerland, and those from other countries. Included are all international studies published from the 1990s that used similar methods. All studies used the TF index to grade the severity of FOP on incisors.

In the present study examiner A recorded prevalences between 18% and 27% depending on population; examiner B recorded prevalences between 7% and 12%. In earlier surveys conducted in Switzerland, De Crousaz (1981) reported conspicuously high prevalences of FOP in the Cantons of Vaud (38%) and Basle City (37%). The fact that drinking water was fluoridated in Basle City may have had an impact, while in Canton Vaud, with its own salt works, practically only fluoridated domestic salt and baker's salt with a fluoride content of 250 ppm F was available since 1970. The values for the prevalences of FOP recorded in Swiss populations range from 7% to 38%. Data were collected over an extensive period of time (1979 to 2006), in regions with different fluoride supplies and by various examiners who used slightly varying methodologies. The median prevalence of FOP was 21%.

International studies conducted in regions without water fluoridation have reported widely differing prevalences (between 8% and 82%). In these surveys the median prevalence was 24.5%. International studies in regions with water fluoridation reported prevalences ranging from 22% to 89%. The median prevalence here was 42.5%. Prevalences of FOP reported for Swiss populations (median 21%), both in the present study and in previous surveys, was similar to those found in foreign regions without water fluoridation (median 24.5%).

### The severity of FOP in Switzerland

Fluoride-associated opacities at the level of TF score 1 are only visible upon close inspection when the tooth surface is dry, whereas FOP with TF score 2 are visible from normal conversing distance. Only FOP of TF score 3 are generally regarded as unaesthetic (Riordan 1993a).

In the present study, only about 1% of participants exhibited FOP of TF score 2. In a single individual, one examiner diagnosed a TF score 3. No higher scores (TF score 4–9) were seen. Fluoride-associated enamel opacities, therefore, are not a cosmetic problem and certainly not a public health concern. Furthermore, the very rare occurrence of unaesthetic FOP must be weighed against the great benefit of fluoride in reducing caries. In earlier surveys conducted in Switzerland, FOP of TF score 3 or even higher were more frequently observed (Table V). This leads to the assumption that the situation has improved.

### Changes in the prevalence of FOP

Changes in the prevalence of FOP were investigated in several countries. Studies from the USA reported an increase in the prevalence of FOP during the period 1934 to 1991 (Rozier 1999). Another increase in prevalence of FOP in the USA was reported for the period 1986/87 to 1999/2002 (Beltran-Aguilar et al. 2005). During the period 1960 to 1990, no changes in the prevalence of enamel opacities could be demonstrated in the United Kingdom (Holloway & Ellwood 1997). In Western Australia, a decrease in the prevalence of FOP was observed for the period 1989/1990 to 2000 (Riordan 2002). The reduction was thought to be related to the decrease in the use of fluoride tablets and the introduction of low-fluoride toothpastes (400 to 550 ppm F).

### Possible reasons for the suspected decrease in prevalence of FOP in Switzerland

In the present study, the prevalence of FOP decreased slightly during the two observation periods (Fig. 1). However, this decline was statistically supported in only one instance (Observation period I, Examiner B).

Possible reasons for changes in prevalence of FOP are changes in the use of fluoride toothpastes, fluoride tablets and fluoridated salt. The fluoride content of domestic salt in Switzerland was increased in 1983 from 90 to 250 ppm F. From this point in time, the use of fluoridated salt was given preference over the use of fluoride tablets (Marthaler 1990). From 1986, low-fluoride children's toothpaste (250 ppm F) was increasingly introduced in Switzerland. The changes in the patterns of use of fluoride supplements and their sales in the critical years are highlighted in Table VI. No details regarding the use and sales of fluoride tablets were available for observation period I. The use of fluoridated salt containing 250 ppm F increased, as did the use of low-fluoride children's toothpastes (250 ppm F). Consequently, toothpastes with higher fluoride content became less popular. In period II the use of fluoride tablets decreased according to information provided by the parents. The sales figures for fluoride tablets also showed an overall decrease. The use of children's toothpastes containing 250 ppm F increased further.

### Strengths and Weaknesses of the Study

The examiners were blind as to the year of survey. In addition, only intra-rater comparisons were considered. The unrandomised selection of military recruits can be seen as a weakness of the study. A bias through selection cannot be ruled out. Furthermore, it is not certain whether all participating recruits and schoolchildren were resident in Switzerland and in the 16 communities of the Canton of Zurich respectively in the first three years of life (critical years).

## Zusammenfassung

In den Jahren 1996 und 2006 wurden Rekruten der Schweizer Armee zahnmedizinisch untersucht. In den Jahren 1995/96 und 2004/05 wurden zufällig ausgewählte Schüler aus 16 Zürcher Landgemeinden zahnmedizinisch untersucht. Anlässlich dieser kariesepidemiologischen Untersuchungen wurden die Schneidezähne aller Rekruten sowie der Schüler der dritten und vierten Klassen fotografiert (Farbdiapositive). Die Diapositive (N = 2049) wurden auf fluoridbedingte Schmelzopazitäten (FOP) hin untersucht. Es wurde der Thylstrup-Fejerskov Index (TF-Index 0-9) verwendet. Sämtliche Diapositive wurden 2 Untersuchern (A und B) vorgelegt. Die Untersucher waren blind bezüglich des Untersuchungsjahres. Untersucher A ermittelte FOP-Prävalenzen zwischen 18% und 27% je nach Population; Untersucher B ermittelte Prävalenzen zwischen 7% und 12%. Der Einfluss der Untersucher auf die Schätzung der Prävalenz war offensichtlich. Die ermittelten Prävalenzen sind deshalb als grobe Schätzungen zu betrachten. FOP des TF-Grades 2 wurden nur bei rund 1% der Untersuchten festgestellt. Nur bei einem einzigen Individuum wurden von einem Untersucher FOP des TF-Grades 3 diagnostiziert. Fluoridbedingte Schmelzopazitäten stellen somit kein kosmetisches und noch weniger ein volksgesundheitliches Problem dar.

Die Prävalenz der FOP ging während Beobachtungsperiode I (1975–77 vs 1985–87 geborene Rekruten) und Beobachtungsperiode II (1985–87 vs 1994–96 geborene Schüler) leicht zu-

Tab. V Comparison data for the prevalence of fluoride-associated opacities (FOP) – (All assessments on incisors using TF-Index)

| Site | Details | Examiner | N | Age (Years) | Proportion (%) with TF Scores ⩾1 | 1 | 2 | ⩾3 | Method | Study |
|---|---|---|---|---|---|---|---|---|---|---|
| **Switzerland, present study** | | | | | | | | | | |
| CH | Recruits 1996 | A | 376 | 19–21 | **27** | 26 | 2 | 0 | Photograph | present study |
| CH | Recruits 2006 | A | 586 | 19–21 | **25** | 24 | 1 | 0 | Photograph | present study |
| ZH, 16 communities | S/children 1995/96 | A | 600 | 9–10 | **22** | 21 | 1 | 0 | Photograph | present study |
| ZH, 16 communities | S/children 2004/05 | A | 487 | 9–10 | **18** | 18 | 0 | 0 | Photograph | present study |
| CH | Recruits 1996 | B | 376 | 19–21 | **12** | 11 | 1 | 0 | Photograph | present study |
| CH | Recruits 2006 | B | 586 | 19-21 | **8** | 8 | 0 | 0 | Photograph | present study |
| ZH, 16 communities | S/children 1995/96 | B | 600 | 9–10 | **9** | 8 | 1 | 0 | Photograph | present study |
| ZH, 16 communities | S/children 2004/05 | B | 487 | 9–10 | **7** | 6 | 0 | 0 | Photograph | present study |
| **Switzerland, previous studies** | | | | | | | | | | |
| VD, 2 communities | S/children 1979 | PD | 280 | 6–13 | **38** | 19 | 16 | 2 | Clinical/Photo | De Crousaz 1981 |
| BS | S/children 1979 | PD | 182 | 6–13 | **37** | 25 | 10 | 3 | Clinical/Photo | De Crousaz 1981 |
| FR/NE, 5 communities | S/children 1979 | PD | 432 | 6–13 | **26** | 17 | 7 | 1 | Clinical/Photo | De Crousaz 1981 |
| ZH, 1 community | S/children 1982 | GM/MS | 304 | 6–16 | **21** | 9 | 8 | 5 | Clinical/Photo | Steiner & Menghini 1984 |
| GL, 14 communities | S/children 1987 | TM/MS | 120 | 10 | **28** | 17 | 9 | 2 | Clinical/Photo | Steiner et al. 1995 |
| TI, 3 communities | S/children 1987 | GM/MS | 99 | 10 | **13** | 5 | 8 | 0 | Clinical/Photo | Steiner et al. 1995 |
| ZH, 8 communities | S/children 1995 | GM/MS/RW | 305 | 9–10 | **21** | 17 | 4 | 0 | Photograph | Weber 1997 |
| GL, 14 communities | S/children 1996 | GM/MS/RW | 144 | 9–10 | **22** | 20 | 1 | 1 | Photograph | Weber 1997 |
| ZH, 1 community | S/children 2002 | AB | 900 | 8–16 | **19** | 13 | 4 | 1 | Photograph | Barman 2004 |
| ZH, 1 community | S/children 2002 | GM | 900 | 8–16 | **8** | 7 | 1 | 0 | Photograph | Barman 2004 |
| ZH, 1 community | S/children 2002 | MS | 900 | 8–16 | **7** | 6 | 1 | 0 | Photograph | Barman 2004 |
| | | | **Median** | | **21** | | | | | |

Tab. V (continued)

| Site | Details | Examiner | N | Age (Years) | Proportion (%) with TF Scores ⩾1 | 1 | 2 | ⩾3 | Method | Study |
|---|---|---|---|---|---|---|---|---|---|---|
| **Foreign regions without DWF** | | | | | | | | | | |
| 3 communities CDN | | | 146 | 7–9 | **22** | 21 | 1 | 0 | Clinical | Clark et al. 2006 |
| Liverpool GB | | | 314 | 8 | **66** | 54 | 11 | 1 | Photograph | Cochran et al. 2004 |
| Oulu FIN | | | 315 | 8 | **82** | 61 | 21 | 0 | Photograph | Cochran et al. 2004 |
| Athens GR | | | 283 | 8 | **53** | 48 | 5 | 0 | Photograph | Cochran et al. 2004 |
| Reykjavik IS | | | 296 | 8 | **68** | 51 | 16 | 1 | Photograph | Cochran et al. 2004 |
| Haarlem NL | | | 303 | 8 | **80** | 54 | 22 | 4 | Photograph | Cochran et al. 2004 |
| Lisbon P | | | 210 | 8 | **51** | 43 | 7 | 1 | Photograph | Cochran et al. 2004 |
| Tamworth GB | | | 200 | 8–10 | **8** | ? | ? | ? | Clinical | Hamdan & Rock 1991 |
| Manchester GB | | | 534 | 14 | **11** | 5 | 4 | 2 | Clinical | Hawley et al. 1996 |
| Norfolk GB | Toothpaste 550 ppmF | | 490 | 9 | **15** | 10 | 3 | 2 | Photograph | Holt et al. 1994 |
| Norfolk GB | Toothpaste 1050 ppmF | | 469 | 9 | **20** | 11 | 6 | 3 | Photograph | Holt et al. 1994 |
| Norfolk GB | Control | | 493 | 9 | **20** | 11 | 7 | 2 | Photograph | Holt et al. 1994 |
| Bunbary AUS | With low F-Toothpastes | | 207 | 10 | **12** | 9 | 2 | 0 | Clinical | Riordan 2002 |
| Bunbary AUS | Without low F-Toothpastes | | 321 | 12 | **33** | 26 | 7 | 1 | Clinical | Riordan & Banks 1991 |
| Northumberland GB | | | 428 | 8–9 | **21** | ? | ? | ? | Photograph | Tabari et al. 2000 |
| Northumberland GB | | | 428 | 8–9 | **23** | 21 | 2 | 0 | Clinical | Tabari et al. 2000 |
| NW England GB | Toothpaste 1450 ppmF | | 218 | 8–9 | **26** | 19 | 5 | 2 | Photograph | Tavener et al. 2004 |
| NW England GB | Toothpaste 440 ppmF | | 226 | 8–9 | **24** | 20 | 4 | 0 | Photograph | Tavener et al. 2004 |
| NW England GB | Control | | 259 | 8–9 | **25** | 20 | 5 | 0 | Photograph | Tavener et al. 2004 |
| Asker N | | | 383 | 8 | **36** | 31 | 4 | 0 | Clinical | Wang et al. 1997 |
| | | | **Median** | | 24.5 | | | | | |
| **Foreign regions with DWF** | | | | | | | | | | |
| Durham USA | | | 219 | 10 | **57** | 39 | 12 | 6 | Clinical | Burt et al. 2000 |
| 3 communities CDN | | | 437 | 7–9 | **45** | 28 | 11 | 6 | Clinical | Clark et al. 2006 |
| Cork IRL | | | 325 | 8 | **89** | 59 | 26 | 4 | Photograph | Cochran et al. 2004 |
| Birmingham GB | Social Class A | | 200 | 8–10 | **26** | ? | ? | ? | Clinical | Hamdan & Rock 1991 |
| Birmingham GB | Social Class B | | 200 | 8–10 | **26** | ? | ? | ? | Clinical | Hamdan & Rock 1991 |
| Perth AUS | | | 350 | 7 | **48** | 31 | 13 | 5 | Clinical | Riordan 1993b |
| Perth AUS | With low F-Toothpastes | | 375 | 10 | **22** | 18 | 4 | 0 | Clinical | Riordan 2002 |
| Perth AUS | Without low F-Toothpastes | | 338 | 12 | **40** | 29 | 9 | 2 | Clinical | Riordan & Banks 1991 |
| Birmingham GB | | | 325 | 8–9 | **39** | 19 | 11 | 8 | Photograph | Sabieha & Rock 1998 |
| Birmingham GB | | | 325 | 8–9 | **34** | 13 | 12 | 9 | Clinical | Sabieha & Rock 1998 |
| Newcastle GB | | | 439 | 8–9 | **52** | ? | ? | ? | Photograph | Tabari et al. 2000 |
| Newcastle GB | | | 439 | 8–9 | **54** | 42 | 9 | 3 | Clinical | Tabari et al. 2000 |
| | | | **Median** | | 42.5 | | | | | |

DWF = Drinking water fluoridation

Tab. VI Consumption and sales of fluoride preparations during the critical years of life

| | [1] Critical Years | Observation Period | [2] F-Tablets Share (%) | [3] F-Tablets 0.25 mg F Number per Head and Year | [4] F-Salt 250 ppm F Grams per Head and Year | [5] F-Toothpastes 250 ppm F Millilitres per Head and Year |
|---|---|---|---|---|---|---|
| Recruits 1996 | 1975–1980 | I | ? | ? | 0 [6] | 0 [7] |
| Recruits 2006 | 1985–1990 | | ? | 96 | 1125 | 104 |
| Schoolchildren 1995/96 | 1985–1990 | II | 52% | 96 | 1125 | 104 |
| Schoolchildren 2004/05 | 1994–1999 | | 19% | 20 | 1083 | 268 |

[1] Critical period during which incisors of the examined individuals were most susceptible to formation of FOP.
[2] Share (%) of individuals, who during the first 5 years of life, regularly or irregularly consumed fluoride tablets (according to information supplied by the parents).
[3] Number of F-Tablets (0.25 mg F) sold in Switzerland per Year and Head (refers to 0- to 5-year-olds; calculation based on information from Novartis, Switzerland).
[4] Number of grams of F-Salt (250 ppmF) sold in Switzerland per Year and Head (refers to the total population; calculation based on information from United Swiss Saltworks).
[5] Total number of millilitres of children's toothpastes (250 ppmF) sold in Switzerland per Year and Head (refers to 0- to 5-year-olds; calculation based on information from GABA, Switzerland).
[6] To some extent, salt with an F-content of 90 ppmF was used.
[7] To some extent, toothpastes with an F-content of ⩾ 1000 ppmF were used. As early as 1975, 90% of toothpastes sold contained fluoride (Schärer 1988).

rück. Der Rückgang ist nur in einem Fall statistisch gesichert (Periode I, Untersucher B).

## Résumé

Des recrues de l'armée suisse ont été soumises à un examen bucco-dentaire dans les années 1996 et 2006. Des écoliers de 16 communes rurales du canton de Zurich, choisis aléatoirement, ont eu un examen bucco-dentaire en 1995/96 et en 2004/05. Lors de ces enquêtes épidémiologiques les incisives de toutes les recrues et des élèves de la troisième et quatrième classe primaire ont été photographiées (diapositives couleur). Les diapositives (N = 2049) ont été examinées dans le but de détecter des opacités d'émail provoqués par la fluorure. L'indice utilisé a été celui proposé par Thylstrup et Fejerskow (indice TF degrés 0–9). Toutes les diapositives ont été évaluées par deux examinateurs (A et B) qui ne connaissaient pas la date des diapositives. L'examinateur A a déterminé une prévalence des FOP entre 18% et 27% selon la population. L'examinateur B a déterminé une prévalence entre 7% et 12%. L'influence des examinateurs sur l'estimation de la prévalence des FOP etait évidente. Par conséquent les prévalences ainsi déterminées doivent être considérées comme des estimations grossières. Des FOP du degré 2 de l'indice TF ont été détectées chez seulement 1% des examinés. Des FOP du degré 3 ont été diagnostiqués chez un seul individu par un des deux examinateurs. Ces données montrent que les FOP ne représentent pas un problème esthétique et encore moins un problème de santé publique. La prévalence des FOP a diminué légèrement pendant la période d'observation I (recrues nées en 1975–77 comparées avec celles nées en 1985–87) ainsi que pendant la période d'observation II (élèves nés en 1985–87 comparés avec ceux nés en 1994–96). Cette diminution n'est statistiquement significante que pour la période I et pour l'examinateur B.

## Appendix

### TF-Index

*TF score 0*
The normal translucency of the glossy creamy white enamel remains after wiping and drying of the surface.

*TF score 1*
Thin white opaque lines are seen running across the tooth surface. Such lines are found on all parts of the surface. The lines correspond to the position of the perikymata. In some cases, a slight "snow-capping" of cusps/incisal edges may also be seen.

*Note:*
Score 1 was also given, if distinct, symmetrical "snow-capping" was seen without white opaque lines.

*TF score 2*
The opaque white lines are more pronounced and frequently merge to form small cloudy areas scattered over the whole surface. "Snow-capping" of incisal edges and cusp tips is common.

*TF score 3*
Merging of the white lines occurs, and cloudy areas of opacity occur spread over many parts of the surface. In between the cloudy areas white lines can also be seen.

*TF score 4*
The entire surface exhibits a marked opacity, or appears chalky white. Parts of the surface exposed to attrition or wear may appear to be less affected.

*TF score 5*
The entire surface is opaque, and there are round pits (focal loss of the outermost enamel) that are less than 2 mm in diameter.

*TF score 6*
The small pits may frequently be seen merging in the opaque enamel to form bands that are less than 2 mm in vertical height. In this class are included also surfaces where the cuspal rim of facial enamel has been chipped off, and the vertical dimension of the resulting damage is less than 2 mm.

*TF score 7*
There is a loss of the outermost enamel in irregular areas, and less than half the surface is so involved. The remaining intact enamel is opaque.

*TF score 8*
The loss of the outermost enamel involves more than half the enamel. The remaining intact enamel is opaque.

*TF score 9*
The loss of the major part of the outer enamel results in a change of the anatomical shape of the surface/tooth. A cervical rim of opaque enamel is often noted.

## References


Barman A M: Bestimmung der Prävalenz von Schmelzopazitäten und Hypoplasien bei Schülern einer Zürcher Gemeinde. Erhebung mittels einer standardisierten fotografischen Methode. Med Diss, Zürich (2004)

Beltran-Aguilar E D, Barker L K, Canto M T, Dye B A, Gooch B F, Griffin S O, Hyman J, Jaramillo F, Kingman A, Nowjack-Raymer R, Selwitz R H, Wu T: Centers for Disease Control and Prevention (CDC): Surveillance for dental caries, dental sealants, tooth retention, edentulism, and enamel fluorosis. United States, 1988–1994 and 1999–2002. Morbidity & Mortality Weekly Report. Surveillance Summaries. 54: 1–43 (2005)

Burt B A, Keels M A, Heller K E: The effects of a break in water fluoridation on the development of dental caries and fluorosis. J Dent Res 79: 761–769 (2000)

Burt B A, Keels M A, Heller K E: Fluorosis development in seven age cohorts after an 11-month break in water fluoridation. J Dent Res 82: 64–68 (2003)

Clark D C, Shulman J D, Maupomé G, Levy S M: Changes in dental fluorosis following the cessation of water fluoridation. Community Dent Oral Epidemiol 34: 197–204 (2006)

Cochran J A, Ketley C E, Arnadottir I B, Fernandes B, Koletsi-Kounari H, Oila A-M, van Loveren C, Whelton H P, O'Mullane D M: A comparison of the prevalence of fluorosis in 8-year-old children from seven European study sites using a standardized methodology. Community Dent Oral Epidemiol 32: (Suppl. 1): 28–33 (2004)

De Crousaz P: Frequence et distribution des opacites d'email des ecoliers de quatre cantons suisses avec differents apports de fluorures. Travail d'habilitation, Genève (1981)

Evans R W, Darvell B W: Refining the estimate of the critical period for susceptibility to enamel fluorosis in human maxillary central incisors. J Public Health Dent 55: 238–49 (1995)

Fejerskov O, Manji F, Baelum V, Møller I J: Dental Fluorosis. A handbook for health workers. Copenhagen: Munksgard International Publishers (1988)

Hamdan M, Rock W P: The prevalence of enamel mottling on incisor teeth in optimal and low fluoride communities in England. Community Dental Health 8: 111–119 (1991)

Hawley G M, Ellwood R P, Davies R M: Dental caries, fluorosis and the cosmetic implications of different TF scores in 14-year-old adolescents. Community Dental Health 13: 189–192 (1996)

Holloway P J, Ellwood R P: The prevalence, causes and cosmetic importance of dental fluorosis in the United Kingdom:s a review. Community Dental Health 14: 148–155 (1997)

Holt R D, Morris C E, Downer M C: Enamel opacities and dental caries in children who used a low fluoride toothpaste between 2 and 5 years of age. Int Dent J 44: 331–341 (1994)

Hong L, Levy S M, Warren J J, Kanellis M J, Wefel J S, Dawson D V: Timing of fluoride intake in relation to development of fluorosis on maxillary central incisors. Community Dent Oral Epidemiol 34: 299–309 (2006a)

Hong L, Levy S M, Warren J J, Broffitt B, Cavanaugh J: Fluoride intake levels in relation to fluorosis development in permanent maxillary central incisors and first molars. Caries Res 40: 494–500 (2006b)

Hunt R: Percent agreement, Pearson's correlation, and Kappa as measures of inter-examiner reliability. J Dent Res 65: 128–130 (1986)

Ismail A I, Messer J G: The risk of fluorosis in students exposed to a higher than optimal concentration of fluoride in well water. J Public Health Dent 56: 22–27 (1996)

Jäger A: Prävalenz der fluoridbedingten Schmelzopazitäten (FOP) in der Schweiz. Med Diss, Zürich (2008)

Marthaler T M: A standardized system of recording dental conditions. Helv odont Acta 10: 1–18 (1966)

Marthaler T M: Fluorid beim Kleinkind. Schweiz Monatsschr Zahnmed 100: 864–867 (1990)

Menghini G D, Steiner M, Marthaler T M, Weber R M: Rückgang der Kariesprävalenz bei Schweizer Rekruten von 1970 bis 1996. Schweiz Monatsschr Zahnmed 111: 410–416 (2001)

Menghini G, Steiner M, Marthaler T, Helfenstein U, Brodowski D, Imfeld C, Weber R, Imfeld T: Kariesprävalenz von Schülern in 16 Zürcher Landgemeinden in den Jahren 1992 bis 2000. Schweiz Monatsschr Zahnmed 113: 267–277 (2003)

Menghini G: Dental fluorosis in salt fluoridation schemes. Schweiz Monatsschr Zahnmed 115: 69–73 (2005)

Pfister J: Prävalenz der fluoridbedingten Schmelzopazitäten (FOP) in der Schweiz. Med Diss, Zürich (2008)

Riordan P J: Perceptions of dental fluorosis. J Dent Res 72: 1268–1274 (1993a)

Riordan P J, Banks J A: Dental fluorosis and fluoride exposure in Western Australia. J Dent Res 70: 1022–1028 (1991)

Riordan P J: Dental fluorosis, dental caries and fluoride exposure among 7-year-olds. Caries Res 27: 71–77 (1993b)

Riordan P J: Dental fluorosis decline after changes to supplement and toothpaste regimens. Community Dent Oral Epidemiol 30: 233–40 (2002)

Rozier R G: The prevalence and severity of enamel fluorosis in North American children. J Public Health Dent 59: 239–246 (1999)

Sabieha A M, Rock W P: A comparison of clinical and photographic scoring using the TF and modified DDE indices. Community Dental Health 15: 82–87 (1998)

Schärer M: Entwicklung und Stand des Kaufs von Mundpflegemitteln, auf Grund marktanalytischer Erhebungen, im Vergleich zwischen 1975 und 1984. Med Diss, Zürich (1988)

Selwitz R H, Nowjack-Raymer R E, Kingman A, Driscoll W S: Prevalence of dental caries and dental fluorosis in areas with optimal and above-optimal water fluoride concentrations: a 10-year follow-up survey. J Public Health Dent 55: 85–93 (1995)

Steiner M, Menghini G: Vorkommen von Schmelzopazitäten an Schneidezähnen bei Schulkindern einer Gemeinde des Kantons Zürich. Schweiz Monatsschr Zahnmed 94: 1150–1155 (1984)

Steiner M, Menghini G, Marthaler T M, Helfenstein U: Epidemiologie von Schmelzopazitäten im Zusammenhang mit der Salzfluoridierung. Dtsch Zahnärztl Z 50: 717–720 (1995)

Tabari E D, Ellwood R, Rugg-Gunn A J, Evans D J, Davies R M: Dental fluorosis in permanent incisor teeth in relation to water fluoridation, social deprivation and toothpaste use in infancy. Br Dent J 189: 216–220 (2000)

Tavener J A, Davies G M, Davies R M, Ellwood R P: The prevalence and severity of fluorosis and other developmental defects of enamel in children who received free fluoride toothpaste containing either 440 or 1450 ppm F from the age of 12 months. Community Dental Health 21: 217–223 (2004)

Tavener J, Davies R M, Ellwood R P: Agreement amongst examiners assessing dental fluorosis from digital photographs using the TF index. Community Dental Health 24: 21–25 (2007)

Thylstrup A, Fejerskov O: Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. Community Dent Oral Epidemiol 6: 315–328 (1978)

Wang N J, Gropen A-M, Ogaard B: Risk factors associated with fluorosis in a non-fluoridated population in Norway. Community Dent Oral Epidemiol 25: 396–401 (1997)

Weber R: Prävalenz von Schmelzopazitäten und Hypoplasien bei Zürcher und Glarner Schülern 1995–1996. Med Diss, Zürich (1997)