Dental Fluorosis Among Schoolchildren in Gozo, Malta

Ethel Vento Zahra[1], Paula Vassallo[2]

[1] B.Ch.D., M.Sc. Dental Surgeon, Department of Dental Public Health, Assistant Lecturer, University of Malta. [2] B.Ch.D., M.Sc. (Lond.), D.D.P.H. R.C.S (Eng), M.B.A (Warwick), FFPHM. Consultant Dental Public Health, Lecturer, University of Malta.

Abstract

Aims: This study aimed to assess the prevalence of dental fluorosis in 5- and 12-year-old schoolchildren in Gozo (a Maltese Island) and to establish awareness of aesthetic changes associated with dental fluorosis of the upper central incisors in 12 year olds. ***Methods:*** All schoolchildren who were 5 (n=270) or 12 (n=339) years old on their last birthday, had lived in Gozo since birth, had six unrestored/non-carious anterior teeth, and were present at school on the day with positive consent forms were examined. Observations were recorded using Thylstrup-Fejerskov (TF) Index (1978). Twelve year-olds were asked about their awareness of marks on upper central incisors. ***Results:*** Among the 5 year olds, only 8 (1.8%) had a TF Index score of 1. Among 12 year olds, 48 (14.2%) had a score of TF 1 or more. Analysis of mean TF scores showed differing values by locality ($P<0.005$). Only three (6.25%) of the 48 children were aware of marks on their upper incisor teeth that were attributable to fluorosis. There was no relationship between mean fluoride concentration (1994-2000) and TF scores by locality among 12 year olds in 2006. ***Conclusions:*** Fluorosis in Gozo is currently not a public health problem. The children who were examined were unaware of aesthetic changes associated with current levels of dental fluorosis.

Key Words: Fluorosis, Prevalence, Schoolchildren, Thylstrup-Fejerskov (TF) Index

Introduction

For more than a century, fluorides have been used to prevent dental caries. Although it has been scientifically proven that small concentrations of fluoride can significantly reduce dental caries without any ill-effects [1], the use of fluoride is still regarded as a controversial issue and is still under investigation. Against a background of exposure to multiple sources of fluoride and changes in the rates of dental decay and dental fluorosis at both population and individual levels, it has been suggested that there is an increasing occurrence of dental fluorosis [2]. This prompted an assessment of dental fluorosis in the Maltese island of Gozo.

There are two main populated Maltese islands—Malta (population 364,040) and Gozo (population 29,893). Until the late 1980s, the Maltese Islands' water supply was entirely naturally fluoridated ground water from boreholes. The mean fluoride level in potable water of the Maltese Islands never exceeded the mean concentration of 1.4 ppm, but certain localities had fluoride levels exceeding 2 ppm. In the early 1990s, reverse osmosis plants started contributing significantly to the water supply in the island of Malta. The "polished water" (i.e., water from a reverse osmosis plant) produced by these plants contains less than 0.2 ppm fluoride. This led to the Maltese population not being exposed to sufficient fluoride for dental fluorosis for caries to be prevented.

Prior to 2004, Gozo's water supply was from naturally fluoridated ground water from boreholes with fluoride levels ranging from 1 ppm to 2.2 ppm depending on the distribution system. In 2004, a new system for water distribution was introduced to meet criteria stipulated in Legal Notices 23/2004 and 116/2004 issued by the Government of Malta [3,4]. In this system, ground water from boreholes is pumped to one reservoir. Some ground water is introduced into a polishing plant and one part of this polished water is blended with two parts of

Corresponding author: Ethel Vento Zahra, Public Health Regulation Department, Ministry for Health, the Elderly and Community Care, St. Luke's Hospital—OPD Level 1, St Luke's Square, G'Mangia, PTA 1010, Malta; e-mail: ethelvz@gmail.com or Paula Vassallo, Public Health Regulation Department, Ministry for Health, the Elderly and Community Care, St. Luke's Hospital—OPD Level 1, St Luke's Square, G'Mangia, PTA 1010, Malta; e-mail: paulavassallo@gmail.com

non-polished ground water. This mixture is then stored in five water quality zone reservoirs from where it is supplied to the households in Gozo [5]. The water produced by polishing plants contains less fluoride than ground water, thus meeting the drinking water directive Council Directive 98/83/EC, which puts the limit for fluoride in drinking water at 1.5 mg/l (1.5 ppm) [6].

A pathfinder survey carried out in Gozo in 1986 by Möller during a consultation visit for the Ministry of Health [7] suggested that there was, at the time, a public health problem with regards to dental fluorosis in Gozo. A score of >0.6 was recorded using Dean's index [1] and exceeded the normal threshold scores of 0.4-0.6. However, Möller (1987) suggested that possibly other enamel opacities could have been mistakenly classified as dental fluorosis [7].

Data collected in 2004 [8] showed that in Gozo, 15% of the 12-year-old children examined (n=60) had marks attributable to fluorosis [8]. Dental fluorosis can cause unnecessary distress and be an economic burden for a minority of the population in its more severe forms.

Aims

Against this background, the aims for this study were:

1. To establish how large a public health problem dental fluorosis currently is in both the deciduous (in 5 year olds) and the permanent dentition (in 12 year olds) in Gozo.
2. To determine the prevalence of fluorosis in the deciduous dentition in Gozo (never determined previously).
3. To determine how aware 12-year-old Gozitan children were with respect to the aesthetic changes to their upper central incisors associated with dental fluorosis.

Methods

Permission to carry out this study was granted by the Education Division on condition that consent for the dental examination was given by parents of the children examined. The University of Malta Research Ethics Committee also gave its approval.

The examiner underwent training in physical characteristics of fluorosis from the data gathered in a literature review, photographs found in books, and from databases of pictures on the Internet. She received practical training in the use of the Thystrup and Fejerskov (TF) Index (1978) [9] from a senior academic clinician who for several years had been actively involved in various studies on dental health and fluorosis in the Maltese Islands.

Population

The study populations of 5-year-old and 12-year-old schoolchildren were chosen since these are the ages at which clinical surveys for oral health are routinely carried out [8]. This was done for comparative purposes and to maintain consistency in the age of the children who were examined.

The inclusion criteria were that children in the study:

- Were 5 or 12 years old at the last birth date.
- Had lived in Gozo from birth (until a minimum of 6 years of age in the 12-year-old group).
- Had a minimum of six unrestored anterior teeth present, without smooth surface carious lesions.

The study was carried out in all existing schools in Gozo. All children who had a positively filled consent form, who were present at school on the day of examination, and who satisfied the inclusion criteria (270 5-year-old and 339 12-year-old children) were examined using intense light and tongue depressors. The teeth were not dried prior to examination. The observations were recorded using the TF Index [9]. The locality of residence until six years of age was recorded. All the 12-year-old children examined were asked the question "Are you aware of any marks on your upper front teeth which will not brush off?" [10], translated into Maltese. The scores and answers were recorded by a dental hygienist acting as a research assistant.

Intra-examiner reliability was tested blindly, the research assistant calling back one child at random, from every group of 20 children seen. Weighted Kappa scores were then calculated.

Data on fluoride levels in the Gozo water supplies were requested from the Institute of Water Technology, responsible for the Routine Check Monitoring Programme and the Audit Monitoring Programme at Water Services Corporation.

Statistical analysis of the data was carried out using statistical software (SPSS version 13; SPSS Inc, Chicago, USA). Non-parametric tests such as the Kruskal-Wallis test, Mann-Whitney test and Spearman's Correlation were used for statistical analysis. The results were presented in graphical and tabular form using Microsoft Excel (Microsoft Corporation, Redmond, USA).

Results

Fluoride availability

The average fluoride level in Gozo's water supply is decreasing with time, especially since the introduction of the collection scheme in 2004. Fluoride levels had already dropped from 2.5 ppm in 1994 to a mean of 0.94 ppm in 2000. They dropped further to a mean of 0.44 ppm in 2006 with an unequal distribution of fluoride levels in different localities.

Enamel mineralisation happens mainly at the age of 6 months to 6 years. Thus, the period between 1994 and 2000 is when the fluoride levels in water could have systemically affected the 12-year-old children to produce the levels of fluorosis found on clinical examination in 2006. The mean fluoride concentration for the different localities can be seen in *Table 1* and the TF scores according to fluoride concentration in water can be seen in *Table 2.*

Fluorosis in 5-year-old Gozitan schoolchildren

Two hundred and seventy (138 male, 132 female) 5-year-old schoolchildren were examined. Ninety-seven (36%) of these children attended church schools and 173 (64%) attended public schools. Twenty-eight (9.3%) 5-year-old children were absent or did not have signed consent forms on the day of the examination (15 female, 13 male). Two (0.6%) males were not included in the study because they did not fulfil all the inclusion criteria.

Only eight of the 5 year olds examined (1.8%) had a recordable score on the TF Index *(Figure 1).* A score of TF 1 was recorded for all (i.e., barely visible to the naked untrained eye).

The prevalence of dental fluorosis in the deciduous dentition was thus currently negligible. There was no significant difference between 5-year-old children attending public or church schools (*P* value 0.070) and between genders (*P* value 0.642).

Table 1. *Mean fluoride concentrations in water and TF scores according to locality*

Locality	**Number of 12 year old subjects**	**Mean Fluoride (ppm) in water**	**TF Score 0**	**TF Score 1**	**TF Score 2**	**TF Score 3**	**TF Score 4**	**TF Score 5**
Fontana	7	0.88	7	0	0	0	0	0
Ghajnsielem	26	1.2	23	2	0	1	0	0
Gharb	14	1.9	12	1	0	0	1	0
Ghasri	7	2	7	0	0	0	0	0
Kercem	19	1.5	18	1	0	0	0	0
Munxar & Xlendi	14	1.3	14	0	0	0	0	0
Nadur	36	1.7	32	3	1	0	0	0
Qala	19	1.7	15	2	1	1	0	0
Rabat	64	1	58	3	1	1	1	0
San Lawrenz	11	1.8	10	0	1	0	0	0
Sannat	23	1.4	21	1	0	1	0	0
Xaghra	50	1.2	33	6	5	4	1	1
Xewkija	28	1	26	1	1	0	0	0
Zebbug & Marsalforn	21	1.7	15	3	1	2	0	0
All areas	339	1.45	291	23	11	10	3	1

Table 2. *TF scores in 12-year-old children according to fluoride concentration in water*

Fluoride Conc. (ppm) in water	**TF Score 0**	**TF Score 1**	**TF Score 2**	**TF Score 3**	**TF Score 4**	**TF Score 5**
≤1	91	4	2	1	1	0
1.01-1.39	70	8	5	5	1	1
1.4-1.79	86	7	2	2	0	0
≥1.8	44	4	2	2	1	0
Total no. of children	291	23	11	10	3	1

Fluorosis in 12-year-old Gozitan schoolchildren

Three hundred and thirty-nine (173 male, 166 female) 12-year-old schoolchildren participated. Seventy-eight (23%) of these children attended church schools, 94 (27.7%) attended public secondary schools, and 167 (49.3%) attended public junior lyceum schools. Twenty-six 12-year-old children were absent or did not have signed consent forms on the day of the examination (19 female, 7 male). Five males and one female were not included in the study because they did not fulfil the inclusion criteria.

Forty-eight (14.2%) children had a TF score of 1 or more. Twenty-three (6.8%) 12-year-old children were scored at TF 1, 11 (3.2%) at TF 2, 10 (2.9%) at TF 3, three (0.88%) at TF 4, and one (0.29%) at TF 5 *(Figure 1)*.

There was no statistically significant difference by gender (*P* value 0.642) or type of school (*P* value 0.072) when using the Mann-Whitney test.

Using the Kruskal-Wallis test, the mean TF scores were analysed by locality and show statistically significant differences (*Figure 2)*. The 95% confidence intervals of the means were then calculated and show that the mean TF score of Xaghra (the locality with the highest fluorosis) is signifi-

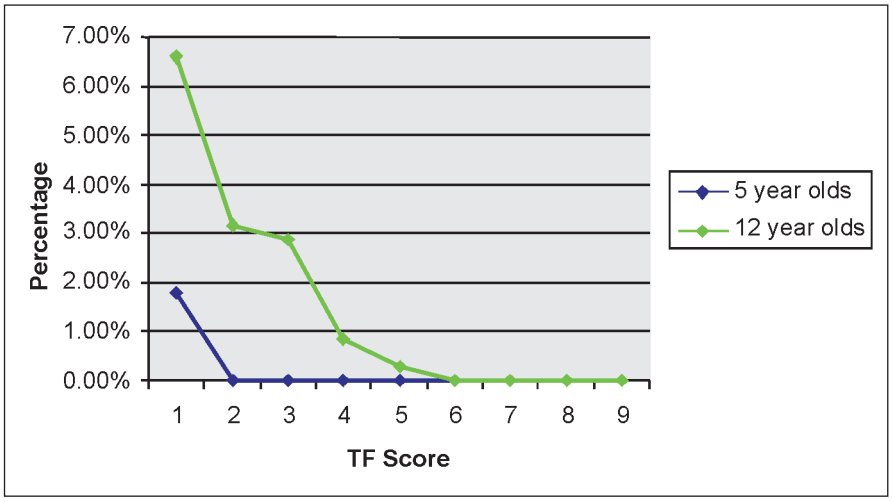

Figure 1. *Positive TF Scores in 5 and 12 year olds in Gozo.*

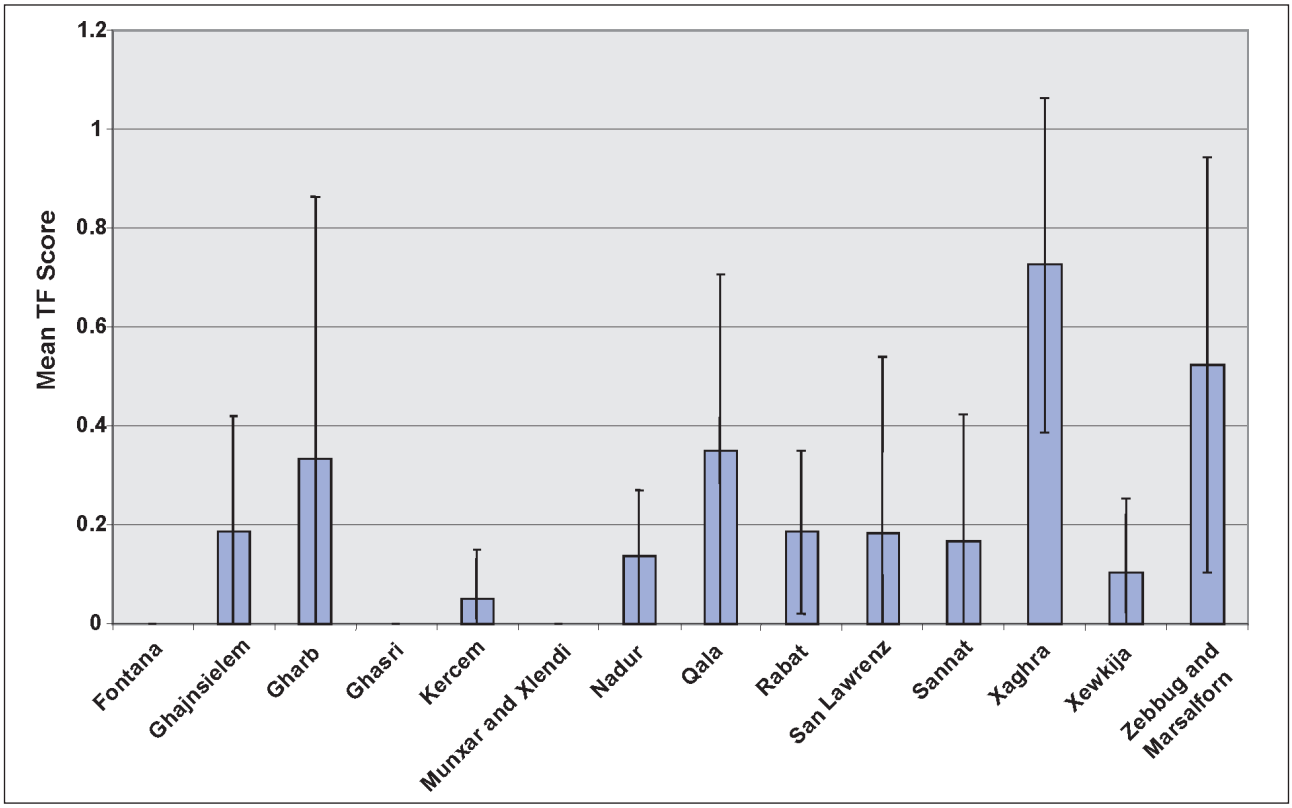

Figure 2. *Mean TF scores with their confidence intervals by locality.*

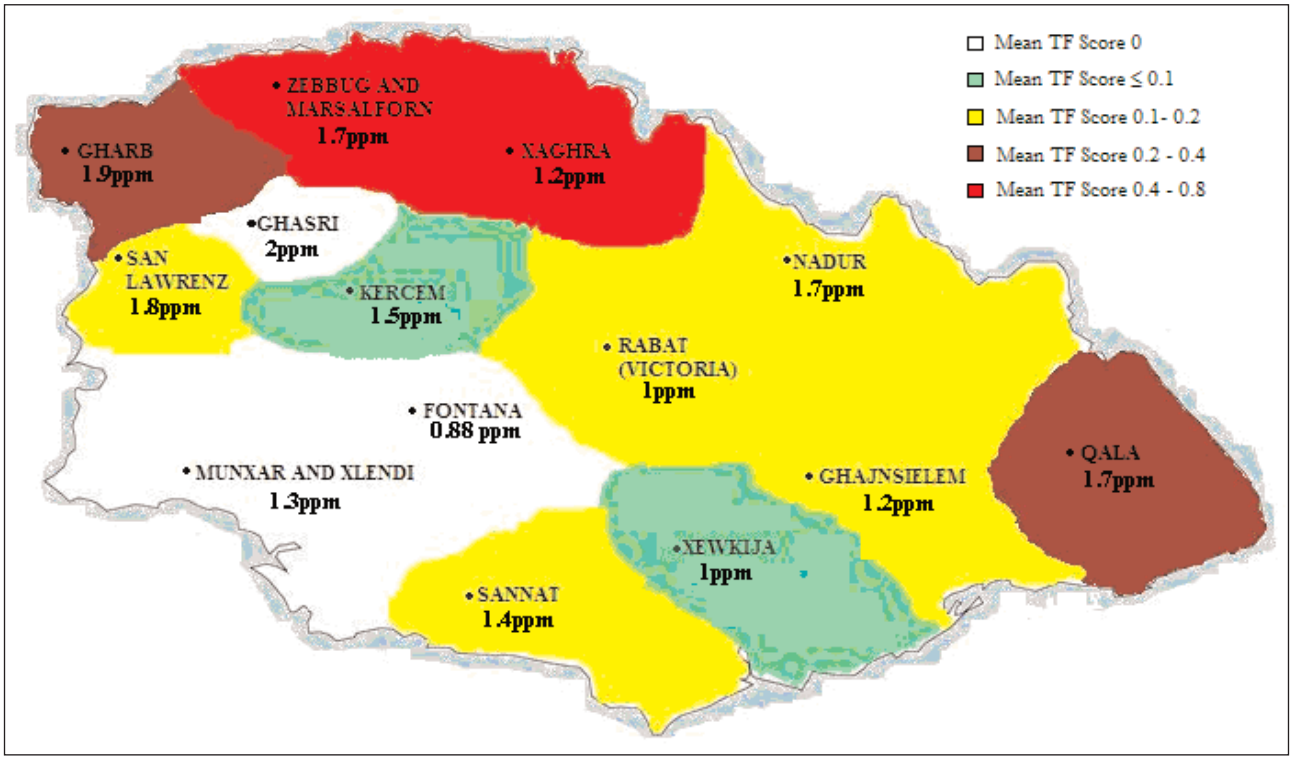

Figure 3. *Map of Gozo showing mean TF scores and mean fluoride concentration for the period 1994-2000 by locality.*

cantly higher than that of all the other localities apart from neighbouring Zebbug and Marsalforn.

Figure 3 maps the mean TF scores by locality in which Xaghra in the south as well as Zebbug, Marsalforn and Gharb on the north-west of the island are the worst affected areas, although this does not follow the same pattern as the fluoride levels in water as shown on the map below.

Correlation between fluorosis and fluoride

The correlation between mean fluoride concentration between 1994 and 2000 and the TF scores in 2006, by locality, was analysed. Spearman's correlation analysis of the data shows no correlation between the two factors (*P* value 0.68).

Aesthetic awareness

Thirty-seven (11%) of the 12-year-old children were aware of marks on their upper incisors that would not brush off, whereas 281 (83%) were not aware of any such marks on their upper incisor teeth. Twenty-one (6%) of the 12-year-old children did not know whether they had any such marks on their front teeth.

Of the 37 (11%) children who were aware of marks on their upper incisor teeth, only three had marks which could be attributed to fluorosis, with a TF score of 2, 3 and 4, respectively; the others had other enamel opacities that are not classifiable as fluorosis. Therefore only three of the 48 (6.25%) children scored for dental fluorosis were actually aware of marks on their upper incisor teeth.

Intra-examiner reliability

A weighted Kappa value of 1 was obtained. Because only 48 out of 339 children aged 12 years had a TF score of 1 or more, ideally a larger number of re-examinations would have been necessary so as to give greater confidence in the results. However, the authors consider that the design of the survey carries a relatively low risk of bias because a single examiner was involved, and thus inter-examiner reliability is not a factor. Although the distribution of the results of the examination is heavily skewed, the authors are of the opinion that those re-examinations that were conducted should in practice give sufficient confidence to accept the results.

Discussion

This study has focused on the impact of persisting high levels of fluoride in water supply of Gozo in the last decade and particularly on the prevalence of dental fluorosis in 12 year-olds, together with their aesthetic perceptions of dental fluorosis.

Concerns regarding the risk for enamel fluorosis are limited to children aged <6 years with the most

critical period for developing fluorosis on the permanent central incisors estimated to be between 22 to 25 months of age [11]. Because children between 22 and 25 months of age are pre-school children, this eliminates the problem of crossing locality boundaries for school (which is relatively uncommon in Gozo anyway, because children mostly attend schools in their locality until they are 10 years old), which might lead to them consuming water with a different fluoride content than at home.

Taking into consideration the decreased levels of fluoride in water since the introduction of the collection scheme, one would expect the levels of dental fluorosis in the new cohorts to decrease even further. In fact, compared to the 1986 data [7], one can already see a decrease in the levels of dental fluorosis. The fluoride levels in the potable water supplied to Gozitan households between 1975 and 1981 (when the 12-year-old children examined in 1986 were 0-6 years old) are not available. The water supplied at the time was unpolished ground water, which one can assume was very similar to the kind of water available between 1994 and 2000.

Actual numbers of imports of fluoridated oral health products such as fluoride toothpastes and mouthwashes are not available for 1975 to 1981, but they would probably be less than those between 1994 and 2000. This confirms the possibility suggested by Möller that the report published in 1987 might have over-scored fluorosis [7].

When taking into consideration the fluoride levels in the public water supplies from 1994 to 2000, which vary, according to locality, between 0.88 ppm and 2.03 ppm, one would expect quite a high prevalence of dental fluorosis with high scores in localities where fluoride concentrations exceed 1 ppm. The results from this study show that this is not the case.

When comparing to the prevalence of dental fluorosis in other European countries such as 12 year olds in the artificially fluoridated (1 ppm) Republic of Ireland at 28% [12] and non-fluoridated Northern Ireland at 18%, 33% of 8-12 year-olds in naturally fluoridated (1 ppm) Scotland [10] and 44.7% of 12 year olds in natural high fluoride areas in Italy [13], the prevalence of fluorosis in Gozo is low.

Data from the latest National Oral Health Survey of the Maltese Islands carried out in 2004 [8] are favourably comparable to the results obtained in this study but did not give scores of fluorosis to the children examined so that indices could not be compared.

The lack of any real correlation between the fluorosis prevalence and the fluoride levels in potable tap water in each locality indicates that the fluoride concentration in drinking water is not the solitary source from which dental fluorosis may be developing. There could be other fluoride vehicles affecting the children, with sufficient systemic absorption of fluoride to cause fluorosis and there has also been a decrease in use of tap water for drinking purposes [8].

The differences in the fluoride content of the public water supplies are reflected in the caries levels of Malta and Gozo [8]. Overall, the data available show that the caries level in the Maltese Islands is low, with the incidence of dental caries being lower among the Gozitan schoolchildren than in their Maltese counterparts. This could be due to the fluoridated water currently available only in Gozo.

Level 3 on TFI scores is considered equivalent to a Dean's Classification of "mild fluorosis" and is judged to be a level that may cause aesthetic concern to the patient [14]. In this study, children seem to be greatly unaware of any aesthetic changes associated with dental fluorosis and seem to be much more aware of non-fluorotic enamel opacities.

The fact that all 12-year-old schoolchildren in Gozo were studied adds to overall validity.

However, there are a number of limitations. As substantial numbers of 5-year-old children were absent or did not have a signed consent form, there could be a degree of selection bias.

Large confidence intervals *(Figure 2)* in the results were inevitable in this study because such small numbers of positive fluorosis cases were available.

Ideally, clinical examinations should be carried out in a dental clinic using compressed air so that the teeth are dry and all defects are clearly visible. This could not be done in this study for logistic reasons. If this study had been carried out in a dental clinic, there could possibly have been an increased detection of TF Scores 1 and 2 because these are the less aesthetically obvious conditions, but this should not influence detection of scores higher than TF 2, as from TF 3 onwards the fluorotic changes are much more obvious and are spread over many parts of the tooth surfaces. Thus, drying in this case should only influence the prevalence but not the severity of fluorosis. The mean TF score was used for statistical analysis as a proxy description for severity.

Conclusions

The level of dental fluorosis in Gozo is negligible in the deciduous dentition of the 5 year olds. Dental fluorosis is also low in the permanent dentition of 12 year olds and the majority of the fluorosis present is of a mild form. The 12-year-old children are not aware of the aesthetic changes on their central incisors associated with dental fluorosis.

There are unexplained differences in the prevalence of dental fluorosis in permanent dentition when analysed in different Gozitan localities that cannot be explained directly through water fluoride levels.

Recommendations

The following recommendations are made:

- Ideally, the 5-year-old children examined in this study should be followed up to assess for the development of fluorosis at age 12 years (in 2013) to explore the link between fluorosis in the deciduous and permanent dentition of these same children.
- The data from this study may serve for comparisons to be made in the future when studies to assess the effect of the newly introduced polished water on dental fluorosis are carried out.
- These studies should ideally be carried out in 2010, to assess possible changes in fluorosis in deciduous dentition (5 year olds) five years after the introduction of the collection scheme and get an intermediate reading for the 12 year olds, and in 2017 to assess possible changes to fluorosis levels in the permanent dentition due to the collection scheme.
- With respect to the higher dental fluorosis prevalence found in some Gozitan localities, more research needs to be conducted to assess the cause in these areas.

Acknowledgements

Thanks for their invaluable help and guidance are given to Prof. John Mark Portelli from the University of Malta for tutoring with regards to dental fluorosis and Dr. Neville Calleja, the Director for Health Information and Research, for help with the statistical analysis in this study. A special thanks to Dr Julian Mama for editing this paper. The authors also express their gratitude to the Department of Public Health for providing the Report on a Visit to Malta, by Möller, I. J. (1987) W.H.O. Regional Office for Europe.

Contribution of each author

EVZ performed the examinations of the children.

PV supervised the whole study.

Statement of conflict of interests

As far as the authors are aware, there were no conflicts of interest.

References

1. Dean HT, Arnold FA Jr, Elvove E. Domestic water and dental caries, v. additional studies of the relation of fluoride domestic waters to dental caries experience in 4425 white children aged 12-14 years, of 21 cities in 4 states. *Public Health Report* 1942; **57**: 1155-1179.

2. Department of Health and Children of Ireland. *Report of the Forum on Fluoridation*. Dublin: Government of Ireland; 2002.

3. Legal Notice 23 of 2004 under the Food Safety Act (Act No. XIV of 2002). Quality of Water Intended for Human Consumption Regulations. *Government Gazette of Malta* 2004; **17**: 531-520.

4. Legal Notice 116 of 2004 under the Food Safety Act (Act No. XIV of 2002). Quality of Water Intended for Human Consumption (Amendment) Regulations. Government Gazette of Malta No.17: 5493.

5. Water Services Corporation Malta. Description of water supply 2006. Accessed (2011 May 120 at: http://www.wsc.com. mt/

6. European Commission (EC). *The Drinking Water Directive (DWD).* Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. Brussels: EC; 1998: pp. 32–54.

7. Möller IJ. Report on a visit to Malta. EuroMAT/ORH 001 301 7H. Copenhagen: World Health Organization Regional Office for Europe; 1987.

8. Vassallo P, Portelli JM. *2004 National Oral Health Survey for the Maltese Islands*.

9. Thylstrup A, Fejerskov O. Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. *Community Dentistry and Oral Epidemiology* 1978; **6**: 315-328.

10. Stephen KW, Macpherson LMD, Harper GW, Stuart RAM, Merrett MCW. A blind caries and fluorosis prevalence study of schoolchildren in naturally fluoridated and nonfluoridated townships of Morayshire, Scotland. *Community Dentistry and Oral Epidemiology* 2002; **30**: 70-79.

11. Evans RW, Darvell BW. Refining the estimate of the critical period during which human maxillary incisors are most susceptible to fluorosis. *Journal of Public Health Dentistry* 1995; **55**: 438-449.

12. Whelton H, Crowley E, O'Mullane D, Cronin M, Kelleher V. *North–South Survey of Children's Oral Health 2002—Preliminary Results*. Dublin: Department of Health and Children; 2003.

13. Angelillo IF, Torre I, Nobile CG, Villari P. Caries and fluorosis prevalence in communities with different concentrations of fluoride in the water. *Caries Research* 1999; **33**: 114-122.

14. McDonagh MS, Whiting P, Wilson PM, Sutton AJ, Chestnutt I, Cooper J, *et al*. Systematic review of water fluoridation. *British Medical Journal* 2000; **321**: 855-859.