



**The Relationship Between Fluoride Concentration
in Drinking Water with Dental Caries and Fluorosis
in Vietnamese Children**

**By
Thuy Thanh Nguyen**

**Submitted for the degree of
Master of Science in Dentistry
Adelaide University
Australia**

Supervised by Professor A John Spencer

**Dental School
Adelaide University
June, 2001**

SIGNED STATEMENT

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference has been made in the text of the thesis.

I give consent to this copy of my thesis, being available for photocopying and loan, if applicable, if accepted for the award of the degree.

Thuy Thanh Nguyen

June 20, 2001

ACKNOWLEDGMENT

I would like to express my sincere gratitude and appreciation to Professor A. John Spencer for his guidance and thorough supervision of my research. His valuable advice, encouragement and support have been appreciated.

I acknowledge gratefully Dr. Kaye Roberts-Thomson for her precious guidance and kind help throughout my study, which were essential to the successful completion of my research.

The advice and expertise of Dr. Perter Arrow was a valuable contribution to the successful completion of my thesis.

I also wish acknowledge to the leaders of Vietnamese Health Ministry, Professor Tran Van Truong, Dr. Trinh Dinh Hai, the leaders of the Institute of Odonto-Stomatology of Ho Chi Minh city and Dr. Ngo Dong Khanh for their organisation and assistance with the fieldwork in Vietnam.

The support and kind help of Dr. John McIntyre, Mrs Judy Stewart, Mr Knute Carter, Mr Fearnley Szuster, Dr. Anna Puzio, Mr Jason Armfield, Ms Liana Luzzi and all friendly staff of the AIHW Dental Statistics and Research Unit of Adelaide University is also acknowledged.

I also wish to thank the dentists in the dental examination teams, the local dentists, the administrators of surveyed schools and the surveyed school children and their parents for

their participation in the survey. Their contribution was crucial in the successful completion of my thesis.

I acknowledge gratefully the Australian Agency for International Development (AusAID) for providing my study scholarship, which assisted me in conducting this research.

Finally, I would like to express my love and respect to my family for all their love, support and encouragement throughout my study.

For my parents, my husband and my children

TABLE OF CONTENT

TABLE OF CONTENT	i
ABSTRACT	ix
LIST OF TABLES	xii
LIST OF FIGURES	xv
LIST OF APPENDICES	xvii
CHAPTER 1. THE RELATIONSHIP OF FLUORIDE IN WATER WITH DENTAL CARIES AND FLUOROSIS	1
1.1 Introduction	1
1.2 Epidemiology of dental caries and dental fluorosis in developing countries	3
1.3 The relationship between fluoride concentration in drinking water and both dental caries and dental fluorosis	5
1.3.1 Origins of fluoride in water.....	5
1.3.2 The relationship of fluoride concentration in drinking water with dental caries	8
1.3.3 The relationship of fluoride concentration in drinking water with dental fluorosis.....	13
1.3.4 The optimum fluoride concentration in drinking water	17
1.4 The relationship of socio-economic and demographic factors, diet habits, dental behaviours and discretionary fluoride with dental caries and dental fluorosis.....	21
1.4.1 Socio-economic and demographic factors	21
1.4.2 Dietary habits	24
1.4.3 Dental behaviours	27
1.4.4 Discretionary fluoride	29
1.5 Rational use of fluoridation in caries control	32

1.5.1	Population versus clinical intervention as risk strategies	32
1.5.2	Fluoridation.....	34
1.5.2.1	Water fluoridation	34
1.5.2.2	Salt fluoridation.....	39
1.6	Rationale and objectives for the present study.....	40
1.6.1.	Rationale for the present study	40
1.6.2	The objectives of the present study.....	41
CHAPTER 2. RESEARCH METHODOLOGY		43
2.1	Study design.....	43
2.2	Sampling strategy.....	43
2.2.1.	Sampling approach.....	43
2.2.2.	Selecting schools	47
2.2.3.	Selecting subjects	48
2.3	Data collection	50
2.3.1	Fieldwork processes.....	50
2.3.2	Ethical considerations	51
2.3.3	Social survey.....	52
2.3.4	Dental examination	53
2.3.4.1	Clinical assessments	54
2.3.4.2	Reliability of survey	58
2.3.5	Collecting and analysing water samples	60
2.4	Data preparation.....	61
2.4.1	Data preparation for questionnaires.....	61
2.4.2	Data preparation for clinical assessments.....	63

2.4.3	Estimation of the fluoride exposure from water samples for the individual	63
2.5	Key variables.....	64
2.5.1	Dependent variables.....	64
2.5.1.1	Dental caries	64
2.5.1.2	Dental fluorosis	65
2.5.2	Independent variables	66
2.5.2.1	Fluoride concentration in drinking water	66
2.5.2.2	Data from the completed questionnaire.....	67
2.6	Data analysis	70
CHAPTER 3. RESULTS		72
3.1	RESPONSE RATE	72
3.2	RELIABILITY Of survey data	73
3.3	SOCIAL CHARACTERISTICS OF SURVEY CHILDREN	74
3.4	DEPENDENT VARIABLES.....	77
3.4.1.	Coronal caries experiences	77
3.4.1.1	Primary dentition.....	78
3.4.1.1a.	The distribution of caries experiences in primary teeth by age group	78
3.4.1.1b.	The distribution of caries experience in primary teeth at cluster level by age group	79
3.4.1.2	Permanent dentition.....	81
3.4.1.2a	The distribution of caries experience in permanent teeth by age group.....	81
3.4.1.2b:	The distribution of caries experience in permanent teeth at cluster level by age group	83
3.4.2	Dental fluorosis.....	86

3.4.2.1	The distribution of fluorosis and Community Fluorosis Index (CFI) by age group	86
3.4.2.2	The distribution of fluorosis and Community Fluorosis Index (CFI) at cluster level by age group	87
3.5	INDEPENDENT VARIABLES	89
3.5.1	The distribution of drinking water sources	89
3.5.2	The usage of discretionary fluoride	99
3.5.2.1	The use of toothpaste	99
3.5.2.2	The use of mouthrinses	100
3.5.2.3	The use of fluoride tablets	101
3.5.3	Dental behaviours	101
3.5.4	Dietary habits	105
3.6	ASSOCIATION BETWEEN FLUORIDE AND CARIES AND fluorosis	108
3.6.1	The age group 6 - 8 years	109
3.6.1.1	The relationship between fluoride concentration and dental caries	109
3.6.1.2	The relationship between fluoride concentration and dental fluorosis	112
3.6.1.3	The relationship between dental caries and fluorosis	114
3.6.2	The age group 9-11 years	115
3.6.2.1	The relationship between fluoride concentration and dental caries	115
3.6.2.2	The relationship between fluoride concentration and dental fluorosis	118
3.6.2.3	The relationship between dental caries and dental fluorosis	119
3.6.3	The age group 12-14 years	121

3.6.3.1	The relationship between fluoride concentration and dental caries.....	121
3.6.3.2	The relationship between fluoride concentration and fluorosis.....	123
3.6.3.3	The relationship between dental caries and fluorosis.....	124
3.6.4	The age group 15-17+ years	125
3.6.4.1	The relationship between dental caries and fluoride concentration	125
3.6.4.2	The relationship between dental fluorosis and fluoride concentration	127
3.6.4.3	The relationship between dental caries and fluorosis.....	129
3.7	CONFOUNDING ASSOCIATIONS	129
3.7.1	The influence of socio-economic and demographic factors on dental caries and fluorosis	130
3.7.1.1	Socio-economic and demographic factors with dental caries	130
3.7.1.1.a	The influence of socio-economic and demographic factors on caries experience of the primary dentition..	130
3.7.1.1.b	The influence of socio-economic and demographic factors on caries experience of the permanent dentition.....	132
3.7.1.2	Socio-economic and demographic factors with dental fluorosis.....	134
3.7.2	The influence of dietary habits on dental caries and fluorosis.....	136
3.7.2.1	Dietary habits with dental caries	136
3.7.2.1a	The influence of dietary habits on caries experience of the primary dentition	136
3.7.2.1.b	The influence of dietary habits on caries experience of the permanent dentition	138
3.7.2.2	Dietary habits with dental fluorosis.....	139

3.7.3.	The influence of dental behaviours on dental caries and fluorosis...	141
3.7.3.1	Dental behaviours with dental caries.....	141
3.7.3.1 a	The influence of dental behaviours on the primary dentition	141
3.7.3.1 b	The influence of dental behaviours on the permanent dentition	142
3.7.3.1	Dental behaviours with dental fluorosis	143
3.7.4	The influence of discretionary fluoride on dental caries and fluorosis	144
3.7.4.1	Discretionary fluoride with dental caries.	144
3.7.4.1.a	The influence of discretionary fluoride on the primary dentition.....	144
3.7.4.1.b	The influence of discretionary fluoride on the permanent dentition	145
3.7.4.2	Discretionary fluoride with dental fluorosis.....	146
3.7.5	Summary	147
3.8	Multivariate models for controlling the relationship between fluoride concentration in drinking water and dental caries and fluorosis.....	149
3.8.1	Multivariate models for caries experience	150
3.8.2	Multivariate model for dental fluorosis	152
CHAPTER 4.	DISCUSSION	154
4.1	Overview of the study	154
4.2	The strengths and the limitations of the study	155
4.2.1	The strengths of the study	155
4.2.1.1	Design.....	155
4.2.1.2	Response rate of the study.....	155
4.2.1.3	Social survey	155

4.2.1.4	Dental examinations	156
4.2.1.5	Drinking water samples	156
4.2.2	The limitations of the study	157
4.2.2.1	Study design	157
4.2.2.2	The reliability and validity of questionnaire response	158
4.2.2.3	The attribution of fluoride exposure.....	158
4.2.2.4	The selecting sampled areas	159
4.3	The distribution and prevalence of dental caries and dental fluorosis in Vietnamese children.....	159
4.3.1	The distribution and prevalence of dental caries in Vietnamese children	159
4.3.1.1	Primary dentition.....	159
4.3.1.2	Permanent dentition.....	160
4.3.2	The distribution and prevalence of dental fluorosis in Vietnamese children	161
4.3.3	The comparison with First National Oral Health Survey of Vietnam	161
4.4	The fluoride concentration of drinking water sources in VIETNAM.....	162
4.5	The influence of socio-economic and demographic indicators, dietary habits, dental behaviours and discretionary fluoride on dental caries and fluorosis.....	163
4.5.1	Association with caries	164
4.5.1.1	Socio-economic and demographic indicators.....	164
4.5.1.2	Dietary habits	164
4.5.1.3	Dental behaviours.....	165
4.5.1.4	Discretionary fluorides	166
4.5.2	Association with fluorosis.....	166

4.5.2.1	Socio-economic and demographic indicators.....	166
4.5.2.2	Dietary habits	167
4.5.2.3	Dental behaviours.....	167
4.5.2.4	Discretionary fluoride.....	168
4.6	The relationship between fluoride concentration in drinking water and dental caries and dental fluorosis in Vietnamese children.....	168
4.6.1	Fluoride concentration in the drinking water and dental caries.....	168
4.6.2	Fluoride concentration in drinking water and dental fluorosis	171
4.6.3	The relationship between fluoride concentration in drinking water, caries and fluorosis	172
4.7	Possible implications for dental health policy	173
CHAPTER 5. CONCLUSION		177

ABSTRACT

According to the First National Oral Health Survey in Vietnam conducted 1989, the prevalence of dental caries in Vietnamese children was high. To prevent dental caries and dental fluorosis, it is essential to investigate factors relating to both dental caries and dental fluorosis. The relationship between fluoride concentration in drinking water with dental caries and fluorosis was first investigated thoroughly in the 1930s and has been continuously explored until now in many countries of the world. Unfortunately, the relationship between fluoride concentration in drinking water with dental caries and fluorosis in Vietnam has never been explored.

The present study was designed to obtain information on dental caries and fluorosis among a representative sample of Vietnamese children. The study also collected information on factors likely to influence caries experience and dental fluorosis and undertook statistical analyses to examine the relationship between fluoride in drinking water, dental caries and dental fluorosis.

The study used a cross-sectional study design with a multistage stratified random sample of Vietnamese children. The study was a part of the Second National Oral Health Survey of Vietnam conducted in 1999. Subjects were selected randomly from school children aged from 6 to 17 years residing throughout Vietnam. At each stage the probability of selection was proportional to population size. A total of 2672 children participated, stratified into four age groups (6 to 8 year-olds; 9 to 11 year-olds; 12 to 14 year-olds and 15 to 17+ year-olds).

Quantitative data collected consisted of a dental examination, a self-reported questionnaire completed by the child's parent and an estimation of fluoride concentration in drinking water samples collected from the child's usual source of drinking at a convenient location near to surveyed schools. In the dental examination, coronal caries criteria of the US National Institute of Dental Research (NIDR) were used to assess dental caries experience on the primary and permanent teeth and dental fluorosis was examined on upper central and labial incisors using Dean's Index. The questionnaire completed by the child's parent sought information about the drinking water source used daily, socio-economic and demographic status, dietary habits, dental care behaviours and discretionary fluoride intake. Fluoride exposure of children was measured by fluoride concentration in the drinking water samples.

Initial findings are presented using descriptive statistics. Bivariate and multivariate analysis were used to examine the influence of social economic and demographic factors, dietary habits, dental behaviours and discretionary fluoride on dental caries and fluorosis at the child level for each of the four age groups. The relationship between fluoride concentration in the drinking water and dental caries and fluorosis was examined using linear regression at cluster levels for each of the four age groups. Fluoride concentration was transformed to a logarithmic scale due to its curvilinear relationship with dental caries.

The analysis found that the prevalence of dental caries remains at high level and may be on the increase. Untreated decay was a main component of caries experience. This indicated insufficient dental treatment capacity in Vietnam. The prevalence of dental fluorosis was low. However, some areas had high numbers of children with fluorosis and a few children had severe forms of fluorosis. The study found that fluoride concentration in the drinking water had an inverse relationship with the mean dmfs and DMFS in all age groups except

the 15–17+ years age group. The results also showed fluoride concentration in the drinking water had a positive relationship with the mean CFI (Community Fluorosis Index) in all age groups.

Analysis also revealed that mother's education level, sugar consumption and dental visit patterns were risk factors for dental caries experience, and residential location of children and parental occupations were risk factors for dental fluorosis.

In conclusion, the naturally-occurring fluoride in daily drinking water was associated with dental caries and dental fluorosis in Vietnamese children. However, socio economic and demographic factors, sugar consumption and dental behaviours also play an important role in the prevalence of dental caries and fluorosis, which in turn influence the relationship between fluoride concentration in drinking water with dental caries and fluorosis of Vietnamese children. This study provides fundamental information to assist government consideration of the implementation of water or salt fluoridation as a population preventive strategy for Vietnam.

LIST OF TABLES

Table 1.1:	The fluoride levels recommended for cool and warm climates	20
Table 2.1:	The selected provinces and districts.....	44
Table 2.2:	The codes were used to assess dental fluorosis.....	55
Table 2.3:	The codes used to assess dental caries	56
Table 2.4:	The codes used to assess gingival status	58
Table 2.5:	The codes used to assess calculus status	58
Table 2.6:	Reliability statistics	59
Table 2.7:	Public health significance of CFI Scores	66
Table 3.1:	The response rate for 14 surveyed provinces	72
Table 3.2:	Reliability of examinations	73
Table 3.3:	Participation by age group.....	74
Table 3.4:	The distribution of surveyed children and population by sex	74
Table 3.5:	The distribution of surveyed children by residence	75
Table 3.6:	Household crowding status of surveyed children.....	75
Table 3.7:	The distribution of children by family income.....	76
Table 3.8:	Parental education level.....	76
Table 3.9:	Parental occupation	77
Table 3.10:	The component of dmfs by age group.....	78
Table 3.11:	The component of DMFS by age group.....	82
Table 3.12:	The distribution of fluorosis and CFI by age group	86
Table 3.13:	The water sources used daily for drinking (n = 2762).	90
Table 3.14:	The quantity of water sources used daily for drinking (n = 2672)	90
Table 3.15:	The distribution and fluoride concentration of water sources in each cluster for children in Primary and Secondary school	93
Table 3.15:	(cont.)	94
Table 3.15:	(cont.)	95
Table 3.16:	The distribution and fluoride concentration of water sources in each cluster for children in High school.....	97
Table 3.16:	(cont.)	98
Table 3.17:	The percentage of using toothpaste.....	99
Table 3.18:	The kind of toothpaste used.....	99

Table 3.19:	Age commenced brushing teeth with toothpaste.....	100
Table 3.20:	Amount of toothpaste used.....	100
Table 3.21:	The percentage of use of mouthrinse	100
Table 3.22:	The kind of mouthrinse used	101
Table 3.23:	The frequency of using fluoride tablet.....	101
Table 3.24:	The percentage of brushing teeth	102
Table 3.25:	The frequency of brushing teeth.....	102
Table 3.26:	Age commenced brushing teeth	102
Table 3.27:	The time since dental visits	103
Table 3.28:	Receipt of dental treatment in the last two years.....	103
Table 3.29:	The reason for dental visit in the last two years	104
Table 3.30:	Treatment received by the children at their last dental visit (in the last two years)	104
Table 3.31:	The frequency of using fish sauce or cooking salt for cooking.....	105
Table 3.32:	The percentage and frequency of sweets used	106
Table 3.33:	The percentage and frequency of drinks used	107
Table 3.34:	The percentage of children adding sugar in drinks	107
Table 3.35:	The percentage of children's families using sugar for cooking	108
Table 3.36:	The frequency of eating fruit.....	108
Table 3.37:	Caries experience, dental fluorosis and fluoride level in drinking water by age group	109
Table 3.38:	Mean dmfs and DMFS by fluoride level in drinking water in 56 clusters of children aged 6-8 years old.	110
Figure 3.10:	The relationship between fluoride concentration in drinking water and permanent caries experience in 56 clusters of children in the age group 6-8 years.	112
Table 3.39:	Mean CFI by fluoride level in drinking water in 56 clusters of children aged 6-8 years.....	113
Table 3.40:	Mean dmfs and DMFS by fluoride level in drinking water in 56 clusters of children aged 9-11 years.....	116
Table 3.41:	Mean CFI by fluoride level in drinking water in 56 clusters of children aged 9-11 years old.....	118
Table 3.42:	Mean DMFS by fluoride level in drinking water in 56 clusters of children aged 12-14 years old.....	122

Table 3.43:	Mean CFI by fluoride level in drinking water in 56 clusters of children aged 12–14 years	123
Table 3.44:	Mean DMFS by fluoride level in drinking water in 32 clusters of children aged 15–17+ years.....	126
Table 3.45:	Mean CFI by fluoride level in drinking water in 32 clusters of children aged 15–17+ years.....	127
Table 3.46:	Mean dmfs in each level of socio-economic and demographic status by age group	131
Table 3.47:	Mean DMFS in each level of socio-economic and demographic status by age group	133
Table 3.48:	Mean CFI in each level of socio-economic and demographic status by age group	134
Table 3.49:	Mean dmfs in each level of dietary habit by age group	136
Table 3.50:	Mean DMFS in each level of dietary habit by age group	138
Table 3.51:	Mean CFI in each level of dietary habits by age group.....	139
Table 3.52:	Mean dmfs in each level of dental behaviour by age group.....	141
Table 3.53:	Mean DMFS in each level of dental behaviour by age group.....	142
Table 3.54:	Mean CFI in each level of dental behaviour by age group	143
Table 3.55:	Mean dmfs in each level of discretionary fluoride by age group.....	144
Table 3.56:	Mean DMFS in each level of discretionary fluoride by age group.....	145
Table 3.57:	Mean CFI in each level of discretionary fluoride exposure by age group .	146
Table 3.58:	Summary of the association of socio-economic and demographic status, dietary habits, dental behaviours and discretionary fluoride with dental caries and fluorosis by age group.....	148
Table 3.59:	Multivariable models for caries experience in primary teeth (dmfs)	150
Table 3.60:	Multi-variables models for caries experience in permanent teeth (DMFS)	152
Table 3.61:	Multivariables models for Community Fluorosis Index (CFI)	153

LIST OF FIGURES

Figure 3.1:	The distribution of dmfs by age group	79
Figure 3.2:	The distribution of the mean dmfs at cluster level by age group	80
Figure 3.3:	The distribution of the prevalence of primary caries experience at cluster level by age group	81
Figure 3.4:	The distribution of DMFS by age groups.....	83
Figure 3.5:	The distribution of the mean DMFS at cluster level by age group.	84
Figure 3.6:	The distribution of the prevalence of permanent caries at cluster level by age group.	85
Figure 3.7:	The distribution of the fluorosis prevalence at cluster level by age group...	88
Figure 3.8:	The distribution of the mean CFI at cluster level by age group	89
Figure 3.9:	The relationship between fluoride concentration in drinking water and primary caries experience in 56 clusters of children in the age group 6-8 years.....	111
Figure 3.11:	The relationship between fluoride concentration in drinking water and dental fluorosis in 56 clusters of children in the age group 6-8 years.....	113
Figure 3.12:	The intersection of the mean dmfs and the mean CFI regression lines in the age group 6-8 years	114
Figure 3.13:	The intersection of the mean DMFS and the mean CFI regression lines in the age group 6-8 years.....	115
Figure 3.14	The relationship between fluoride concentration in drinking water and primary caries experience in 56 clusters of children in the age group 9-11 years.....	116
Figure 3.15:	The relationship between fluoride concentration in drinking water and permanent caries experience in 56 clusters of children in the age group 9-11 years.....	117
Figure 3.16:	The relationship between fluoride concentration in drinking water and dental fluorosis in 56 clusters of children in the age group 9-11 years	119
Figure 3.17:	The intersection of mean dmfs and mean CFI regression lines in the age group 9-11 years	120
Figure 3.18:	The intersection of mean DMFS and mean CFI regression lines in the age groups 9-11 years.	121
Figure 3.19:	The relationship between fluoride concentration in the drinking water and dental caries in 56 clusters of children in the age group 12-14 years.	122
Figure 3.20:	The relationship between fluoride concentration in drinking water and dental fluorosis in 56 clusters of children age group 12-14 years	124

Figure 3.21:	The intersection of mean DMFS and mean CFI regression lines in the age group 12–14 years.....	125
Figure 3.22:	The relationship between fluoride concentration in the drinking water and dental caries in 32 clusters of children in the age group 15–17+ years.....	126
Figure 3.23:	The relationship between fluoride concentration in the drinking water and dental fluorosis in 32 clusters of children in the age group 15–17+ years.....	128
Figure 3.24:	The intersection of mean DMFS and mean CFI regression lines in the age group 15–17+ years	129

LIST OF APPENDICES

APPENDIX A:	Questionnaire Form.....	179
APPENDIX B:	Examination Form.....	189
APPENDIX C:	Diagnostic Criteria For Dental Examinations	191
APPENDIX D:	Fluoride Concentration in Drinking Water Samples of Survey Provinces	200
APPENDIX E:	Response Rate by Age Groups and by Clusters	219
APPENDIX F:	The Mean and Percentage of dmfs, DMFS, Fluorosis and Fluoride Concentration in Drinking Water by Age Group	223