Articles published in this section have been reviewed by three members of the Editorial Review Board

Fluoride excretion of adults living in border regions with either water or salt fluoridation

Summary

The canton of Basel-Stadt was the only canton in Switzerland which introduced drinking water fluoridation (DWF) at 1 ppm (mg/l). All other cantons have relied on fluoridated domestic salt at 250 ppm F as the main vehicle for basic fluoride exposure. It has been suggested that persons living and working in the DWF areas or persons commuting to the DWF areas may be exposed to higher than optimal doses of fluoride. The objective of this present study was to determine the urinary fluoride excretion of adults living and or working in neighboring areas of either salt or water fluoridation.

In this study, 24-hour urine was collected from 69 healthy subjects and tested for fluoride concentration. The mean fluoride concentration for all participants was 0.55 ± 0.25 ppm (mg/l) ranging from 1.14 to 0.09 ppm. The mean fluoride excretion was 0.95 ± 0.47 mg F/d ranging from 0.18 to 2.12 mg F/d. The 33 subjects living in a DWF region showed a mean urine fluoride concentration of 0.64 ± 0.24 ppm (mg/l) and a mean fluoride excretion of 1.14 ± 0.48 mg F/d. Those 36 subjects living in a region without DWF showed a mean urine fluoride concentration of 0.47 ± 0.24 ppm (mg/l) and a mean fluoride excretion of 0.78 ± 0.40 mg F/d. A significant difference between the two means of the groups living in regions with or without DWF was detected when the Mann-Whitney statistical test was applied ($p < 0.005$). The combined intake of fluoridated drinking water and fluoridated table salt in the subgroup of 11 subjects who commuted showed an overall increase in fluoride urine concentration. The measured values, however, were not significantly different from the other subgroups.

Schweiz Monatsschr Zahnmed 116: 362–366 (2006)

Key Words: urinary fluoride, fluoridation, fluoride excretion

Accepted for publication: 21 January 2006

Corresponding Author:
J. S. Guindy
Private practice, Dorfstrasse 81, CH-8706 Meilen, Switzerland
Tel. + 41 044 793 2424, Fax: + 41 044 793 2424
E-mail: Pharaoh.Joseph@bluewin.ch

Joseph S. Guindy[1,2], Ralph Gysin[1]*, Marius Kränzlin[3], Thomas C. Gasser[4], Kirsten Hauck[1] and Jürg Meyer[1]*

[1] *Institute for Preventive Dentistry and Oral Microbiology, and*
[2] *Department of Periodontology, Endodontology and Cariology, School of Dental Medicine, University of Basel, Switzerland*
[3] *Department of Endocrinology, and*
[4] *Department of Urology, School of Medicine, University of Basel, Switzerland*

* *These authors contributed equally to this paper*

Introduction

In May 1962, drinking water fluoridation (DWF) was introduced at 1 ppm F (0.8 ppm F in summer) in the Swiss canton of Basel-Stadt as well as a few nearby communities (population about 250,000). Caries prevalence amongst school children in Basel-Stadt was reduced by a magnitude of 40–80% (Gülzow et al. 1974, Gülzow et al. 1982, Marthaler 1996). In all other Swiss

cantons, fluoridated table salt at 250 ppm F (250 mg F/kg) has been available since 1983 and has reached a market share of 84% (Steiner et al. 1985, Steiner et al. 1989, Marthaler & Meyer 2004). Caries prevalence amongst school children has similarly declined to a relatively stable low level (Marthaler 1983, Menghini et al. 2003, Guindy et al. 2000). Since 1992, fluoridated table salt has become increasingly available in the bordering regions of France and Germany.

The population of northwestern Switzerland, as well as those living in border regions of the neighbouring countries is very mobile. These populations commute regularly for purposes of work, shopping and leisure activities between regions with or without drinking water fluoridation and regions with or without fluoridated table salt. Thus, some of them may have consumed fluoridated drinking water as well as fluoridated table salt and therefore, may have been exposed to higher than optimal doses of fluoride. The purpose of this study was to determine fluoride excretion in adults living and working in regions of water or salt fluoridation (Gysin 1999).

Materials and Methods

Subjects

Healthy persons living in the geographic northwestern region of Switzerland were asked to participate on a voluntary basis in this study. Dentists and employees in related dental occupations were excluded. Subjects donating 24-hour urine were also recruited from a private endocrinology practice, the urology clinics of the University of Basel and patients seeking dental treatment at the school of dentistry at the same university. All subjects were previously informed about the procedures and signed an informed consent declaration. The University of Basel Ethics Commission (Protocol Nr. M182/96) approved the study.

Urine collection and handling

Urine was collected between January 1997 and April 1998. All subjects were asked to collect urine over a 24-hour-period in two-litre urine collection flasks which were supplied to them. The collected urine was either sent to our laboratory by post or delivered in person. In all cases the total volume of urine from each donor was measured and two 50 ml aliquots were stored at –20 °C for further analysis.

Fluoride, pH and creatinine determination

All samples were first thawed and shaken twice on a Vortex to assure homogeneity. 500 µl of the samples were then mixed with an equal volume of TISAB III 2 X Conc. pH 5.1 (total ionic strength adjustment buffer, 94-09-11 ORION Research Cambridge, Mass). The fluoride concentration was determined with a fluoride electrode and a potentiometer (Model 96-09 ORION Research Cambridge, Mass). A standard calibration curve was obtained from standard solutions of 0.2, 0.5, 1.0, and 5 ppm, which were diluted from a 100-ppm stock solution (94-09-07 ORION Research Cambridge, Mass). All samples were tempered in a 25 °C water bath before the fluoride concentration measurement. The electrode was calibrated against the standards every four hours or after 20 consecutive measurements.

In order to obtain optimal fluoride measurements all urine samples were independently measured twice by two researchers. The mean standard deviation of this continuous calibration was 0.0099 ppm with a minimum of 0.002 ppm and a maximum of 0.07 ppm. In this study only four urine samples showed a standard deviation greater than 0.04 ppm. The electrodes did not show linearity when fluoride concentration was below 0.1 ppm. Only one urine sample was recorded as showing a lower level of 0.09 ppm. During the collection period the F-concentration of the drinking water in Basel varied around a mean of 0.87 ± 0.05 ppm except for the summer months of June, July and August when it was reduced to 0.72 ± 0.02 ppm.

5 ml urine were used for creatinine determination, which was carried out using a Boehringer Mannheim System Hitachi 917 and WAKO Creatinine F L-Type, Stable Liquid-Type reagent F DAOS method at the chemical laboratories of the University Hospital Basel.

Questionnaire

Along with the donation of urine, all subjects were asked to answer and fill in a questionnaire concerning their domicile, work place, gender, age and weight. A second part of the questionnaire included questions on the following aspects:

1. Medication and dosage.
2. Oral hygiene habits, frequency of oral hygiene, products used, fluoride content in their toothpaste as well as use of other fluoride containing oral care products. The subjects were also asked to indicate when a professional dental cleaning had been last performed on their teeth.
3. Dietary habits, type of salt used, intake of tap and mineral water, tea and fish. The subjects were also asked to indicate the source and amount of drinking water consumed at work and at home
4. Specific questions were asked concerning the 24 hours during which urine was collected. Questions concerned specific medication and dosage, intake of tap or mineral water, meals and location of the meal intake as well as frequency of oral hygiene, type of toothpaste used, frequency and other types of fluoride intake.

Statistical analysis

Information obtained from the questionnaire was compiled by using a FileMaker Pro 4.0 TM (Claris Corp., Ltd., Dublin, Ireland) data bank. Measurement results were compiled by using Excel 5.0a tables (Microsoft Corp., Washington, USA). Data analysis and statistical comparisons were obtained by using StatView 4.02 (Abacus Concepts, Berkeley, California, USA), all processed on a Power Macintosh TM G3.

Results

69 persons (37 females, 32 males) participated in the study. All answered and returned the questionnaire. Twenty of the subjects provided a second 24-hour urine collection, reaching the total number of 89 collections. The mean age of the subjects was 44.4 ± 15 years. Table I shows the number of participants in relation to the type of fluoridation at their domicile and working place. Natural fluoride concentration for the nine subjects

Tab. I Study participants' domicile, work place and fluoride excretion

Fluoridation at Residence	Work place	N	Mg F/d	SD	Min	Max
DWF	DWF	31	1.17	0.48	0.42	2.12
DWF	Salt	2	0.63	0.13	0.54	0.73
Salt	Salt	27	0.93	0.44	0.33	1.57
Salt	DWF	9	0.71	0.38	0.18	1.59
		Σ 69				

Tab. II Urine volume distribution

	N	Mean Vol (ml)	SD (ml)	Maximum	Minimum
Females	37	1,741.6	482.9	2,600	690
Males	32	1,833.5	588.3	3,045	740
Without DWF	36	1,735.8	507.3	3,045	885
With DWF	33	1,837.1	561.5	2,980	690
Total	69	1,784.2	528.5	3,045	690

living in five communities without DWF varied between 0.05 and 1.0 (mg/l).

Urine volumes

The average urine volume collected was 1,784±529 ml. Table II shows the distribution of subjects in relation to gender and DWF. No significant difference was detected between the groups.

No difference between first and second urine collection

The mean fluoride excretion of the twenty subjects who donated urine a second time was 0.87 ± 0.36 (mg F/d) and 0.93 ± 0.36 (mg F/d) for the first and second donations, respectively. The difference of the mean urine fluoride excretion (0.06 mg F/d) was statistically not significant.

Urinary fluoride excretion

Mean urinary fluoride excretions relating to gender and domicile are shown in Fig. 1. Table I summarizes the mean urine fluoride excretion in commuters who lived and worked in regions with DWF or salt fluoridation.

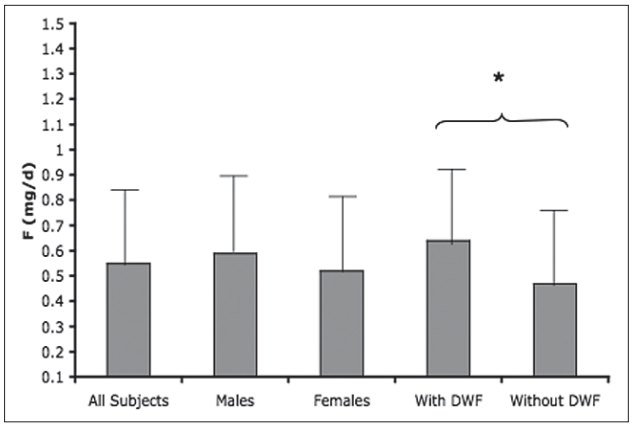

Fig. 1 Mean urine fluoride excretions relative to gender and DWF domicile
** = Statistically significant difference (p = 0.005)*

As expected for the group living in the DWF area, all 33 subjects reported that fluoridated table salt was not for sale. However, four reported the use of fluoridated table salt at home. These four subjects showed a mean fluoride concentration of 1.33 ± 0.53 (mg F/d) in the excreted urine. Two subjects' reports from the DWF region could not be evaluated with respect to the use of fluoridated salt. The twenty-seven other subjects showed a mean of 1.12 ± 0.48 (mg F/d).

Twenty-one of the 36 subjects living in the region without DWF reported the use of fluoridated table salt. They had 0.69 ± 0.33 (mg F/d). Fourteen subjects from a non-DWF region who did not use fluoridated domestic salt had 0.93 ± 0.47 (mg F/d). One subject's answers could not be evaluated.

Of the 27 subjects living and working in the same non-DWF region thirteen reported non-use of fluoridated table salt and showed a mean fluoride concentration in the excreted urine of 0.92 ± 0.48 (mg F/d). One of these subjects reported drinking circa 700 ml bottled fluoridated water per day and another reported drinking 2400 ml bottled fluoridated water per day. These subjects excreted 0.62 and 1.10 mg F/d respectively.

One of the nine subjects who reported living in a non-DWF region, but was working in the region with DWF reported drinking circa 800 ml of fluoridated water per day. This subject showed a urine fluoride concentration of 1.18 mg F/d.

Relation of urine fluoride excretion to the frequency of tooth brushing and fluoride rinses

Sixty-two participants in the study reported the use of a variety of toothpastes containing between 0.10%–0.15% fluoride. The frequency of toothbrushing was reported as once, twice, three or more times per day. In Table III we show the relation between the fluoride concentration in the excreted urine of the subjects of different regions and the frequency of tooth brushing.

Ten of the 69 participants in this study reported rinsing with a fluoride rinse during the time of urine collection, eight of these rinsed once per day and had a mean of 1.06 ± 0.42 (mg F/d) in the excreted urine. The other two reported rinsing more than once a day and showed a mean of 1.25 ± 0.19 (mg F/d) in the excreted urine. The remaining study subjects (n = 59) who abstained from fluoride rinsing altogether had a mean of 0.93 ± 0.48 (mg F/d) in the excreted urine. The difference of these mean values was not significant (t-Test).

Creatinine concentration, excretion and fluoride-creatinine ratio

The mean creatinine concentration in all subjects' urine, the mean excreted creatinine as well as the fluoride-creatinine ratio is shown in Table IV.

Tab. III Relation between total fluoride excreted by the subjects in different regions and frequency of tooth brushing

Brushing frequency	All subjects Fluoride excretion in mg/d	N	Residence in DWF region Fluoride excretion in mg/d	N	Residence in non-DWF region Fluoride excretion in mg/d	N
Never	0.23	1	–	–	0.234	1
1/day	0.94 ± 0.55	10	1.29 ± 0.77	3	0.79 ± 0.41	7
2/day	0.97 ± 0.42	21	0.99 ± 0.38	11	0.95 ± 0.49	10
3/day	0.88 ± 0.47	27	1.07 ± 0.49	15	0.64 ± 0.32	12
> 3/day	1.22 ± 0.55	7	1.64 ± 0.16	4	0.65 ± 0.09	3
Not reported	1.08 ± 0.16	3	–		1.08 ± 0.16	3
Total	0.95 ± 0.47	69	1.14 ± 0.48	33	0.78 ± 0.40	36

Tab. IV Creatinine concentration and excretion as well as fluoride-creatinine quotient with relation to domicile and gender.

	N	Concentration (mmol/l)	Creatinine excretion (mmol/d)	Fluoride/Creatinine quotient ($\times 10^{-3}$)
Females	37	5.63 ± 2.48	9.10 ± 2.99	5.41 ± 2.97
Males	32	9.80 ± 4.80	15.80 ± 5.37	4.03 ± 2.65
Without DWF	36	7.29 ± 3.91	11.72 ± 5.00	3.88 ± 1.98
With DWF	33	7.86 ± 4.65	12.70 ± 5.82	5.74 ± 3.40
Total subjects	69	7.56 ± 4.26	12.21 ± 5.40	4.77 ± 2.89

Discussion

The level of urinary fluoride excretion has been found to correspond with the fluoride intake and meal patterns (Marthaler et al. 1995). Children and adults living in regions with constant levels of fluoride in tap water had urinary fluoride concentrations directly corresponding to those of the drinking water (Zipkin et al. 1956, Collins & Segreto 1984). Historically, urinary fluoride concentrations were also used to monitor salt fluoridation programmes. However, as intake and excretion of fluoride from drinking water and domestic salt follow different kinetics, several studies indicated that 24-h urine collection provided more reliable measurements (Hefti et al. 1981, Wespi und Bürgi 1982). Alternatively, timed urine collections have been used as well (Marthaler et al. 1995, Villa et al. 2000, Marthaler & Schulte 2005).

In this study the 24-hour urinary fluoride excretion of adults living in Basel, Switzerland, and in adjacent regions with either fluoridation of the drinking water or table salt was measured.

Twenty-one (58.3%) of the 36 subjects living in regions without DWF and indicating the use of fluoridated table salt excreted 0.69 – ± 0.33 mg F/d. This is less than the excretion of 0.99 ± 0.46 mg F/d from those stating no use of fluoridated domestic salt. The higher excretion related to these 24 subjects may be due to inaccurate reporting or other factors not revealed by the questionnaires. Other fluoride sources which have been considered in this study did not significantly correlate to fluoride excretion.

Creatinine concentration in urine was measured as an indicator of subject compliance. Normally creatinine excretion in human urine is dependent on muscle mass and body weight. There is a relative constant excretion in the range of 0.75–1.88 g/d for females and 1.36–2.37 g/d for males (Löffler & Petrides 1988). The mean creatinine excretion in this study was 1.38 g/d ± 0.61 g/d. Females' creatinine excretion was 1.03 ± 0.34 g/d, clearly less than that of males which was 1.79 ± 0.61 g/d. The mean creatinine excretion was, however, within the given norm, which indicated that the subjects have complied and collected urine over 24 hours.

Wespi & Bürgi (1982) postulated a fluoride/creatinine ratio (mmol F/mmol C) of 6.29×10^{-3} based on the presumption that an optimal fluoride concentration in urine is 1 ppm. Subjects living in a DWF region showed an (F/C) of $5.74 \times 10^{-3} \pm 3.40 \times 10^{-3}$; those living in a non-DWF region showed an (F/C) of $3.88 \times 10^{-3} \pm 1.98 \times 10^{-3}$. Obviously these values are below those determined in the work of Wespi & Bürgi (1982)

The level of the individual oral hygiene and use of individual fluoride prophylactic measures must be taken into consideration as an additional fluoride source when fluoride intake and its effects are assessed. Barnhart et al. (1974) and later Feuerle (1989) have shown that fluoride intake through intensive oral hygiene and caries prophylaxes are minimal in adults as well as children. More recent studies have shown that 9–17% of the fluoride introduced into the oral cavity through the use of fluoride rinses is retained in the mouth or swallowed (Fritzsche & Saxer 1989). The same research also showed that rinsing with 200–300 ppm F resulted in F retention of 0.4 mg. This confirmed previous work, which showed that use of different oral hygiene products would increase the F intake.

In this present study 10 of the 69 subjects indicated the use of fluoride rinses. This subgroup excreted 1.11 ± 0.417 mg F/d. Those who did not use any fluoride rinse excreted 0.93 ± 0.484 mg F/d. The difference was statistically not significant.

The combined intake of fluoridated drinking water and fluoridated table salt in the commuter subgroup may have shown an overall increase in fluoride urine excretion. The measured values however were not significantly different from the other subgroups and no cause for alarm. In general, subgroups that combined different sources of fluoride intake need not worry about toxic fluoride concentrations.

In April 2003 DWF in the Canton of Basel-Stadt was discontinued after 41 years and substituted by salt fluoridation (Marthaler & Meyer 2004). It remains to be seen if this measure has any long-term effect on the dental health of the general population.

Acknowledgments

We thank Prof. Thomas Marthaler for comments on an earlier version of the manuscript as well as Frau Dr. med. dent. Brigitte Helmy-Frei for translating the abstract into German.

Zusammenfassung

Der Kanton Basel-Stadt war der einzige Kanton in der Schweiz, der eine Trinkwasserfluoridierung (TWF) von 1 ppm (mg/l) einführte. Alle anderen Kantone bauten auf fluoridiertes Haushaltssalz zu 250 ppm F, als Hauptträger für eine Basisversorgung mit Fluorid.

Es wurde vermutet, dass Personen, die in TWF-Gebieten leben oder arbeiten, oder Personen, die zwischen TWF- und F-Salz-Regionen pendeln, einer höheren als der optimalen Dosis von Fluorid ausgesetzt sein könnten. Das Ziel dieser vorliegenden Studie war es, die Fluoridausscheidung im Urin von Erwachsenen, die in benachbarten Regionen mit Salz- oder Wasserfluoridierung leben oder arbeiten, zu bestimmen. In dieser Studie wurde der 24-Stunden-Urin von 69 gesunden Probanden gesammelt und auf seine Fluoridkonzentration untersucht.

Die mittlere Fluoridkonzentration aller Teilnehmer lag bei 0,55 ± 0,25 ppm; die Einzelwerte lagen im Bereich zwischen 1,14 und 0,09 ppm. Die durchschnittliche Fluoridausscheidung betrug 0,95 ± 0,47 mg F/Tag bei Einzelwerten zwischen 0,18 und 2,12 mg F/Tag.

Die 33 Personen, die in einer TWF-Region lebten, wiesen eine mittlere Harn-Fluorid-Konzentration von 0,64 ± 0,24 ppm und eine durchschnittliche Fluoridausscheidung von 1,14 ± 0,48 mg F/Tag auf.

Bei 36 Probanden, die in einer Region ohne TWF lebten, zeigte sich eine mittlere Harn-Fluorid-Konzentration von 0,47 ± 0,24 ppm (mg/l) und eine durchschnittliche Fluoridausscheidung von 0,78 ± 0,40 mg F/Tag. Ein signifikanter Unterschied zwischen den zwei Mittelwerten der Gruppen wurde bei der Anwendung des Mann-Whitney-Tests festgestellt ($p < 0,005$).
Die kombinierte Einnahme von fluoridiertem Wasser und fluoridiertem Tafelsalz bei einer Untergruppe von Pendlern zeigte eine Gesamtzunahme der Fluorid-Harn-Konzentration. Die gemessenen Werte unterschieden sich jedoch nicht wesentlich von jenen der anderen Gruppen.

Résumé

Le canton de Bâle-Ville fut le seul canton suisse qui introduisit une fluoration d'eau potable (FEP) à 1 ppm (mg/l). Tous les autres cantons se basèrent sur le sel domestique fluoré à 250 ppm de F en tant qu'apport principal de fluorure. L'hypothèse a été émise, selon laquelle les personnes vivant ou travaillant dans les régions de FEP ou les pendulaires voyageant entre les régions de FEP et de sel fluoré pourraient être exposés à une dose de fluorure supérieure à la dose optimale. Le but de la présente étude était de déterminer l'élimination de fluorure dans l'urine chez les adultes vivant ou travaillant dans des régions limitrophes aux régions de sel fluoré ou de FEP.
Dans cette étude, l'urine de 69 personnes saines a été collectée sur 24 heures à des fins d'analyse du taux de fluorure. La concentration moyenne de fluorure pour tous les participants était de 0,55 ± 0,25 ppm (mg/l); les valeurs individuelles se situèrent entre 1, 14 et 0,09 ppm. L'élimination moyenne de florure était de 0,95 ± 0,47 mg F/jour avec des valeurs individuelles allant de 0,18 à 2,12 mg F/jour. Pour les personnes habitant dans une région de FEP, au nombre de 33, la concentration moyenne de fluorure détectée dans l'urine était de 0,64 ± 0,24 ppm (mg/l) et l'élimination moyenne de fluorure de 1,14 ± 0,48 mg F/jour. Pour les personnes habitant dans une région sans FEP, au nombre de 36, la concentration moyenne de fluorure détectée dans l'urine était de 0,47 ± 0,24 ppm (mg/l) et l'élimination moyenne de fluorure de 0,78 ± 0,40 mg F/jour. L'analyse statistique d'après le test de Mann-Whitney ($p < 0,005$) a montré une différence significative entre les 2 moyennes des groupes. Pour un sous-groupe de pendulaires, au nombre de 11, la prise combinée de sel domestique fluoré et d'eau potable fluorée montra une augmentation générale de la concentration de fluorure détectée dans l'urine. Toutefois, les valeurs mesurées ne se différencièrent pas de façon significative de celles des autres sous-groupes.

References

Barnhart W, Hiller L, Leonard G, Michaels S: Dentifrice usage and ingestion among four age groups. J Dent Res 53: 1317–1322 (1974)

Collins E M, Segreto V A: Urinary fluoride levels of children residing in communities with naturally occurring fluorides in the drinking water. J Dent Child 5: 352–355 (1984)

Feuerle G: Fluoridausscheidung im Urin bei Kindern und Jugendlichen nach Gebrauch von Fluoridgelee und fluoridhaltiger Spüllösung. Med Diss Zürich (1989)

Fritzsche T, Saxer U P: Fluoridretention und -clearance nach Spülungen mit fluoridierten Mundwässern. Schweiz Monatsschr Zahnmed 99: 299–306 (1989)

Guindy J S, Weber C, Meyer J: Die Zahngesundheit von 7- und 12-jährigen Schülerinnen und Schülern im Kanton Solothurn. Acta Med Dent Helv 5: 119–124 (2000)

Gülzow H J, Kränzlin H, Maeglin B, Ritzel G, De Roche C H, Savoff K, Schmidt R: Kariesbefall und Kariesfrequenz bei 7–15-jährigen Basler Schulkindern im Jahre 1972 nach 10-jähriger Trinkwasserfluoridierung. Schweiz Monatsschr Zahnmed 84: 19–29 (1974)

Gülzow H J, Maeglin B, Mühlemann R, Ritzel G, Stäheli D: Kariesbefall und Kariesfrequenz bei 7–15-jährigen Basler Schulkindern im Jahre 1977, 15 Jahre nach Einführung der Trinkwasserfluoridierung. Schweiz Monatsschr Zahnmed 92: 255–262 (1982)

Gysin R: 24-Stunden-Fluoridausscheidung von Bewohnern der Grenzregion von Trinkwasser- und Salzfluoridierung. Med Diss Basel (1999)

Hefti A, Wespi H J, Regolati B, Marthaler T M: 24-Stunden-Ausscheidung von Fluorid im Urin bei Salz- und Trinkwasserfluoridierung. Schweiz Monatsschr Zahnmed 91: 559–565 (1981)

Löffler G, Petrides P E: Physiologische Chemie, Springer-Verlag, Berlin, 1988

Marthaler T: Practical aspects of salt fluoridation. Schweiz Monatsschr Zahnheilkd 12: 1197–1214 (1983)

Marthaler T M, Steiner M, Menghini G, De Crousaz P: Urinary fluoride excretion in children with low fluoride intake or consuming fluoridated salt. Caries Res 29: 26–34 (1995)

Marthaler T M: Water fluoridation results in Basel since 1962: Health and political implications. J Publ Health Dent 56: (Spec. Issue) 265–270 (1996)

Marthaler Th, Meyer J: Drinking water fluoridation in Basle 1962–2003. Community Dent Health 21: 1–3 (2004)

Marthaler T M, Schulte A G: Monitoring salt fluoridation programs through urinary excretion studies. Schweiz Monatsschr Zahnmed 115: 679–684 (2005)

Menghini G, Steiner M, Marthaler T, Helfenstein U, Brodowski D, Imfeld C, Weber R, Imfeld T: Caries prevalence among students in 16 Zurich districts in the years 1992 to 2000. Schweiz Monatsschr Zahnmed 3: 267–277 (2003)

Steiner M, Marthaler T M, Menghini G, Helfenstein U: Urinary fluoride excretion of schoolchildren in connection with table salt fluoridation. Schweiz Monatsschr Zahnmed 12: 1109–1117 (1985)

Steiner M, Menghini G, Marthaler T M: Kariesbefall bei Schulkindern des Kantons Glarus, 13 Jahre nach der Einführung des höher fluoridierten Salzes. Schweiz Monatsschr Zahnmed 99: 897–901 (1989)

Villa A, Anabalon M, Cabezas L: The fractional urinary fluoride excretion in young children under stable fluoride intake conditions. Community Dent Oral Epidemiol 5: 344–355 (2000)

Wespi H J, Bürgi W: Fluoridausscheidung im Urin unter Salz- und Trinkwasserfluoridierung. Schweiz Med Wochenschr 112: 1033–1038 (1982)

Zipkin I, Likins R C, McClure F J, Steere A C: Urinary fluoride levels associated with use of fluoridated waters. Public Health Rep 8: 767–772 (1956)