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Dental Fluorosis (DF) and its Relationship with Fluoride Levels in Drinking Water in Three States in Malaysia

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Abstract: Relationship between fluoride levels in drinking water and dental fluorosis is investigated. Total 247 respondents from three areas in Malaysia, namely Kota Kinabalu in Sabah state, Pasir Mas in Kelantan State and Kuala Terengganu in Terengganu State was recruited after fulfilling a few inclusive and exclusive criteria. Water samples were collected for three consecutive days and then analysed for fluoride in a DR/2010 direct reading spectrophotometer using the SPADNS method. Dental Fluorosis (DF) was visually determined by a competent dentist using the Tooth Surface Index of Fluorosis (TSIF). Fluoride levels in all three areas were below or within the national standard (0.5-0.9 mg L^{-1}). Generally, the lowest DF score (0) was measured at all study areas and the highest DF score (4) was measured in Kuala Terengganu, from 3 respondents. Mean DF score for all three study areas was 0.50±0.89. Males have lower mean DF score (0.41±0.88) compared to females (0.59±0.90). The prevalence of DF as a whole was at 31.6% or 78 respondents, who had at least score (1). The range of DF score was from 0-4. Dividing into areas, prevalence was highest in Kuala Terengganu at 47.0%, compared to Pasir Mas (27.1%) and Kota Kinabalu (20.3%). Statistically, there were no relationship between fluoride levels in drinking water and score of fluorosis. The prevalence of DF obtained in this study was lower compared the national study results of 77%. Mean score of DF from all three areas was <1 and from that it is said that dental fluorosis was not a problem in all areas studied.

Key words: Fluoride, dental fluorosis, Malaysia, school children, water

INTRODUCTION

Dental Fluorosis (DF), a hypoplasia or hypomineralization of tooth enamel or dentin produced by the chronic ingestion of excessive amounts of fluoride during the period, when teeth are developing, ranges in intensity from barely noticeable whitish striations to confluent pitting and staining (Horowitz, 1986). Radiographically detectable mineralization of the primary incisors occurs by 24 months of age and prior to 6 years of age for the second molars and premolars. Therefore, DF does not occur, when exposure occurs in children >6-7 years of age (Ishii and Suckling, 1986).

Fluoride has the potential to become toxic. As fluoride is used as a means to control and eradicate dental caries, it is important to know the amount of fluoride to be used and the types of treatment for each exposure. The toxic effect of fluoride can be chronic or acute. Acute toxicity will result in death, when a person ingests doses of 2.5-5.0 g, which is equivalent to 2,500-5,000 L of water containing 1.0 mg L^{-1} of fluoride. For dissolved fluoride such as hydrofluoric acid and sodium fluoride, the acute dosage is 2.0-10.0 g (Horowitz *et al*., 1984). The presence of fluoride under acid conditions encourages the formation of fluorhydroxyapatite and hence, remineralisation of the enamel surface. Fluorhydroxyapatite is less soluble than hydroxyapatite and thus, prevents further demineralisation of tooth enamel. A less important benefit is that fluoride may also help to reduce the metabolic activity of bacteria. These three benefits result from having small amounts of fluoride present in the oral environment through, its topical application (Ellwood, 2006). Water fluoridation was instituted as a public health measure >50 years ago to help limit dental caries. However, with the advent of fluoridated dentifrices, fluoridated infant formulas and commercially prepared beverages with fluoridated water, the incidence of DF is increasing (Simko, 1997). Chemicals

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found as contaminants in drinking water can be grouped conveniently into three classes: inorganic, organic and radionuclides (Neal, 1985). One such example is fluoride and this inorganic compound is purposely added into water supplies as a prophylactic against dental caries. Fluoridated public drinking water system is by far the most effective way to ensure healthy teeth of the community. This is because, water is the main nutrient for humans and fluoride readily dissolves in water. Fluoridated drinking water can be classified as a diet that influences the prevention of tooth-related diseases (Ericsson and Ribellius, 1971).

In the US, there are 59,000 public water systems, where about 50,000 have not reported violation in a recent count (Cutrovo, 1985). From the remaining 9,000 violations, about 1,500-3,000 inorganic standard violations, half of these are fluoride. A study by the Ministry of Health Malaysia (2002) found that drinking water in a few states in the country has higher fluoride content than the recommended national average. This may alleviate the prevalence of DF (Ministry of Health Malaysia, 2002).

The aim of this study was to determine fluoride levels in drinking water and its relationship with DF amongst respondents and also to determine, if there were significant differences in fluoride levels and score of DF between all three study areas.

MATERIALS AND METHODS

Study design and location: This research was funded by University Putra Malaysia (sponsoring information). This cross-sectional study was conducted between November 2003 and 2004 with three areas chosen: Pasir Mas (60, 02, 34'N, 1020, 08, 19'E) in Kelantan State, Kuala Terengganu (50, 18, 43'N, 1030, 07, 08'E) in Terengganu State and Kota Kinabalu (50, 58, 36'N, 160, 06, 57'E) in Sabah State. Both Pasir Mas and Kuala Terengganu are situated in Peninsular Malaysia, while Kota Kinabalu is situated in Sabah State in East Malaysia (Fig. 1).

Recruitment of respondents was performed at three schools in the study area concerned, with the age range of between 12-13 years old. This age group was chosen as they had just finished their final exams and was available for recruitment. They must fulfill a few inclusive and exclusive criteria as well as getting written permission from their parents. The inclusive criteria used were exclusive usage of tap water for drinking and cooking, do not have kidney disease and diabetes, life-long residents of the study area and have complete permanent teeth.

DF was visually determined by a competent dentist using the Tooth Surface Index of Fluorosis (TSIF) improvised by Horowitz *et al*. (1984). This method was used, since there was no need to dry the tooth prior to determination of score of fluorosis. The minimum score is (0), while the maximum score is (7) (Table 1). Levels in drinking water were determined by analyzing water samples taken from homes of respondents.

Three replicates from each sampling site were collected and then analyzed for fluoride using a DR/2010 HACH brand direct reading spectrophotometer. The SPADNS method is used to determine fluoride levels in

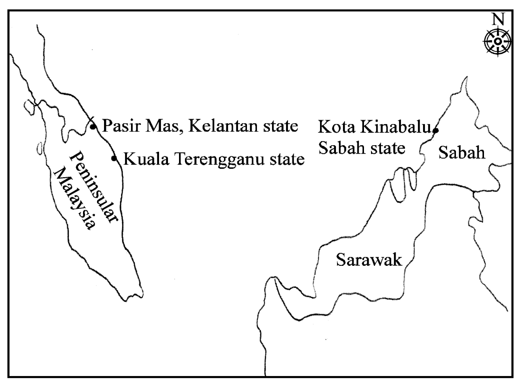

Fig. 1: Map showing the three study areas

Table 1: Tooth Surface Index of Fluorosis (TSIF) (Horowitz *et al*., 1984)

Scores	Description
0	Enamel shows no evidence of fluorosis
1	Enamel shows definite evidence of fluorosis, namely areas with parchment-white color that total less than one-third of the visible enamel surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth (snowcapping)
2	Parchment-white fluorosis totals at least one-third of the visible surface, but less than two-thirds
3	Parchment-white fluorosis totals at least two-thirds of the visible surface
4	Enamel shows staining in conjunction with any of the preceding levels of fluorosis. Staining is defined as an area of definite discoloration that may range from light to very dark brown
5	Discrete pitting of the enamel exists, unaccompanied by evidence of staining of intact enamel. A pit is defined as a definite physical defect in the enamel surface with a rough floor that is surrounded by a wall of intact enamel. The pitted area is usually stained or differs in color from the surrounding enamel.
6	Both discrete pitting and staining of the intact enamel exist
7	Confluent pitting of the enamel surface exists. large areas of enamel may be missing and the anatomy of the tooth may be altered. Dark brown stain is usually present

water samples. It involves the reaction of fluoride with a red zirconium-dye solution. This method is accepted by the United States Environmental Protection Agency (USEPA) for reporting for drinking and wastewater analysis (HACH Company USA, 2003). Calibration and standardization of the equipment was done prior to analysis to minimize errors.

Independent sample t-test is used to determine differences in fluoride levels between study areas, whereas Chi-square analysis is used to determine any relationship between DF score and fluoride levels in drinking water.

RESULTS AND DISCUSSION

There were 247 respondents aged 12 and 13 years old, who fulfilled all inclusive and exclusive criteria. Out of the 247 respondents, 121 (49.0%) were males and 126 (51.0%) were females. There were 168 (68.0%) 12 and 79 (32.0%) 13 years old children, who participated in the study (Table 2).

Mean fluoride level was highest in Pasir Mas (0.44+0.12 mg L^{-1}) compared to the other two study areas, Kota Kinabalu with 0.08+0.06 mg L^{-1} and Kuala Terengganu with 0.34+0.13 mg L^{-1}. As a whole, 214 (86.6%) of water samples had fluoride levels under the lower limit of the national standard (0.5 mg L^{-1}), while the remaining 33 (13.4%) were within the range of the national standard (0.5-0.9 mg L^{-1}). No readings were above the national standard (Table 3).

In a study to determine tap fluoride levels in Estonia, Indermitte *et al.* (2007) reported that fluoride levels in drinking water were found to vary from 0.01-6.95 mg L^{-1}, with mean value of 0.88+0.90 mg L^{-1}. Low fluoride water (up to 0.3 mg L^{-1}) were detected in 25% of water samples but 14% of samples exceeded Estonia's official limit value for fluoride in drinking water (1.5 mg L^{-1}). Ayyaz *et al.* (2002) reported in a study to assess levels of fluoride in domestic water supplies in Pakistan, where 84.0% out of 987 water supplies had fluoride levels <0.7 ppm. This study showed that naturally fluoridate water supply in the study areas has a level of only 0.078 mg L^{-1}. Generally, the lowest DF score (0) was measured at all study areas and the highest DF score (4) was measured in Kuala Terengganu, from 3 respondents. Mean DF score for all three study areas was 0.50+0.89. Males have lower mean DF score (0.41+0.88) compared to females (0.59+0.90). When divided into the three study areas, Kota Kinabalu had the lowest mean DF score with 0.29+0.64 compared to Pasir Mas with 0.38+0.71 and Kuala Terengganu at 0.83+1.15.

In Kota Kinabalu, females had lower mean DF score at 0.20+0.531 compared to males at 0.36+0.72. But in Pasir Mas, mean DF score among males were lower (0.14+0.42) compared to females (0.55+0.82). Same went to Kuala Terengganu, where mean DF score among males was lower (0.71+1.21) compared to females (0.95+1.08), as shown in Table 4.

Szpunar and Burt (1988) conducted a study on dental caries, fluorosis and fluoride exposure in Michigan schoolchildren in four communities (Cadillac -0.0 ppm; Hudson -0.8 ppm; Redford -1.0 ppm; Richmond -1.2 ppm) and they reported that the mild nature of the fluorosis in the children is underscored by the fact that there was no tooth surface assigned a TSIF score >2. All fluorosed surfaces in Cadillac children were given a TSIF score of 1, compared with 98.4% in Hudson, 97.3% in Redford and 96.2% in Richmond.

The DF range in this study was from 0-4. This shows higher severity compared to the study in Michigan. prevalence of DF in all areas was at 31.6% or 78 respondents, who had at least score (1). Dividing into areas, prevalence was highest in Kuala Terengganu at 47.0% or 39 respondents, compared to Pasir Mas with 27.1% or 23 respondents and Kota Kinabalu with only 20.3% or 16 respondents (Table 5).

In a study to determine the prevalence of dental caries and fluorosis in 1,060, 10-12 years old Japanese children, who received drinking water containing trace amounts to 1.4 ppm of fluoride. Tsutsui *et al.* (2000) found that prevalence of fluorosis ranged from 1.7-15.4% and the increase in fluorosis with increasing fluoride exposure was limited entirely to the milder forms.

The prevalence in the three study areas in Malaysia was much higher compared to the study in Japan. A report by Rahimah and Latifah (1998) stated that DF prevalence among 12-16 years old children was at 62-88%.

Table 2: Age and gender of respondents

Areas	No. of respondents	Age/years	Percentage	Gender	No. of respondents	Percentage
Kota Kinabalu	79	13	32.0	Male	44	55.7
				Female	35	44.3
Pasir Mas	85	12	34.4	Male	36	42.4
				Female	49	57.6
Kuala Terengganu	83	12	33.6	Male	41	49.4
				Female	42	50.6
Total	247		100.0	Total	247	

Table 3: Mean and range level of fluoride

Areas	Mean fluoride level (mg L^{-1})	Range of fluoride level (mg L^{-1})	Percentage of samples compared to national standard <0.5 mg L^{-1}	0.5-0.9 mg L^{-1}	>0.9 mg L^{-1}
Kota Kinabalu	0.08±0.06	0.00-0.36	100.0	0.0	0.0
Pasir Mas	0.44±0.12	0.24-0.85	71.8	28.2	0.0
Kuala Terengganu	0.34±0.13	0.07-0.62	89.2	10.8	0.0
All three areas	0.29±0.18	0.00-0.85	86.6	13.4	0.0

Table 4: Score of DF between study areas and gender

Areas	Gender	Score of fluorosis 0	1	2	3	4	Mean±DF
Kota Kinabalu	Male	33	7	3	1	0	0.36±0.72
	Female	30	3	2	0	0	0.20±0.53
	Total	63	10	5	1	0	0.29±0.64[a]
Pasir Mas	Male	32	3	1	0	0	0.14±0.42
	Female	30	13	4	2	0	0.55±0.82
	Total	62	16	5	2	0	0.38±0.71[a]
Kuala Terengganu	Male	27	7	1	4	2	0.71±1.21
	Female	17	17	2	5	1	0.95±1.08
	Total	44	24	3	9	3	0.83±1.15[a]
All three areas (N = 147)		169 (68.4%)	50	13	12	3	0.50±0.89
	Male						0.41±0.88
	Female						0.59±0.90

[a]Mean for both males and females in the respective study areas

Table 5: Prevalence of DF based on single and all areas

Areas	Prevalence of DF (No. of respondents) Males	Females	Prevalence in each area (males + females)	Prevalence in all areas (No. of respondents)
Kota Kinabalu (N = 79)	25.0 (11)	14.3 (5)	20.3 (16)	31.6 (78)
Pasir Mas (N = 85)	11.2 (4)	38.8 (19)	27.1 (23)	
Kuala Terengganu (N = 83)	34.1 (14)	59.5 (25)	47.0 (39)	

Another study on the prevalence of DF in the Federal Territory of Kuala Lumpur on 957 respondents aged 11-12 years old found that the prevalence was at 77% (Noriah, 1997).

Taking all sites into account, there are significant differences in fluoride levels between all three areas ($p<0.05$).

Also, there is a significant difference in DF score between males and females ($z = -2.312$, $p<0.05$). When divided into areas, only Pasir Mas has a significant difference in DF score between males and females ($z = -2.830$, $p<0.05$) compared to the other two study areas. There was no significant relationship between fluoride levels with DF score.

CONCLUSION

Mean fluoride level from all study areas was found to be below or within the national standard of 0.5-0.9 mg L^{-1}. The prevalence of DF obtained in this study was lower compared the state study results of 77%. Mean score of DF from all three areas was <1 and from that it can be said that DF was not a problem in the areas studied.

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REFERENCES

Ayyaz, A.K., H. Whelton and D.O. Mullane, 2002. A map of natural fluoride in drinking water in Pakistan. Int. Dental J., 52 (4): 291-297. PMID: 12212818. http://journals.indexcopernicus.com/abstracted.php?level=5&icid=830770.

Cutrovo, J.A., 1985. Regulations of Contaminants in Drinking Water. 1st Edn. In: Rice, R.G. (Ed.). Safe Drinking Water. The impact of chemicals on a limited resource. Chelsea Michigan: Lewis, pp: 183-195. ISBN: 0-9614032-0-9.

Ellwood, R.P., 2006. Fluorosis revisited. British Dental Health Foundation: Word of Mouth-Dental Health and Practice. http://bdhf.atalink.co.uk/articles/71.

Ericsson, Y. and U. Ribellius, 1971. Wide variations of fluoride supply to infants and young children. Pediatric Dentist, 1: 44-54.

HACH Company USA, 2003. SPADNS method for deter mining fluoride in water, wastewater and seawater: Method 8029. http://www-nmcphc.med.navy.mil/downloads/epm/fdpmu_standard_operation_procedures/complete_dr5000_sop_may2009.pdf.

Horowitz, H.S., W.S. Driscoll, R.J. Meyers, S.B. Heifetz and A. Kingmann, 1984. A new method for assessing the prevalence of dental fluorosis-the tooth surface index of fluorosis. J. Am. Dental Assoc., 109: 37-43. PMID: 6611361. DOI: 10.1159/000217856. http://jada.ada.org/cgi/content/abstract/109/1/37?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=1&author1=Horowitz&andorexacttitle=and&andorexacttitleabs=and&andorexactfulltext=and&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT.

Horowitz, H.S., 1986. Indexes for measuring dental fluorosis. J. Public Health Dental, 46 (4): 179-183. PMID: 3465956. http://archive.lib.cmu.ac.th/full/T/2543/mph0943no_bib.pdf.

Indermitte, E., E. Karro and A. Saava, 2007. Tap water fluoride levels in Estonia. Fluoride J., 40 (4): 244-247. http://www.fluorideresearch.org/404/files/FJ2007_v40_n4_p244-247.pdf.

Ishii, T. and G. Suckling, 1986. The appearance of tooth enamel in children ingesting water with a high fluoride content for a limited period during early tooth development. J. Dental Res., 65: 974-977. DOI: 10.1177/00220345860650071501. PMID: 3458759. http://jdr.sagepub.com/cgi/content/refs/65/7/974.

Ministry of Health Malaysia, 2002. Annual Report, Engineering Division. http://vlib.moh.gov.my/cms/documentstorage/com.tms.cms.document.Document_752b015d-c0a81049-1a82e920-420527fd/Annual%20Report%202007.pdf.

Neal, R.A., 1985. Chemicals and Safe Drinking Water: National and International Perspective. 1st Edn. In: Rice, R.G. (Ed.). Safe Drinking Water. The impact of chemicals on a limited resource. Chelsea, Michigan, Lewis, pp: 1-8, 183-195. ISBN: 0-9614032-0-9.

Noriah, Y., 1997. A survey on the enamel abnormality on permanent teeth among 11-12 years old school children in Federal Territory of Kuala Lumpur. Dental Department Federal Territory of Kuala Lumpur, Ministry of Health Malaysia.

Rahimah, A.K. and A.L. Latifah, 1998. Fluoride level in dentrifices. Ann. Dentist. Univ. Malaya, 5: 2-5. http://majlis.fsktm.um.edu.my/document.aspx?FileName=468.pdf.

Simko, L.C., 1997. Water fluoridation: Time to reexamine the issue. Pediatric Nurse, 23 (2): 155-159. PMID: 9165930. http://grande.nal.usda.gov/ibids/index.php?mode 2=detail&origin=ibids_references&therow=106117.

Szpunar, S.M. and B.A. Burt, 1988. Dental caries, fluorosis and fluoride exposure in Michigan schoolchildren. J. Dental Res., 67: 802. DOI: 10.1177/00220345880670050101. PMID: 2295998. http://jdr.sagepub.com/cgi/content/refs/67/5/802.

Tsutsui, A., M. Yagi and A.M. Horowitz, 2000. The prevalence of dental caries and fluorosis in Japanese communities with up to 1.4 ppm of naturally occurring fluoride. J. Public Health Dental, 60 (3): 147-153. PMID: 11109211. http://www.egohid.eu/Documents/Health_Surveillance_in_Europe_2008.pdf.