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Urinary fluoride levels in Jamaican children in 2008, after 21 years of salt fluoridation

Key words: Fluoride, salt, urinary fluoride excretion

Summary   Rationale: In 1984, the $DMFT_{12}$ in Jamaican children was 6.7 (very severe). In 1987, national salt fluoridation was implemented (250 mg F-/kg salt). In 1995, a national survey showed a substantial decrease of caries severity ($DMFT_{12}$ of 1.8). Objectives: To see whether the favorable exposure of fluoride was continued. Methods: Assessment of urinary fluoride parameters based on WHO guidelines. Children were sampled in two urban and two rural sites. Valid nocturnal and daytime urinary collections were obtained from 128 children (mean age 4.7 y). A questionnaire administered to parents provided information on oral hygiene practice, and use of fluoride via salt, dentifrices or supplements.

Results: Excretion rate values extrapolated to 24h were 271 in urban and 330 µgF/24 h in rural, F-concentrations were in the range of 1.13 and 1.30. Almost all children were reported to use toothpaste, most with 600 to 1000 ppm F; 65% of children use more than the recommended amount of toothpaste. Fluoridated salt was consumed by 98% of the children. There was no other apparent usage of fluorides. Conclusions: Urinary excretion results point to a suboptimal exposure of fluoride, whereas concentrations would suggest an optimal or slightly higher intake. Dentifrices with 500 ppm F should be made available in order to minimize the risk of enamel fluorosis.

Introduction

The use of fluorides has advanced the reduction of dental caries prevalence in many countries. It is anticipated that this trend will continue. In the 1960s and 1970s, caries decline was obtained after introduction of the use of fluoride in community prevention programs particularly through drinking water. Fluoride in toothpaste, when used daily, is now considered as the main factor in the substantial decline of dental caries prevalence where this phenomenon has occurred. Regrettably, community prevention programs are not sufficiently available worldwide, particularly in developing countries, and in some industrialized countries dental caries prevalence appears to be on the increase (Petersen 2003). Methods for providing fluoride to entire communities at low cost are still needed and are indeed the only available means of reaching those communities and regions in the world where oral care and particularly fluoride toothpastes are not available and/or not affordable.

In the mid 1980s, dental caries in Jamaican children was very severe according to information in the World Health Organization Global Data Bank and from data obtained from a national epidemiological study conducted in 1984 (Warpeha 1985). The Ministry of Health of Jamaica in collaboration with Alkali Limited, the only salt refinery in the country, implemented a national salt fluoridation program in 1987, based on studies conducted in Switzerland (Marthaler et al. 1978), Hungary (Toth 1978), Colombia (Mejia et al. 1976) and on the actual success of salt fluoridation in Switzerland over time. This initiative was in response to the severity of the oral health situation, the inability to introduce water fluoridation on a national scale and a resolution of the CARICOM Ministers Responsible for Health (1977) recommending the introduction of fluoridated salt. The fluoride added was 250 + 50 mg F/kg salt.

In 1995, eight years after implementation of fluoridation of all salt for human consumption, a second national survey, under the auspices of PAHO, showed a very significant decrease of caries severity compared with the 1984 study. The mean

number of decayed, missing and filled teeth (DMFT) among 12-year-old Jamaican school children had been reduced to 1.1 (ESTUPINAN-DAY ET AL. 2001) compared to 6.7 found in 1984 (WARPEHA 1985). A thorough investigation into methodological and biological factors showed that most of the reduction in dental caries between 1984 and 1995 was attributable to the introduction, in 1987, of salt fluoridation (WARPEHA ET AL. 2001). Similarly, the use of fluoridated salt is thought to be an important factor in the reduction of dental caries levels in Costa Rica (SOLORZANO ET AL. 2005), Mexico (IRIGOYEN & SANCHEZ-HINOJOSA 2000), Uruguay (PUCCI & DOL 1997) and Colombia (TOVAR ET AL. 1999).

The only untoward effect of the use of fluoride-based prevention strategies is the occasional occurrence of mild enamel fluorosis (WHO 1994). However, it is generally recognized that the enamel fluorosis is to be monitored where fluorides are used for controlling dental caries. The World Health Organization recommends that fluoride exposure level be determined prior to introducing any fluoride-based program for dental caries prevention. It is also recommended to monitor fluoride exposure 6 months and 24 months after the start of the program and to maintain continuous monitoring as part of epidemiological surveillance systems (BAEZ 2000).

As part of the biological monitoring of fluoride exposure, studies of the urinary fluoride excretion of Jamaican children were conducted in 1987 and 1989 (WARPEHA & MARTHALER 1995). The present study was carried out to compare the current excretion level with that of 1987 and 1989 and with international standards. In Jamaica, the Ministry of Health is responsible for the biological monitoring of the salt fluoridation program.

Methods and materials

Sampling of children and natural fluoride exposure

The design considered the selection of two urban and two rural schools. Sampling was carried out using the equal probability selection method with probability proportional to size. The country is divided into fourteen parishes of which five are urban and nine rural. Most schools enroll over 35 children but 355 schools in rural areas and 273 schools in urban communities enrolled less than 35 children. There are a number of schools that are not recognized by the Ministry of Education. The qualifying schools enrolled a total of 48,992 children in urban and 38,312 in rural schools. All qualifying schools with their official code and number of children enrolled were listed; considering resources available, a decision was made to select

Fig. 1 Approximate location of 3 communities where the children were sampled are depicted by black dots; the square shows the fourth location, which was Kingston (urban location)

two urban and two rural schools each enrolling 35 children or more and to make the selection at random using PPS. Urban schools selected were Cedar Grove in the Parish of St. Catherine and New Haven in the Parish of St. Andrews. Rural schools selected were Neighborhood in the Parish of Clarendon and Congregation Yahweh in the Parish of Trelawny. The approximate location of communities is shown in Figure 1 depicted by the black dots.

An attempt was made to include at least 35 children 3–5 years of age in each school to yield a sample of 140 children. Staff from the Ministry of Health assisted in formulating the invitation to parents and administrating permission slips to allow children to participate. Sixty-four participants were enrolled in urban and 64 in rural schools. The breakdown of participants is depicted in Table I.

Two periods of monitoring were planned, one nocturnal and one supervised daytime collection during the period children would attend school. In addition, a questionnaire was administered to the parents to obtain information on tooth brushing practices, use of toothpaste, fluoride supplements and fluoridated salt.

The mean age of urban children was 4.6 and 4.8 years for rural children with an approximate equal representation of both genders. Sixty percent of fathers of urban children who answered the questionnaire indicated having a professional occupation as opposed to 23% of fathers living in rural communities. Sixty-two percent of fathers living in rural areas had labor occupations compared to 17% of fathers living in urban communities. Sixty-four percent of mothers in urban settings and 67% in rural areas had attained secondary education. In rural areas, 80% of children used a single brand of adult toothpaste, most of them containing 1,000 to 1,100 ppm F, but an

Tab. I Distribution of sample and numbers of children enrolled				
Parish	**School**	**Type**	**Estimated**	**Age years**
St. Catherine	Cedar Grove	Urban	35	3–5
New Haven	St. Andrews	Urban	35	3–5
Neighbourhood	Clarendon	Rural	35	3–5
Congregation Yahweh	Trelawny	Rural	35	3–5
Total			140	

Enrolled	**Females**	**%**	**Males**	**%**	**Age years**
Urban	31	48	33	52	3–6
Rural	33	52	31	48	2–5
Total	64	100	64	100	

additional 11% used other brands of adult toothpaste. In urban areas 65% of children used a single brand of adult toothpaste and an additional 8.4% used other brands of adult toothpaste. The conclusion is that 76.5% in urban areas and 89% of rural children used adult toothpaste. Regarding quantity of toothpaste placed on the toothbrush parents of urban children responding indicated that 58.6% used too much (more than a pea-size), 27.6% excessive (the entire head of the brush covered with toothpaste) and only 13.8% used a pea-size amount. In rural children 70.2% use too much, 14.9% excessive and 14.9% a pea size.

Geologically, Jamaica is without a mineral source of fluoride, with only few waters having 0.38 to 0.51 ppm fluoride (reaching only 20,000 people in 1984, WARPEHA ET AL. 2001). Fluoride concentrations <0.3 ppm F were present in 95% of the sources which provided water to 99% of the population. All children of the sample were living in regions with less than 0.4 ppm F in the drinking water. In the Capital, Kingston, there was less than 0.25 ppm F in the water and bottled carbonated beverages had similar concentrations. Accordingly, waterbourne fluoride was negligible in view of the exposure to fluoride via salt and dentifrices.

Field work, analysis of urinary fluoride

The study was conducted during the last week of February 2008. Collection procedures followed WHO guidelines (MARTHALER 1999). Parents collected nocturnal urine samples in plastic tubes and entered times on the label provided; samples were transferred to the school early in the morning where volume of the collection was determined and recorded. Supervised day samples were collected at school, data recorded and samples maintained cool before they were transferred to the laboratory of the Government Chemist in Kingston for analysis.

Ionic strength buffer solution was added to each sample, before fluoride concentrations were determined using an electronic meter (Orion 720A) and a fluoride specific ion electrode (Orion 9609BN). Electrodes were calibrated with fresh, serially-diluted standard solutions. All fluoride determinations were carried out in duplicate and the results averaged.

Statistical evaluation of the data

Initially, 64 children were selected for each of the two groups (Tab. I). The numbers of children who did not provide valid urinary collections at all (in most cases, because the time at beginning or end of collecting urine was not recorded) were three in the urban and six in the rural sample, respectively.

Accordingly, the number of children with one or two collections was reduced to 61 and 58, as shown in Table II.

All data were arranged to concur with the standard tables for automatic evaluation (MARTHALER 1999). Provisional tabulations were then used to detect weaknesses in the data. First, collections with durations of less than 90 minutes (= 1.5 hours) were not considered valid because incomplete voiding of the bladder at the beginning or the end of the collection may result in considerable error in short time collections; the longer the collection period (CP), the smaller are effects of incomplete voiding.

In the urban sample, the shortest CP was 3.6 h at night and 1.68 h in daytime (the next shortest being 2.43 h). Consequently, there were no collections to be excluded (invalidated). In the rural sample, there were 4 subjects with CP of less than 90 minutes in the daytime samples (0.50 h, 0.83 h, 1.03 h, 1.42 h). These collections were not considered valid and were eliminated. This had the favorable secondary effect that the two collections with the largest, unrealistic flow of 325 and 326 ml/h were invalidated. One more collection (subject 87, daytime) was eliminated: its duration was only 1.55 h and its fluoride excretion appeared to be excessive: 192 µgF/h. The numbers of valid collections and their average durations are shown in Table II. When added, the collections on average lasted slightly longer than half of the 24 h period.

Three extrapolation patterns were chosen to obtain 24 h estimates from the actual nocturnal and daytime results in order to illustrate the effect of the three patterns on the 24 h results.
– In extrapolation 1 it is assumed that a child had three noteworthy meals leading to an elevated fluoride excretion during a total of 8 hours. In fact, high excretion may last between two and three hours, an approximate 8 hours per day.
– For extrapolation 3, only "two noteworthy meals" are assumed to lead twice to two-hour episodes of high excretion, equal to four hours in one 24 h cycle.
– Extrapolation 2 is based on the assumption that the majority of children would have on average an elevated excretion between the extreme situations of extrapolations 1 and 3. Extrapolation 2 was, therefore, set halfway between extrapolation 1 and 3, resulting in 6 hours of high excretion and 18 hours of low excretion, these 18 hours including 10 to 11 hours of sleep as evidenced by the duration of the nocturnal period.

Accordingly, the following extrapolations were regarded as most appropriate:

Tab. II   Results of the valid nocturnal and daytime urinary collections obtained from the Urban and Rural children

	Urban Children, N = 61		Rural Children, N = 58	
	Nocturnal	**Day**	**Nocturnal**	**Day**
Number of valid collections obtained	59	41	58	40
Average duration of collection, hours	9.9	4.9	11.2	3.0
Fluoride excretion, µgF/24h				
Median	**7.50**	**13.99**	**5.71**	**28.99**
Range	1.3–35.4	2.8–62.4	0.59–30.6	2.6–98.3
Average	**8.89**	**18.48**	**8.17**	**30.55**
Standard deviation	6.32	13.32	6.74	21.96
Confidence limits (p = 0.95)	7.2–10.5	14.3–22.7	6.40–9.94	23.5–37.6
Mean F concentration	1.327	1.281	1.261	1.237
Mean urinary flow, ml/h	7.8	16.2	6.63	27.9

Extrapolation	Low excretion, night and part of daytime	High excretion after food intake	Total duration
1	16 hours	8 hours	24 hours
2	18 hours	6 hours	24 hours
3	20 hours	4 hours	24 hours

Results

Fifty-nine urban children donated nocturnal urine with a mean collection period of 9.9 hours (1.7 SD) (Tabl. II). Mean excreted urine volume was 72.3 ml with a fluoride concentration of 1.327 mg/l. The mean urinary flow was 7.9 ml/h (4.4 SD) and the mean excretion rate was 8.9 µg/h (6.3 SD). Fifty-eight rural children donated nocturnal samples, the mean collection period was 11.2 hours (1.9 SD); the mean excreted urine volume was 70.8 ml and the fluoride concentration 1.261 mg/l (0.712 SD); urinary flow was 6.6 ml/h (3.6 SD) and the mean excretion rate was 8.2 µg/h (6.7 SD).

Forty-one valid daytime collections were available from the urban children and the mean collection period was 4.9 hours (1.6 SD). Mean excreted volume was 64.8 ml, the fluoride concentration at 1.281 mg/l (0.817 SD). Mean urinary flow was 16.2 ml/h (8.2 SD) and the excretion rate 18.5 µg/h (13.3 SD). Forty rural children donated valid daytime urine collections. Mean duration of collection was 3.0 hours (0.7 SD) with a mean urine volume of 89.8 ml and a fluoride concentration of 1.237 mg/l (0.712 SD). Mean urinary flow was 27.9 ml/h (18.8 SD) and excretion rate 30.6 µg/h (22.0 SD).

Table II shows the results regarding the nocturnal and daytime collections in detail. There is little variation regarding ppm F, the 4 concentrations ranging between 1.237 and 1.327 mg/l. Nocturnal flow was low, urban children urinated 7.9 ml/h and rural children 6.6 ml/h. In daytime, the urban children had a flow of 16.2 ml/h, whereas the rural children had 27.9 ml/h. Excretions showed a similar situation: 30.6 versus 18.5 µgF/h. The differences are highly significant regarding both flow and fluoride excretion.

The results of the three chosen extrapolations to twenty-four hours are compared in Table III; they were based on the data from those children who provided both valid nocturnal and daytime collections. The urban and rural fluoride excretion results were lower in extrapolation 3 as compared to extrapolation 1 when looking at both medians and averages; the average difference was 39 µgF/24h (299 versus 260) in the urban children but amounted to 92 µgF/24h (362 versus 270) in the rural children. Extrapolation 2 resulted in intermediate results as expected. Fluoride concentrations remained largely unaffected.

Discussion

Excretions and effect of the extrapolation patterns

It is obvious that "intermediate" extrapolation 2 is most appropriate and is used preferentially for discussing the results. Detailed results obtained from extrapolation 2 are shown in Table IV. In the average excretions of 271 µgF/24h (urban) and 330 (rural), the results from all valid collections are considered. Table V relates 24 hour fluoride excretions to bodyweight obtained from Extrapolation 2. On this basis, the average excretion was 14.5 µgF/24h/kg in the urban and 17.9 µgF/24h/kg in the rural children.

Earlier Jamaican results from seven children 2–6 years of age showed a mean excretion of 169 µgF/24h (WARPEHA & MARTHALER 1995). The excretion of 271 and 330 µgF/24h as shown in Table IV is almost twice as high as the 1987 result.

The average excretion by the urban and rural children (271 and 330 µgF/24h) was approximately at the upper reference value corresponding to low fluoride intake as listed in Tab. VI.

Tab. IV   Detailed results based on extrapolation No. 2 (18 h low and 6 h high excretion) on the data from the children with two valid collections and in addition considering the data of the nocturnal and daytime results from the children who provided only one collection

	Urban Children	Rural Children
Fluoride excretion, µgF/24 h		
Average	271	330
Standard error	25.2	26.5
Confidence limits (p = 0.95)	220–322	277–384
Mean urinary flow, ml/24h	239	241

Tab. V   Fluoride excretion per body weight (µgF/24h/kg) and urinary flow from those children who provided two valid collections, based on extrapolation 2

	Urban Children	Rural Children
Subjects	39	40
Median	12.0	15.7
Range	2.7–48.2	03.5–49.6
Average	**14.5**	**17.9**
Standard deviation	9.5	11.0
Confidence limits (p = 0.95)	11.4–17.5	14.3–21.4
Mean urinary flow, ml/24h/kg bodyweight	12.0	16.5

Tab. III   Comparison of results obtained from the three extrapolation patterns in the children providing both collections

	Extrapolation 1		Extrapolation 2		Extrapolation 3	
	Urban	Rural	Urban	Rural	Urban	Rural
Number of children with both collections	39	40	39	40	39	40
Median F excretion, µg/24h	239	319	222	290	208	216
Range	84–1066	74–903	75–1012	63–818	61–958	53–753
Mean F excretion, µg/24h	**299**	**362**	**279**	**316**	**260**	**270**
Stand. deviation	196	223	185	193	177	167
Mean urinary F concentration, ppm	1.280	1.152	1.288	1.140	1.301	1.130
Mean urinary flow, ml/24h	253	331	236	289	220	246

The lower and upper excretions of 360 and 480 µgF/24h postulated for optimal fluoride usage (Tab. VI) are clearly higher than the values obtained in the present study.

In the case of the nocturnal excretion the averages of 8–9 µgF/h are in between provisional standard values corresponding to low fluoride usage. On the other hand the daytime excretions (18 and 31µgF/h) corresponded well with the postulated lower and upper values for optimal fluoride usage (18 and 27 µgF/h).

The fluoride concentrations between 1.237 and 1.327 ppmF were slightly higher than the preliminary standards of 0.9 and 1.2 ppm (for all ages; Tab. VI) under conditions of optimal fluoride usage (MARTHALER 1999).

An earlier excretion study had been conducted in San Isidro in Southern Texas, where the climate is similar to that in Jamaica, albeit somewhat drier. Children four to six years of age had been consuming water with an average concentration of 1.32 mgF/L (1.32 ppmF, median 1.30) at home. Additional fluoride exposure resulted from fluoride toothpastes containing 1,000 to 1,100 ppm fluoride; such toothpastes were also used in daily toothbrushing exercises at school where the tap water contained 1.0 to 1.3 ppm fluoride. Depending on the extrapolation patterns (in that study, three collections were the rule and the average duration of the collections was 15h of 24h), extrapolated excretion averages varied between 688 and 777 µgF/24h, depending on the extrapolation pattern. Fluoride excretion was roughly twice as high as in Jamaica, which would agree with the higher overall fluoride exposure from fluoride-rich drinking water, particularly in view of the hot climate in Southern Texas, and use of fluoride toothpastes both at home and routinely at school brush-ins (BAEZ ET AL. 2000). In a survey conducted in the early 1990s in San Isidro and other eleven communities along the US Mexico border in which 1276 school age children were examined for enamel fluorosis using Dean's criteria, the largest proportion found were in the questionable category (32.1%), followed by very mild (29.6%) and normal (28.9%). Eight and one half percent (8.5%) of children were scored with mild fluorosis; 0.5%. with moderate and only 0.3% with severe fluorosis (BAEZ & BAEZ 1995).

Estimation of fluoride intake

As summarized by VILLA (2004) several papers "have shown that there is a linear relation between the amount of F excreted (or retained) and total F ingestion". Further analyses by VILLA suggest that the higher the intake, the lower is the excreted fraction. With no data available on fluoride intake of the Jamaican children, the fraction of excreted fluoride is not known. For his paper, VILLA compiled a table presenting both fluoride ingestion and excretion in children. From that table, the data of those groups of children were selected who had fluoride excretions similar to the present material (ranging from 260 to 476 µgF/24h, seven papers). The results from the seven papers are shown in Table VII.

The fraction of the excreted fluoride varied from 0.297 to 0.848 and the respective average was 0.492. When the two highest (0.848, 0.792) and the two lowest ratios were excluded, the average was 0.403. For the following approximations, excreted fractions of 0.5 and 0.4 were chosen. Nevertheless, the two studies indicating unusually high fractional excretion suggest that the fraction 0.3 should also be considered for model

Tab. VII Fluoride excretion and total intake, µgF/24h, in groups of children similar regarding age and excretion to the Jamaican ones studied in this paper

Age	Excretion, µgF/24h	Intake, µgF/24h	µgF (excreted)/ µgF (ingested)
5–6	260	750	0.347
3–4	280	330	0.848
3–5	297	1000	0.297
4	330	1100	0.300
3–5	339	428	0.800
3–5	358	1019	0.355
3–6	476	931	0.515

Data extracted from Table I in VILLA (2004); for the complete bibliography see VILLA

Tab. VI Confidence limits of present results (separately for urban and rural children) compared to WHO Provisional Standards (Lower and Upper) for urinary fluoride excretion and concentration under Low or Optimal fluoride usage*

	Excretion, µgF/24h		Nocturnal excretion, µgF/h	
	Lower	**Upper**	**Lower**	**Upper**
Standards, age 3–5 years				
Low F intake	170	290	6	10
Optimal F usage	360	480	12	17
Present study, age 2–6 years				
Urban	220 to 332		7.25 to 10.54	
Rural	279 to 385		6.40 to 9.54	
Standards, age 6–7 years				
Low F intake	190	310	7	11
Optimal F usage	480	600	15	22
Fluoride concentration (ppm)				
Standards, all ages				
Low F intake	0.2	0.5	0.2	0.4
Optimal F usage	0.9	1.2	0.7	0.9
Urban	1.02 to 1.55		1.07 to 1.54	
Rural	0.94 to 1.30		1.07 to 1.46	

* (MARTHALER 1999)

	Urban Children	Rural Children
Excretion, µgF/24h	271	330
Calculated total F-ingestion, µg/24h		
Excreted fraction = 0.5	542	660
Excreted fraction = 0.4	**678**	**825**
Excreted fraction = 0.3	903	1100
Excretion µgF/24h/kg	14.5	17.9
Calculated total F-intake µgF/24/kg		
Excreted fraction = 0.5	29	36
Excreted fraction = 0.4	**36**	**45**
Excreted fraction = 0.3	48	60

Tab. VIII Estimates of total fluoride ingestion in micrograms (upper part of the table per 24h, lower part per 24h/kg bodyweight) when the fraction of excreted fluoride is assumed to be 0.5, 0.4 and 0.3 of the ingested fluoride. (The 24h fluoride excretions are those shown in Tab. IV and V.)

calculations. In the case of the urban children, who excreted 271 µgF/24h, the assumption that only half (50%) of the ingested fluoride is excreted leads to an estimated total fluoride intake of 271*(1/0.5) or 542 µg in 24 hours. If, on the other hand, it is assumed that only 30% of the fluoride is excreted, then the estimated intake rises to 903 µgF/24h (Tab. VIII, upper part). The respective results from the rural children are 660 and 1100 µgF/24h. The estimate of 40% excretion (fractional excretion 0.4) may be best, leading to a total fluoride intake of 678 and 825 µgF/24h for the urban and rural children, respectively (Tab. VIII, bold figures). The highest supposed intake, 1.1 mgF/day (s. Tab. VIII), corresponds well with the common recommendation for 0.75 mg supplemental fluoride per day (via fluoride tablets), which results in a total intake of approximately 1.0 mg fluoride due to some 0.25 mg fluoride provided by low-fluoride water and solid food.

The same computations were made for the excretion per bodyweight shown above in Table V. Based on the extrapolation 2, the urban children ingested 36 µgF/24h/kg (14.5*[1/0.4]), while for the rural children the ingestion was 45 µgF/24h/kg (see the row with bold figures in the lower part of Tab. VIII). When expressed in milligrams (mgF/24h/kg), the calculated ingestions of 0.036 and 0.045 are sligthly below the frequently used threshold of 0.05 to 0.07 mgF/24h/kg bodyweight, which is generally considered as safe and not leading to unsightly enamel fluorosis (MARTINEZ-MIER ET AL. 2003, FRANCO ET AL. 2005).

Fluoride intakes per day based on assumptions 1 and 3 are also presented in Table VIII. When assuming a 50% excretion (assumption 1), the total fluoride ingestion would amount to 0.54 and 0.66 mgF/24h/kg (542 and 660 µgF/24h/kg). On the other hand, assumption 3 results in the highest estimates, 0.048 (urban children, Tab. VIII) and 0.060 mgF/24h/kg (rural children), which do not exceed the upper limit of 0.07 mgF/24h/kg.

In conclusion, the excretion results indicate a suboptimal exposure to fluoride, while on the basis of the urinary concentration, the fluoride intake would seem optimal.

Sources of fluoride intake

The excreted fluoride mirrors the intake from all sources of fluoride, not only from fluoridated salt. Several papers from Latin America document that toothpastes containing fluoride are in fact an important, and sometimes the major, source of ingested fluoride even when the salt is fluoridated (FRANCO ET AL. 2005; MARTINEZ-MIER ET AL. 2003). Even in the USA, where mere pea-size portions of dentifrice to be put on the brush have been recommended for decades, the fluoride intake from dentifrice equaled the intake from fluoridated water (ROJAS-SANCHEZ ET AL. 1999).

The intake of snacks, in Jamaica routinely prepared with fluoridated salt, was considered to be a minor source of fluoride intake, and this applies as well for crackers, cakes and other starch-containing products. Although they were routinely prepared with fluoridated salt, the amounts were small and would hardly result in a noticeably elevated urinary excretion. It should be noted that, on the other hand, the presence of fluoride in the oral cavity via snacks and similar in-between foods is important for the caries preventive effectiveness; even small quantities of fluoride, particularly when trapped in food remnants for usually 10 to 30 minutes, will prolong presence of fluoride in the oral fluid (or mixed) saliva, contributing to the topical protective effect.

A look at the questionnaires and the market reveals that low-fluoride toothpastes as commonly used by European children up to 5–7 years are scarcely available and seldom used in Jamaica. Results of questionnaires administered to parents of children participating in the fluoride exposure study indicate that essentially all children use toothbrushes and toothpaste. Eighty percent of respondents indicated that children use adult toothpaste twice a day; half of the participants started using toothpaste at 1 year and 23% at 2 years. Interestingly, 70% of urban children and 59% rural children use too much toothpaste on the toothbrush, and 15% of urban children use excessive amounts compared with 28% in the rural area. The main reason for selecting a brand of toothpaste was flavor. Use of adult toothpaste and excessive amounts on the toothbrush certainly lead to considerable unintentional fluoride ingestion. An exploratory study including toothpaste brands available in Jamaica showed that the majority of toothpastes in the market contain fluoride between 550 to 1,000 ppm. No studies on toothpaste ingestion have been conducted on the island. Further studies might provide clues as to what extent fluoride intake from dentifrices and other sources contributed to the relatively high excretion.

Ninety-six percent of rural and 100% of urban children were consuming fluoridated salt. Only one family in a rural area indicated using a non-fluoridated brand of salt. From all respondents, only 2 children in each area indicated taking fluoride supplements at the time of the survey.

Enamel fluorosis

For decades, some level of slight enamel fluorosis has been the trade-off for effective caries prevention depending on fluorides. In addition, in view of the low dental treatment levels, some degree of fluorosis is clearly preferable to the progressive destruction of teeth by caries. Very mild and mild fluorosis at mouth prevalence from 7% to 16% was considered acceptable in regions with optimally fluoridated waters (BURT & EKLUND 1992). In the Jamaican children, with 24 of 695 children (3.4%) showing questionable and only 5 children very mild or mild levels (ESTUPINAN-DAY ET AL. 2001), enamel fluorosis has not been a problem at all.

Recently, the results of a national Costa Rican survey of enamel fluorosis, conducted in 1999, i.e. 12 years after the initiation of the national salt fluoridation program (salt with

225–275 ppmF since 1987), were published. The maxillary anterior teeth and first bicuspids were scored essentially according to the WHO criteria based on Dean's scale (SALAS-PEREIRA ET AL. 2008). In the 12-year-old children (n = 1250) born when the fluoridation began, 57.9% had no signs of fluorosis, 27.5% had questionable or very mild fluorosis. Only 9.1%, 4.2% and 1.4% had mild, moderate or severe fluorosis, respectively. The role of ingested fluoride toothpaste, in use for many years before 1987, was not discussed. The general conclusion is that the combination of fluoride used in both dentifrices and salt, also implemented successfully in Costa Rica (SOLORZANO ET AL. 2005) and Switzerland (MENGHINI 2005), does not lead to objectionable enamel fluorosis levels.

Conclusions

At this time, there is obviously no reason to change the salt fluoridation scheme conditions as they have been maintained over twenty years in Jamaica. In fact, this paper showed that the current fluoride exposure assures virtual freedom from enamel fluorosis, while the targetted decline of caries has been met or has surpassed expectations. However, for proper maintenance of the scheme, strict quality control at producer and consumer levels is indispensable to ascertain the good results obtained up to now. A further study would be desirable to include a larger number of communities and to verify whether salt used in Jamacia complies with the new regulation (2008) that all salt, whether produced on the island or imported, must contain 200–250 ppm fluoride. A current mapping of fluoride in drinking water is also indicated.

Dedication

This article is dedicated to the memory of Rosalie A. Warpeha, who with assistance from Dr. G. Gillespie of the Pan American Health Organization and Prof. T. M. Marthaler from the University of Zurich, initiated the salt fluoridation project in the early 1980's and continued to work for it until her untimely death in 2006.

Acknowledgments

Zusammenfassung

Ausgangslage: Im Jahre 1984 lag der mittlere DMFT bei 12-jährigen Kindern von Jamaica bei 6,7. 1987 wurde ein nationales Programm der Salzfluoridierung (250 mgF/kg Salz) eingeführt. 1995 erbrachte eine nationale Erhebung einen stark verminderten mittleren DMFT von 1,1.

Ziel: Prüfung ob der Stand der Fluoridversorgung weitergeführt wird.

Methoden: Erfassung der Fluoridparameter im Urin gemäss den WHO-Richtlinien. Stichproben von Kindern wurden in zwei städtischen und zwei ländlichen Gebieten ausgewählt. Nacht- und Tagurine wurden von 128 Kindern eingesammelt (mittleres Alter 4,7 Jahre). Mittels eines Fragebogens wurde der Stand von Mundhygiene-Gewohnheiten und der Gebrauch von Fluorid in Salz, Zahnpasten oder Tabletten erfragt.

Resultate: die auf 24 Stunden extrapolierte mittlere renale Fluoridausscheidung betrug bei den städtischen Kindern 271, bei den ländlichen 330 µgF/24h. Die mittleren Fluoridkonzentrationen lagen im engen Bereich von 1,13 und 1,30. Die Kinder verwendeten durchweg Fluoridzahnpasten, meistens mit 600 bis 1000 ppmF; 65% benutzten zu viel Zahnpaste, davon ein Drittel deutlich zu viel. Andere Fluoridpräparate wurden selten verwendet. Fluoridiertes Salz wurde von 98% der Kinder benutzt. Schlussfolgerungen: Die Exkretionsresultate legen eine suboptimale Fluoridversorgung nahe, wogegen die Fluoridkonzentrationen eher auf eine optimale oder leicht höhere Versorgung hindeuten. Strikte Qualitätskontrolle beim Produzenten und beim Konsumenten sind unerlässlich, um die erreichten ausgezeichneten Resultate abzusichern. Zahnpasten mit maximal 500 ppmF sollten erhältlich gemacht werden, um das Risiko von Schmelzfluorosen niedrig zu halten.

Résumé

Antécédents: En 1984 le DMFT des enfants de la Jamaique atteignait 6.7 (niveau inquiétant). En 1987 la Jamaique lançait un programme de fluoration du sel (250 mgF/kg sel). En 1995 une enquête nationale constata une réduction importante de lésions carieuses (DMFT de l.l)

Objectif: Vérifier si le taux de fluor doit être fourni à même dosage favorable.

Méthodes: Etablir les paramètres urinaires selon les directives de la WHO. Prendre des échantillons parmi des enfants de deux sites urbains et ruraux. Des spécimens d'urine nocturne et diurne ont été obtenus de 128 enfants (âge moyen 4.7 ans). Un questionnaire a été soumis aux parents afin de déterminer l'hygiène orale pratiquée ainsi que l'emploi de fluor au moyen de sel, de dentifrices ou suppléments.

Résultats: Extrapolées sur 24 heures, les excrétions rénales moyennes de fluor atteignaient 271 ugF dans les sites urbains, 330 ugF dans les sites ruraux. Les concentrations de fluor ne variaient qu'entre 1.13 et 1.30. Selon le questionnaire distribué presque tous les enfants employaient une pâte dentifrice, la plupart de 600 à 1000 ppmF; 65% des enfants employaient trop de pâte dentifrice, dont un tiers une quantité excessive. 98% des enfants consommaient du sel fluoré. D'autres sources de fluor étaient l'exception.

Conclusions: Les résultats de l'excrétion urinaire indiquent un approvisionnement en fluor moins qu'optimal, tandis que les concentrations de fluor semblaient indiquer un approvisionnement optimal ou légèrement supérieur. Des contrôles sévères de la qualité au niveau des producteurs et des consommateurs s'imposent afin de confirmer les bons résultats obtenus. Des dentifrices à 500 ppmF devraient être disponibles pour réduire le risque de fluorose de l'émail.

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