ADELAIDE UNIVERSITY
AUSTRALIA

SUB CRUCE LUMEN

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 facrors, 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 group12–14 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

CHAPTER 1

THE RELATIONSHIP OF FLUORIDE IN WATER WITH DENTAL CARIES AND FLUOROSIS

1.1 INTRODUCTION

Dentistry is undergoing a rapid change in Vietnam. There are indications that the burden of dental disease is increasing, especially dental caries among children and children, make up one-third of the total population. According to data from the First National Oral Health Survey in Vietnam in 1989, the prevalence of dental caries in Vietnam was a high 57 per cent among 12-year-olds and 60 per cent among 15-year-olds. In 1989 the prevalence of dental caries varied across geographic areas; it was lowest in the coastal and delta areas, and highest in the major cities and mountainous areas (Tran 1991). Dental caries is a problem for the dental public health programme in Vietnam due to the fact that dental caries constitutes a sizeable burden of disease. To meet current treatment needs would require a large health budget to cover working time, labour and materials. Anecdotally, dental fluorosis is perceived as a problem in some areas, with people seeking assistance with aesthetic problems related to fluorosis. Vietnam is a developing country and is densely populated. Resources available to manage dental problems are limited. Developing a strategic approach to preventing dental caries and dental fluorosis in Vietnamese children is a high priority for the government and the population as a whole.

Dental caries: Dental caries results from a complex interaction between three principal factors: bacteria, substrate or diet, and host susceptibility. Bacteria and plaque must be present on the tooth surface. These plaque bacteria produce acid by fermenting ingested carbohydrates, especially refined sugars. This acid causes localized demineralization of enamel surface and if the process is not checked it will result in progressive destruction of the tooth (Newbrun 1989).

Dental caries is a widespread disease that eventually leads to pain and tooth loss if untreated. However, dental caries can be prevented. Theoretically, the caries process can be interrupted or terminated in one of four ways: reduction in the numbers of cariogenic bacteria or disruption of their ability to metabolize fermentable carbohydrates; dietary control of carbohydrate intake; reduction in the time of substrate in the mouth; and enhancement of the ability of tooth structure to withstand acid dissolution (Newbrun 1989; Nikiforuk 1985; Winter 1988; Beck, Kohout & Hunt 1988). One of these dental caries preventive methods, the enhancement of the ability of the tooth structure to withstand acid dissolution, is best achieved by the use of fluorides (Nikiforuk 1985; WHO 1984a; Leverett, 1982).

Dental fluorosis: Dental fluorosis is defined as a permanent hypomineralization of enamel, characterized by greater surface and subsurface porosity than in normal enamel. This results from excessive fluoride ingestion during the period of tooth development, essentially the first seven years of life (Fejerskov, Manji and Baelum 1990; Burt and Eklund 1992). Again dental fluorosis can be prevented through avoidance of excessive fluoride ingestion during first seven years of life. The most common source of excessive fluorides is probably natural water in many countries where ground water is the most common source of drinking water. Other sources may include tea and staple food such as fish, food, industrialised products and fluoride supplements (Burt and Eklund 1992; Newbrun 1986)

To create an effective preventive strategy for the whole population, it is essential to seek factors directly affecting dental caries and fluorosis. The prevalence of dental caries and dental fluorosis is strongly affected by factors such as fluoride in drinking water, dietary habits, dental hygiene and socio-economic status. Of these, the concentration of fluoride in drinking water could be considered as one of the most important factors influencing the prevalence of both dental caries and dental fluorosis. Therefore, knowledge of the relationship between fluoride concentrations in drinking water and dental caries and fluorosis is fundamental; this information will enable us to more effectively manage dental caries without dental fluorosis resulting.

The purpose of the present study was to investigate the relationship between fluoride concentration in daily drinking water and dental caries and dental fluorosis prevalence in Vietnamese children. Such knowledge will inform the establishment of appropriate preventive strategies to reduce dental caries prevalence and minimise dental fluorosis.

1.2 EPIDEMIOLOGY OF DENTAL CARIES AND DENTAL FLUOROSIS IN DEVELOPING COUNTRIES

Epidemiological surveys of populations assessing the prevalence of dental caries are extremely useful tools in determining oral disease patterns for a nation. Basic World Health Organization data and results obtained from national surveys show a continuing decrease in dental caries prevalence in many of the highly industrialized countries but a high prevalence of dental caries in many developing countries (WHO 1984a; Leverett, 1982; Winter 1990; Ettinger 1999; Barmes 1999). In developing countries, particularly in Asia, the prevalence of dental caries and dental fluorosis may be affected by a number of factors. The diet of the people may consist largely of easily fermentable carbohydrates. There may be limited knowledge of dental hygiene. The concentration of fluoride in natural drinking water in some areas may be below the levels required for optimum preventive efforts.

In Thailand, it has been reported that sugar consumption increased from 4.7 kg per person in 1961 to 12.5 kg per person in 1982 (Ettinger 1999). The National Oral Health Survey of Thailand in 1986 showed that the mean dmft at age 5 – 6 years was high, ranging from 2.71 to 9.04 and the mean DMFT ranged from 0.63 to 1.11 at age 15 – 16 years. Fluoride levels in household well water supplies ranged from 0.004 to 2.48 ppm and the prevalence of dental fluorosis, described by the Community Fluorosis Index (CFI), ranged from 0.05 to 0.74 (Sonpaisan & Davies 1989).

According to an Oral Health Survey conducted on 10,686 children aged 6 – 14 years in the southernmost provinces of China in 1987, the prevalence of dental caries was highest (62.5 per cent) in Quangdong city. Factors for an increasing caries prevalence in Quangdong children may be a gradual changes in the dietary pattern as a result of increasing affluence in combination with insufficient dental hygiene (Wang, Shen & Schwarz 1994).

Indonesia is also a developing country with a population at risk of deteriorating oral health. The mean DMFS of 12 and 15-year-old children in Jakarta in 1990 were 3.65 and 6.23 respectively. Available data indicated that dental caries may be increasing and it is probable that oral health may further deteriorate in children if Western diets are adopted (Morgan et al. 1992).

A cross-sectional survey involving 303 aboriginal children aged 6 – 15 years was carried out in Selangor, West Malaysia. The mean df teeth for the 6 – 9-year-old group was 4.9, with a mean of 4.2 decayed teeth and 0.7 filled teeth. The relatively high df scores were probably due to lack of oral hygiene and dental awareness among both the parents and the children themselves (Kadir & Yassin 1990).

A survey conducted in Lucknow, India found that definite fluorosis was evident in 24 per cent of children ingesting water with 0.4 – 0.8 ppm of fluoride. The unusually high degree of fluorosis may have been affected by drinking habits, dietary pattern, nutritional levels, climate or other factors influencing the quantity of water ingested. This survey also showed a slightly higher prevalence of dental caries in rural than in urban areas. This may be due to variations in dietary patterns and lack of knowledge concerning oral hygiene among the rural children (Nanda et al. 1974).

There is evidence from the above sources that dental caries prevalence remains high and dental fluorosis is not managed in some developing countries. It is necessary to plan oral health programmes and select appropriate preventive strategies for communities to prevent dental caries and control dental fluorosis.

1.3 THE RELATIONSHIP BETWEEN FLUORIDE CONCENTRATION IN DRINKING WATER AND BOTH DENTAL CARIES AND DENTAL FLUOROSIS

1.3.1 Origins of fluoride in water

Fluoride is the ionic form of the element fluorine. The fluoride ion is abundant in nature and occurs almost universally in soils and water in varying concentrations. Fluoride is ubiquitous in soil and water so that all plants and animals contain fluoride to some extent. It seems likely that all forms of life must have adapted to thrive with continuous exposure to small amounts of fluoride (Burt & Eklund 1992; Newbrun 1986; WHO 1970). Humans absorb fluoride from food, water, and to a lesser extent, air, but the amount of fluoride which humans ingest daily is mainly from fluoride in water. The origins of fluoride in water are from the sea, the atmosphere and the earth's crust.

The sea: The bulk of the water normally available to human life is involved in the hydrological cycle, which may be regarded as being initiated in the sea. Seawater contains significant quantities of fluoride. Normally, fluoride levels have been variously recorded as 0.8 – 1.4 ppm but the concentration may be enhanced locally by undersea volcanic activity (Fejerskov, Ekstrand & Burt 1996; Kappana et al. 1962). It is known that appreciable quantities of fluoride and other halogens escape from seawater into the atmosphere and return into the water by way of rain or snowfall as well as precipitation. This in turn becomes a small source of natural fluoride in water (WHO 1970; Fejerskov, Ekstrand & Burt 1996).

- ***The atmosphere:*** Fluoride is found in the atmosphere, originating from the dusts of fluoride-containing soils, outcroppings of fluoride-containing minerals, ocean spray, gaseous industrial wastes, smoke from burning coal and gases emitted in areas of volcanic activity. All these sources may act to increase fluoride in rain or precipitation. In populated areas coal smoke is regarded as one of the chief contributors to atmospheric fluoride. Therefore, the fluoride concentration of rain in polluted areas and in areas of volcanic activity may be substantially increased (WHO 1970; Fejerskov, Ekstrand and Burt 1996).

- ***The earth's crust:*** The amount of fluoride entering water either directly from the sea or from the atmosphere is likely to be smaller than the amount derived from the solvent action of water on the rocks and soil of the earth's crust.

Fluoride occurs in various types of rocks (WHO 1970). In plutonic rock, fluoride concentrations range from 20 to 4000 ppm. Fluoride concentrations vary from 80 to 2500 ppm in volcanic and hypabyssal rocks (Correns 1956). Granite rocks were recorded as having a mean fluoride content of 1330 ppm (Correns 1969). In sedimentary rocks fluoride values range 80–450 ppm for a variety of sandstones, 40–80 ppm for geywacke, and 360 ppm for loess (Correns 1969).

Fluoride in soils is derived primarily from the geologic parent material with only a minor proportion coming from airborne sea spray. Soil fluoride varies widely but generally ranges from 50 to 500 ppm (Vinogradov 1967).

Volcanic activity can contribute large amounts of fluoride to surface soils by way of ash deposited on the nearby terrain. During the 1970 eruption of Mt. Hekle in Iceland, the ash deposited in the first day in Southern and Northern Iceland contained 2000 and 1400 ppm, respectively (Fuge & Anderews 1988).

The use of fluoride-containing phosphate fertilizers and sewage sludge on agricultural soil has been reported to increase fluoride soil appreciably (WHO 1970; WHO 1994).

Due to these origins of fluoride in water, the amount of fluoride in drinking water sources is variable. The concentration of fluoride in rainwater is usually low (less than 0.1 ppm) unless there is contamination by industrial emissions or volcanic activity. Most surface water sources (river, lake and stream) contain less than 0.1 ppm of fluoride. However, the concentration is influenced by fluoride from other sources such as polluted rainwater or discharge of industrial waste and sewage into water. The concentrations in fluoride of ground-water (well- or bore-water) are affected by factors such as availability and solubility of fluoride-containing minerals, porosity of the rocks or soils through which the water passes, time of contact, temperature, pH and presence of other elements. Hence, ground-water has a greater fluoride content than other water sources. The concentration can differ greatly within a relatively small area or at different depths of sources (Newbrun 1986; WHO 1970; WHO 1994).

The amount of fluoride ingested from drinking water is dependent on the fluoride content of the water, and this will influence the prevalence of dental caries and dental fluorosis. It is for this reason that the fluoride content in drinking water sources needs to be investigated.

1.3.2 The relationship of fluoride concentration in drinking water with dental caries

The relationship between fluoride concentration in drinking water and dental caries was discovered about 70 years ago, in the 1930s. Dean observed a selected sample of 236 9-year-old children who were continuously exposed to waters of different fluoride concentration. The history of exposure was personally verified in each instance by an interview with the child's parent. It indicated that, of 114 children who had continuously used domestic water comparatively low in fluoride (0.6 to 1.5 ppm), only 4 or 5 per cent were caries free. On the other hand, of 122 children who had continuously used domestic water containing 1.7 to 2.5 ppm of fluoride, 22 to 27 per cent were caries free (Dean 1938). Following this discovery, Dean and his colleagues conducted a further study, which compared caries experience of children in Galesburg and Monmouth with that in Macomb and Quincy. Of the 319 children examined at Galesburg with 1.8 ppm of fluoride in the water and the 148 children examined at Monmouth with 1.7 ppm of fluoride in the water, the numbers of carious permanent teeth per 100 children were 201 and 205, respectively. At Macomb and Quincy, examinations of 112 and 306 children disclosed rates of 401 and 633 teeth per 100 children, respectively. At Galesburg and Monmouth about 35 per cent of those examined were caries free. In Macomb and Quincy only 14 and 4 per cent, respectively, were free from dental caries. A further interesting observation was that 16 times as much interproximal caries occurred in Macomb and Quincy as in Galesburg and Monmouth (Dean et al. 1939). Extensive epidemiological surveys of the prevalence of dental caries and dental fluorosis in communities in the United States were carried out by Dean and his associates during the late 1930s. They examined 7,257 children 12 – 14 years old in 13 cities (4 different states) and in 8 suburbs in Chicago with naturally high or low fluoride concentrations in the public water supplies. The children living in areas where the water supply contained less than 0.5 ppm of fluoride showed 19 times as much proximal surface caries experience in the 4 upper permanent incisors than children living in areas where the water contained from 0.6 to 2.6 ppm of fluoride. The communities using the low fluoride waters were all characterized by high dental caries experience. These results showed an inverse relationship between fluoride concentration in the drinking water and caries prevalence (Dean et al. 1941; Dean, Arnold & Evolve 1942).

Similar results were reported in a survey conducted by Eklund and Striffler in 41 cities to find the relationship between the DMFT of children aged 12-14 years and the fluoride concentration in domestic water supplies, which ranged from 0.18 to 2.6 ppm. The reduction in the mean DMFT was significant within the range 0.1 – to 1.2 ppm of fluoride concentration in drinking water (Eklund & Striffler 1980).

Heller and his colleagues used data from the 1986-1987 National Survey of US school children aged 4-22 years, which showed that the sharpest declines in dmfs and DMFS scores were associated with fluoride levels in water between 0.0 and 0.7 ppmF, with little additional decrease between 0.7 and 1.2 ppmF (Heller, Eklund & Burt 1997).

Studies of the effect of fluoride in natural water on dental caries have also been reported in England. Forrest examined permanent teeth of children in Essex and Buckinghamshire in the south-east of England in four areas having natural fluoride in their water supply: West Mersea (5.8 ppmF), Burnham-on-Crounch (3.5 ppmF), Harwich (1.6 - 2.0 ppmF) and Slough (0.9 ppmF) and two areas having low fluoride in their water supply. In the areas with low fluoride concentration in the water, the DMFT index was triple that in the high fluoride concentration areas. The percentage of caries-free children was five times higher in the high fluoride content areas than in the low fluoride areas (Forrest 1956).

The anti-caries effectiveness of fluoride in drinking water on primary teeth has also been demonstrated by research carried out by Timmis in 1971. This was conducted on the caries experience of 5-year-old children living in high and low fluoride areas in Essex (England). It showed that children in the low fluoride areas had a mean dmft of 4.9 but in the high fluoride areas they had a mean dmft of 2.7. The caries experience of primary teeth in the high fluoride areas was nearly 50 per cent lower than that in the low fluoride areas (Timmis 1971).

Another study in children from two Libyan cities with different levels of fluoride in their drinking water, comprising 833 children aged 6 years and 704 children aged 12 years from Benghazi with 0.8 ppm of fluoride and Jardinah with 1.8 ppm fluoride, reported that in both 6-year-old and 12-year-old children the caries prevalence in Benghazi was significantly higher than in Jardinah (Hawew et al. 1996).

In Europe the relationships of fluoride in natural water with dental caries have also been researched. In Denmark Thylstrup and his associates reviewed the trend of dental caries prevalence from 1972 to 1980 in Danish school children aged 7 – 15 years living in two communities with about 0.4 ppm and 1.5 ppm of fluoride in the drinking water. The results showed that in the high fluoride area prevalence of dental caries is consistently lower than in the low fluoride area (Thylstrup, Bille & Brunn 1982).

The prevalence of dental caries was assessed by Angelillo in randomly selected children aged 11 – 13 years, who were lifelong residents of three areas of Naples (Italy) with 4.0 ppm, 1.0 ppm and 0.3 ppm concentrations of fluoride in their drinking water. The children living in the 4.0 ppm fluoride concentration area had significantly lower dental caries scores (DMFT = 0.59 and DMFS = 1.01) than those in the 1.0 ppm fluoride concentration area (DMFT = 1.67 and DMFS = 2.87) and those in the lowest fluoride area (DMFT = 1.97 and DMFS = 3.48) (Angelillo et al. 1990). After that he and his associates observed 12-year-old school children living in two areas with drinking water naturally containing 2.5 ppm and 0.3 ppm of fluoride. However, the study did not show a great difference of dental caries between high and low fluoride areas. In the high fluoride area, 46.8 per cent of children were caries free (DMFT = 0) and DMFT and DMFS were 1.4 and 1.6, respectively; in the low fluoride area, 48.4 per cent of children had a DMFT = 0 and DMFT and DMFS were 1.5 and 2.6, respectively (Angelillo et al. 1999).

The association of dental caries and fluoride in drinking water was also investigated in other countries in the world. The report of an epidemiologic oral health survey of 2,279 children aged 7, 8, 12 and 13 years carried out in eight different regions in Argentina showed that both the mean dmf and DMF per child were substantially lower in natural fluoride areas than in low fluoride areas (de-Muniz 1985).

In Zimbabwe 1386 of 5 – 6-year-old and 1326 of 12-year-old school children were examined for dental caries. Fluoride concentrations in the drinking water sources of schools were determined and were found to be in the range 0.05 – 2.5 ppm. In both age groups the prevalence and severity of dental caries were significantly lower in higher fluoride levels in drinking water (> 0.8 ppmF) (Sathananthan, Vos & Bango 1996).

The study on the caries prevalence among children aged 7, 12 and 15 years in the Baltic States (Lithuania) described the correlation of caries prevalence with fluoride content in drinking water. There was an inverse association between caries and fluoride content in drinking water in all three age groups (Aleksejuniene, Arneberg & Eriksen 1996).

A study of a total of 457 6 – 12-year-old lifelong resident children from three Brazilian areas with 2 – 3 ppm, 0.7 ppm and 0.01 ppm of fluoride in their drinking water showed that there was a trend for the mean dmft to decrease significantly with increasing levels of fluoride in the drinking water (Cortes, Mullane & Bastos 1996).

Children aged 6, 12 and 15 years were examined for dental caries in three cities in Saudi Arabia with varying levels of naturally occurring fluoride in the drinking water. Jeddah is less than 0.3 ppm, Rabagh is 0.8 ppm and Mecca is 2.5 ppm. The results clearly showed that the caries prevalence in the three age groups of children in both high fluoride areas (Rabagh and Mecca) were approximately 50 per cent lower than their counterparts in Jeddah where the level of fluoride in the water supply is less than 0.3 ppm (Al-Khateeb et al. 1990).

Research in Sudan also assessed the caries prevalence of children living in areas with either 0.25 or 2.5 ppm of fluoride in the drinking water. In the low fluoride areas 75 per cent of the children have decayed permanent teeth compared to 66 per cent in the high fluoride area but the mean DMFT was not significantly different between children from the two areas, being 2.6 ± 2.3 and 2.1 ± 2.3, respectively. However, in the primary teeth both the prevalence and distribution of caries were significantly lower in the 2.5 ppm area than in the low fluoride area (Ibrahim, Bjorvatn & Birkeland 1997).

It can be seen that the concentration of naturally occurring fluoride in the drinking water closely relates with dental caries, that is there is an inverse relationship between caries and fluoride content in drinking water.

1.3.3 The relationship of fluoride concentration in drinking water with dental fluorosis

Fluoride in drinking water contributes to preventing dental caries, but overexposure of fluoride concentration in water can cause dental fluorosis, which is an undesired side effect of excessive fluoride ingestion during the period of early tooth development. The proportion of the population exhibiting fluorosis and the severity within individuals depend upon the quantity of fluoride ingested. It is believed that both the prevalence and the severity of fluorosis increase with increased fluoride concentration in water. However, the prevalence and severity of fluorosis also depend on the time of fluoride consumption (WHO 1970; Fejerskov, Ekstrand & Burt 1996). During the 1930s Dean and coworkers conducted extensive epidemiologic surveys to establish the relationship between mottled enamel, or 'chronic endemic dental fluorosis', and the level of fluoride in water supplies. A report of data from four cities, Colorado Springs, Monmouth, Galesburg and Pueblo, and from Texas showed the mottled enamel index found depended on the fluoride concentration of the drinking water (Dean & Evolve 1935; Dean, Dixon & Cohen 1935). Following this discovery, Dean's further studies investigated mottled enamel on school children aged 9 – 11 years, one in 10 cities and another in 4 cities. The children selected in these surveys had a continuous residence since birth and constantly used the city water during their life. Fluoride concentration in the city water ranged from 0.6 to 4.4 ppm. As has been pointed out previously, mottled enamel depends on the fluoride content in the drinking water. However, it is possible that other constituents of the water may have some influence on the activity of fluoride (Dean & Evolve 1936; Dean & Evolve 1937). The incidence and degree of mottled enamel were also observed in a survey of 13 USA cities, which described increasing dental fluorosis with increase of fluoride concentration in drinking water (Dean, Arnold & Evolve 1942). Additional evidence presented in Dean's surveys inducted the relationship between dental fluorosis and dental caries. The severity of dental caries, in general, was lower in mottled enamel areas as compared with areas with normal enamel. The prevalence of dental caries in the population was inversely proportional to the prevalence of mottled enamel (Dean 1938; Dean et al. 1939).

Heller and his associates used data from the 1986-1987 national survey of US school children to investigate the relationship of dental fluorosis with different fluoride levels in drinking water in children aged 4 - 22 years. The results showed that fluorosis prevalence was 13.5 per cent, 21.7 per cent, 29.9 per cent and 41.4 per cent for children who consumed <0.3, 0.3 to < 0.7, 0.7 to <1.2 and >1.2 ppm of fluoride in water, respectively, and the mean fluorosis severity increased with increasing water fluoride level (Heller, Eklund & Burt 1997).

A study in 0.25 and a 2.5 ppm fluoride areas in the Sudan also measured the effect of fluoride in water on the prevalence of dental fluorosis in children aged 6 to 16 years who were lifelong residents of their rural villages. The Community Fluorosis Index (CFI) was 1.3 ± 0.8 and 2.1 ± 0.9, respectively (Ibrahim, Bjorvatn & Birkeland 1997).

Angelillo and his colleagues conducted a survey in three randomly selected areas of Naples (Italy) supplied drinking water naturally containing different fluoride concentrations (0.3 ppm, 1 ppm and 4 ppm). A total of 690 school children aged 11 – 13 years were examined. All children were born and raised in their respective communities and had never been exposed to fluoride supplements. The prevalence of teeth with enamel defects was 2.2 per cent, 5.7 per cent and 20.3 per cent, respectively (Angelillo et al. 1990). His further study was the assessment of dental caries and dental fluorosis prevalence in 12-year-old school children in areas with drinking water naturally containing more than 2.5 ppm and less than 0.3 ppm of fluoride. Fluorosis was reported among 55.3 per cent and 94.5 per cent of children in the high and low fluoride areas, respectively. The CFI for all permanent teeth was significantly higher, 0.8, in the high fluoride area than the value, 0.1 measured in the low fluoride community (Angelillo et al. 1999).

Relying on the results of studies, it can be seen that dental fluorosis increases correspondingly with the concentration of fluoride in drinking water.

However, apart from the influence of fluoride concentration in drinking water on the prevalence of dental fluorosis, the age of children exposed to high level fluoride also plays an important role in the risk for dental fluorosis. This is due to the fact that the transition or early-maturation stage of enamel formation is most susceptible to the effects of chronic fluoride ingestion at high levels of fluoride in drinking water (DenBesten & Thariani 1992).

The community of Rigolet, Labrador, Canada discovered that the fluoride concentration in the drinking water from the new town well, which became operational in December 1983, was higher than 2.0 ppm. The students in Rigolet were examined for fluorosis. The results showed that students who were 5 years or older on December 1, 1983 had lower prevalence of fluorosis than the students who were less than one year old (Ismail & Messer 1996).

Ishii and Suckling reported the prevalence of fluorosis of children in the Ikeno district of Japan. This district was accidentally exposed to drinking water containing 7.8 ppm of fluoride for 12 years, following which water with 0.2 ppm fluoride was substituted. Dental examinations for local children revealed that children aged 7 years or less and aged 11 months or more at the removal of the high fluoride water had fluorosis (Ishii & Suckling 1991).

Evans conducted a study to assess the prevalence of fluorosis 8 years after reducing the fluoride concentration in Hong Kong water supplies from 1.0 to 0.7 ppm in four districts. Dental fluorosis was assessed by Dean's community fluorosis index (CFI) on upper central incisors in 2382 children aged from 7 (exposed to 0.7 ppm of fluoride in water only) to 13 years. The results clearly demonstrated that the level of dental fluorosis had decreased significantly in the four districts, not only in statistical terms but also in clinical terms, and that development of dental fluorosis may occur from 12 to 32 months following enamel secretion (Evans 1989). Another study by Evans and his colleagues in 1986 on a representative sample of 1,085 Hong Kong Chinese children aged 7 – 12 years to determine the prevalence of fluorosis also confirmed the previous results. Subject data were grouped by month of birth relative to June 1978 when designed fluoride concentration of the community water supply was reduced from 1.0 ppm to 0.7 ppm. The result indicated that the maxillary central incisors were most at risk of fluorosis from fluoride in drinking water between the ages of 15 and 24 months for males and 21 and 30 months for females (Evans & Darwell 1995).

Murray and Rugg-Gunn remarked on McKay's study, which demonstrated that only children who had been born and lived all their life in high fluoride areas had mottled enamel, and children who had been born elsewhere and bought to the areas when 2 or 3 years of age were not affected (Murray & Rugg-Gunn 1982). Rozier and Dudney also confirmed this evidence in their study. They observed children exposed to home drinking water naturally fluoridated at optimum levels and supplemented by school water with fluoride content of 4.5 ppm from the ages of 5 and 6 years. These children did not show objectionable dental fluorosis (Rozier & Dudney 1981).

According to these studies, dental fluorosis prevalence has a positive relationship with fluoride concentration in drinking water and an inverse relationship with dental caries prevalence. Additionally, the first seven years of life, in particular from 12 to 36 months, is the period of most risk of fluorosis if children are exposed to high fluoride ingestion.

1.3.4 The optimum fluoride concentration in drinking water

Fluoride concentration is regarded as optimum if it produces a near maximal decline in dental caries without creating an unacceptable level of dental fluorosis. Therefore, the choice of an optimum fluoride concentration in drinking water is an important aim of public dental health. According to the results of Dean's studies about the relationship between fluoride concentration in drinking water and dental caries and fluorosis, the optimum fluoride concentration in drinking water should be at 1 ppm. Relatively low dental caries experience rates were found associated with the use of drinking water containing 1 or more ppm fluoride, and fluorosis was of no public health significance if the amount of fluoride in drinking water did not exceed 1 ppm (Dean & Evolve 1937; Dean et al. 1941; Dean, Arnold & Evolve 1942).

Eklund and Striffler stated that the limit of the optimum fluoride concentration in drinking water is approximately 1.2 ppm of fluoride after observing the prevalence of DMFT for 12 – 14-year-olds children in 41 USA cities (Eklund & Striffler 1980). Relying on the results of a study on children aged 4-22 years about the relationship between fluoride concentration in drinking water and dental caries and dental fluorosis, Heller and coworkers showed that a suitable trade-off between caries and fluorosis appears to occur around 0.7 ppm of fluoride (Heller, Eklund & Burt 1997).

According to the above studies, it is important to realize that there is no single optimum level of fluoride which is valid at all times and for all communities. Several factors must be taken into consideration in order to establish the best concentration of fluoride for a particular community. The optimum concentration of fluoride in the drinking water depends upon the annual average maximum daily temperature in the community because temperature influences the amount of water ingested. Individuals living in colder climates drink less fluid than those residing in hotter areas, where sweating is a major influencing factor (Newbrun 1986; Harries & Christen 1987).

Galagan observed the prevalence of dental fluorosis and dental caries in children in USA communities with different environmental conditions. Arizona children, living in a climate where the mean annual temperature is approximately 70°F, had a higher fluorosis index and a lower caries rate than children who used water with the same fluoride concentration but who lived in the mid-West where the mean annual temperature is approximately 50°F. (Galagan & Lamson 1953; Galagan 1953). The measurement of fluorosis and caries prevalence indicated that children born and raised in areas with a mean annual temperature of 70°F drink more water than children living in areas with a mean annual temperature of 50°F. The quantity of fluoride ingested from the drinking water is dependent not only on the concentration of fluoride, but also on the volume of water ingested. Thus, water consumption of children associate strongly with climatic factors. Another study by Galagan and his associates investigating the mount of fluid consumed showed that, under normal living conditions, water intake increased directly with increases in temperature (Galagan & Vermillion 1957).

Richards and his co-workers (1967) conducted a comprehensive 5-year study on more than 9,000 California children aged 12–14 years in 18 specific fluoride–temperature zones to determine the relationship between fluoride concentration in the drinking water, dental caries, dental fluorosis and temperature of environment. The results also found that the relationship between fluoride levels in the drinking water and dental caries and fluorosis was associated with temperature of environment (Richards et al. 1967).

Temperature is the most important element of the climatic environment so the optimum fluoride concentration should be adjusted to temperature. Therefore, in the Great Lakes area 1.2 ppm of fluoride may be considered optimum, whereas 0.6 ppm in Southern Arizona may be considered equally effective. Galagan and Vermillion suggested the following formula to estimate optimum fluoride concentrations for community water supplies:

$$\textbf{Parts per million of fluoride} \quad \frac{0.34}{E}$$

The value 0.34 for the constant is reasonable from the standpoint of optimum fluoride ingestion through water. E is the estimated average daily water intake for children up to 10 years of age in ounces of water per pound of body weight. It may be calculated from the estimation equation **E = - 0.038 + 0.0062 × temperature**, where temperature is the mean maximum temperature in degrees Fahrenheit for at least a 5-year period (Galagan & Vermillion 1957).

For practical purposes the United States Public Health Service set up the standards for fluoride in water supplies. The optimum fluoride concentration was given for certain ranges of annual average maximum daily air temperatures (Dunning 1977). This is presented in Table 1.1.

Table 1.1: The fluoride levels recommended for cool and warm climates

*Annual Average Maximum Daily Air Temperature**		*Recommended Control Limits Fluoride concentration in parts per million*		
^{0}C	^{0}F	**Lower**	**Optimum**	**Upper**
10.0 - 12.1	50.0 - 53.7	0.9	1.2	1.7
12.2 - 14.6	53.8 - 58.3	0.8	1.1	1.5
14.7 - 17.7	58.4 - 63.8	0.8	1.0	1.3
17.8 - 21.4	63.9 - 70.6	0.7	0.9	1.2
21.5 - 26.2	70.7 - 79.2	0.7	0.8	1.0
26.3 - 32.5	79.3 - 90.5	0.6	0.7	0.8

(* Source: US Public Health Service, 1962)

However, besides the influence of a temperate climate, the optimum level of fluoride could be adjusted by additional fluoride ingestion through the amount and kind of food eaten, drinking habits and discretionary fluoride. The fluoride concentration in Hong Kong water was reset from 1.0 ppm to 0.7 ppm in 1978. One of the factors which was considered in this change was fluoride from other sources (Evans, Lo & Lind 1987). The tea drinking habits of children in Sri Lanka was also a factor considered when the optimum level of fluoride in ground water for caries protection was determined (Warnakulasuriya et al. 1992).

In order to establish the best concentration for a particular community, it is necessary to consider carefully many factors which could influence the fluoride ingestion of the population.

1.4 THE RELATIONSHIP OF SOCIO-ECONOMIC AND DEMOGRAPHIC FACRORS, DIET HABITS, DENTAL BEHAVIOURS AND DISCRETIONARY FLUORIDE WITH DENTAL CARIES AND DENTAL FLUOROSIS

Apart from the influence of fluoride concentration in drinking water on the prevalence of dental caries and fluorosis, there may be other factors which have indirect or direct influences on the prevalence of dental caries and fluorosis, such as socio-economic and demographic factors, dietary habits, dental behaviours and fluoride supplements.

1.4.1 Socio-economic and demographic factors

In all societies members are divided into various social strata or layers. Each person therefore has a social status, which is the position he or she occupies within the social system. Social status is based upon sociological factors, which are residency, age, race, sex, family income, individual occupation or parent's occupation, and individual education or parent's education. Additional factors such as car ownership, home ownership, household crowding and family status (married, single) may also be referenced to classify a person's social status. These social factors have an interactive relationship among themselves, for example high occupation often goes with high education, high income, car ownership, home ownership and low percentage of household crowding, and vice versa (Murray 1989; Townsend, Phillimore & Beattie 1988). Social status is achieved during the lifetime of an individual. Therefore, it enables us to make generalizations about the lifestyle, habits and attitudes of an individual as well as a group in the same socio-economic status. This is fundamental in understanding the relationship between social status and dental health (Murray 1989; Townsend, Phillimore & Beattie 1988; Enwonwu 1974).

Enwonwu observed the influence of socio-economic factors on the prevalence and intensity of dental caries in a nutrition survey. The survey subjects were 3370 Nigerians, 89 per cent of which were under 20 years of age, and 238 children of Western European origin resident in the major cities in Nigeria. Most of the rural Nigerian villages studied showed low df and DF index values. Contrary to findings in privileged communities, dental caries was frequently seen in children of educated, high socio-economic groups living in Nigerian cities as well as in the children attending boarding school located in the major towns (Enwonwu 1974).

The association of urbanization with the prevalence of dental caries of school children in Nigeria's new capital territory was examined by studying 315 urban, 303 semi-urban and 297 rural school children. The mean number of decayed teeth were 27 per cent, 24 per cent and 12 per cent, respectively. Urban and semi-urban children had higher risk for dental caries than their rural reference group (El-Nadeef, Adegbembo & Honkala 1998).

In the Tameside and Glossop Health Authority districts in the north-west of England, five primary schools with highest prevalence of dental caries were compared with five primary schools with lowest prevalence of caries. It was found that the high caries communities had a lower percentage of private houses and homes with cars, a lower proportion of social class 1 and 2, and more children with single parents. They also had more children receiving clothing allowances and free school meals. The parents in the high caries communities were reported to have higher proportions of social and financial problems (Gratrix & Holloway 1994).

Dental caries prevalence (percentage of caries-free) and experience (DMFS) were recorded in 414 Indian children at age 12 years and 401 white children at the same age in two South African communities to explore the relationship between dental caries and four social factors: education level, family income, parental occupation and ratio of rooms to persons. Among the Indian children 29.5 per cent were caries free, significantly less than the 40.1 per cent of the white children. DMFS scores were also higher in the Indian group (3.65 ± 3.98) compared to the white group (2.66 ± 3.49). Caries experience was not significantly influenced by any of the social factors within the Indian group whereas, in the white group, caries experience was significantly influenced by social class, work group, family income and room to person ratio. Another mention was an opposite trend in income group, in which caries prevalence was lowest in the Indian low income group, but highest in the white low income group (Cleaton-Jones et al. 1994).

Rowe and his associates reviewed the USA Ten-States Nutrition Survey of 1968 – 1970 to find out the effect of age, sex, race and economic status on dental caries experience of children aged 5 – 20 years. The data clearly showed that for every tooth at every age and for both sexes, black children had less dental caries experience than white children. The difference in caries experience between the two races was large and consistent. Girls exhibited slightly greater dental caries experience than boys in both races. Overall, the low income groups exhibited less dental caries than the high income groups (Rowe et al. 1976).

Data from the Third National Health and Nutrition Examination Survey in 1988 – 1994 in the USA for 10,332 children aged from 2 to 18 years indicated that the mean dft and DMFT were related inversely to income level. It also found that Mexican-American and African-American children were more likely to have a higher prevalence of caries than non-Hispanic white children (Vargas, Crall & Schneider 1998).

Irigoyen and Szpunar reported the prevalence of dental caries in four regions of the State of Mexico for 2,275 school children 12 years of age. They demonstrated that higher dental caries scores were found in rural areas than in urban centers and the female group had a higher mean DMFS value than the male group (Irigoyen & Szpunar 1994).

Slade and his co-workers collected data from 6,704 Queensland children aged 5 – 12 years and 6,814 South Australian children aged 5 – 15 years and evaluated inequalities in children's dental caries experience among socio-economic status groups. This investigation revealed that, in both states, children with lower socio-economic status had greater levels of caries experience than children with higher socio-economic status (Slade, Spencer & Stewart 1996).

According to the results of the above studies, the prevalence of dental caries is influenced by socio-economic factors. However, the influential level of socio-economic factors in dental caries prevalence depends on the particular circumstances of each community.

1.4.2 Dietary habits

Diet can affect the teeth in two ways: firstly, while the tooth is forming before eruption by systemic ingestion and, secondly, by a local oral effect after the tooth has erupted into the mouth. Various foods and beverages are known to contain moderately high levels of fluoride as well as fermentable carbohydrates, especially sugar (Murray 1989; Fejerskov et al. 1988).

Levy and Fejerskov reviewed fluoride exposure from foods and beverages. They demonstrated that tea leaves are a particularly rich natural source of fluoride and fluoride is rapidly released into tea infusions. In communities where tea drinking is common, it can contribute substantially to total fluoride intake (Levy 1994; Fejerskov, Ekstrand & Burt 1996).

A survey in Sri Lanka of 380 children at age 14 years living in four geographic areas with water containing fluoride levels of 0.09 – 8.0 ppm showed that among children consuming drinking water containing under 1.0 ppm, 32 per cent had mild forms and 9 per cent severe forms of dental fluorosis. The reasons for the high prevalence of dental fluorosis were that these children have consumed a lot of locally grown tea from infancy (Warnakulasuriya et al. 1992).

Mann and his colleagues discovered an association between the number of cups of tea consumed on an average day and the prevalence of dental caries and fluorosis of 475 Arab youths at age 6 – 8 years and 16 – 18 years in the northern sector of Israel. The results of this study clearly revealed a significant association between dental caries and tea drinking habits. Heavy tea drinking was accompanied by evidence of fluorosis and lower levels of caries (Mann et al. 1985).

Levy and Fejerskov also showed that infant formula, 'market basket' foods, bottled water, soft drink, beer and other alcoholic beverages contain fluoride close to the fluoride concentration of water supplies due to the use of fluoridated water in their manufacture. The consumption of these foods and beverages could be, therefore, regarded as increasing the risk of fluorosis (Levy 1994; Fejerskov, Ekstrand & Burt 1996).

In the local oral effect, the consumption of sugars is considered as a most important dietary factor influencing the prevalence of dental caries (Murray 1989). A 3-year longitudinal study was carried out in 747 school children aged 10 – 15 years residing in non-fluoridated rural communities in South-central Michigan to analyse the relationship between caries experience and consumption of sugar from all sources. It was concluded that higher average daily consumption of sugars and higher between-meal consumption of sugars were a risk factor for children susceptible to approximal caries (Burt et al. 1988).

The study conducted by Arnadottir and his associates in 1994 examined the relationship between approximal caries and sugar consumption in teenagers living in three fluoride-deficient areas in Iceland. The results of this study indicated that the frequency of between-meals sugar consumption was associated with approximal caries, with frequency of candy consumption being the most important of the sugar variables. Between-meal consumption of sugar remained a risk factor for the occurrence of dental caries, especially in populations with moderate to high levels of dental caries experience (Arnadottir et al. 1998).

The effect of sugar cane chewing on the development of caries in Tanzania has also been investigated. Two groups were selected. These groups had a similar socio-economic background, had similar levels of fluoride in drinking water, consumed similar amounts of refined sugar per day, but had a significant difference in the number of pieces of sugar cane chewed per day. The results showed that the group which had more sugar cane chewing had significantly higher mean DMT and DMS scores than the group that had less sugar cane chewing (Frencken, Rugarabamu & Mulder 1989).

A dental health survey in the Arussi province, Ethiopia revealed that a high tea consumption was assumed to increase fluoride intake but the persons who had the habit of sweetening tea or coffee had a higher mean DMFT value (2.20 ± 2.79; $n = 1111$) than those who did not (1.68 ± 2.23; $n = 166$) (Olsson 1978).

The study of the influence of sweets intake and tooth brushing on dental caries among 700 children in Japan demonstrated that the prevalence of caries in those who frequently consumed confectionery and beverages was higher than the prevalence in those who did not take them (Akizawa et al. 1990).

It is clear that the relation between diet and dental caries and fluorosis comes from many sources of food and beverages. The amount and frequency of the consumption of foods and beverages are factors influencing the prevalence of dental caries and fluorosis and sugar consumption appears to be an important dietary item in caries aetiology (Murray 1989).

1.4.3 Dental behaviours

Dental caries is initiated by an acid decalcification of the enamel surface. Acids are derived from fermentable sugar by enzymatic action. Therefore, if the time of sugars and acids in the mouth was limited, the incidence of caries would be decreased (Newbrun 1989). One dental behaviour which is often discussed as effective in reduction of caries, is tooth brushing and frequency of tooth brushing. The relationship between tooth brushing and frequency of tooth brushing with dental caries remains controversial. Some studies have found a relationship, but some studies have not.

Fosdick conducted an experiment on 946 individuals comprising 423 controls and 523 test subjects. All of those in the experimental group were instructed individually to brush their teeth thoroughly within 10 minutes after each ingestion of sweets or foods with an accepted technique. Toothbrushes and neutral dentifrices were provided to all experimental subjects. The persons in the control group were not supplied with dentifrices or brushes and were instructed to continue with their customary oral hygiene habits. At the end of the 2-year experiment, the individuals in the experimental group had a statistically significant lower incidence of caries than those in the control group (Fosdick 1950).

Berenie and his associates observed the relationship of the frequency of tooth brushing and caries experience in the 384 school children 9 – 13 years of age living in western New York. The findings indicated a trend toward decreased prevalence of caries activity with increased frequency of daily brushing (Berenie, Ripa & Leske 1973).

Data from a 3-year clinical trial, which was conducted on 846 British children aged 11 years, were used to evaluate the relationships between oral hygiene status and dental caries incidence and between tooth brushing frequency and caries incidence. After three years, dental caries increments were less in the children with good oral hygiene and in those who bushed their teeth more frequently, but the differences were small (Tucker, Andlaw & Burchell 1976).

Another study was conducted over three years on 261 British schoolgirls aged 11 years to investigate the effect of a school-based plaque control program on dental caries and gingivitis. Girls in the experimental group visited a hygienist every fortnight during school term to brush and receive a professional prophylaxis using a fluoride-free polishing paste. Girls in the control group received the oral hygiene instruction normally given in school. After three years, the results indicated that the program was not effective in reducing the caries increment (Ashley & Sainsbury 1981).

The relationship between tooth brushing and frequency of tooth brushing with dental caries has not been clearly established. However, in theory, dental caries could be prevented by highly efficient removal of plaque by tooth brushing by highly motivated and well-instructed children (Andlaw 1978; Sutton & Sheiham 1974).

Another dental behaviour also discussed is dental visiting, which was found to be associated with dental caries. Barrette et al. conducted a dental health assessment on 347 children in Ottawa, Canada. They found that the prevalence level of dental caries among the children who had visited a dentist had of a mean def or DMF four times higher than the children who had never visited a dentist (Barrette et al. 1981). A longitudinal study carried out on Medicaid preschool children aged five years and under at the time of their first dental visit to evaluate profile and cost of dental services provided to urban low-income groups also confirmed the previous result. There was a high prevalence of dental caries and consequently high treatment needs among children seeking a dental visit (Nainar 1998).

1.4.4 Discretionary fluoride.

Discretionary fluoride, in the form of tablets, drops, toothpaste and commercial mouthrinse is readily available. Its use may reduce dental caries, but has been implicated as a risk factor for dental fluorosis.

Hesselgren and Thylstrup observed the prevalence of dental caries in 1493 children in Danish community (Denmark) in three periods: 1961–1963; 1968–1970 and 1976-1978. These data showed a remarkable reduction of caries activity presumably resulting from school-based preventive programs and the widespread use of fluoride dentifrice, which was introduced in Denmark in 1964 (Hesselgren & Thylstrup 1982).

A preventive program was conducted in four mixed schools located in a non-fluoridated area in the west of France. Children in the test group brushed their teeth every school day with fluoridated toothpaste. In addition to daily-supervised tooth brushing, topical application of fluoride gel was provided every two months, except during summer vacation. The children in the control group received neither oral hygiene instruction nor prophylactic treatment. The 3-year results showed a significant reduction of caries: 44 per cent for primary teeth and 60 per cent for permanent teeth (Kerebel et al. 1985).

Blinkhorn and his co-worker conducted a clinical trial for fluoride dentifrice and mouthrinse effect on the incidence of dental caries in 751 children aged 14 – 15 years. At the completion of the program at three years, both the dentifrice and mouthrinse reduced the incidence of dental caries, but their combined use at the same time had no greater effect than either used alone (Blinkhorn et al. 1983).

Disney and her colleagues compared the effectiveness of fluoride mouthrinse on the high and low caries-forming children living in fluoride deficient and fluoridated sites. After four years' exposure to weekly rinsing, both high-caries and low-caries children in rinse groups demonstrated increments of surfaces and DMFS values lower than control groups (Disney et al. 1989).

A weekly-supervised fluoride mouthrinse has been available for school children in Hisayama, Japan since 1984. After four years of the program, the value of DMFS for 12-year-old school children decreased to less than 3.0, but since 1992 it has again increased. Oral examinations conducted on 101 school children aged 12 years in 1994 revealed that the DMFT and DMFS indices of the children in a continuing mouthrinse group were significantly lower than those discontinuing mouthrinse for one year or more (Yamaguchi et al. 1997).

Wang and Riordan reported on dental caries experience in Norway in children using fluoride toothpaste and in children using fluoride toothpaste and fluoride tablets during the period 0.5 – 4.0 years and 6 – 8 years of age. There was no water fluoridation and little naturally occurring fluoride in the drinking water. Multivariate analyses showed that the children complying with recommendations for use of fluoride tablets during the period 0.5 – 4.0 years of age had lower caries experience and fewer decayed surfaces in primary teeth than other children (Wang & Riordan 1999).

Simultaneously with recognition of the effectiveness of discretionary fluoride on dental caries, the use of discretionary fluoride is also regarded as a risk for fluorosis.

Mascarenhas and Burt investigated the use of fluoride toothpaste on 1,189 seventh grade children with a mean age of 12.2 years. The findings indicated that the use of fluoride toothpaste before the age of six years was a risk indicator for fluorosis. Among children with fluorosis, beginning brushing before the age of two years increased the severity of fluorosis significantly (Mascarenhas & Burt 1998).

To evaluate sources of fluoride as risk factors for dental fluorosis, a sample of 157 children aged 8 – 17 years were examined for dental fluorosis and fluoride history during the first eight years of life was assessed by a questionnaire completed by each child's parent. The results found that the risk of fluorosis was significantly greater for children who had greater exposure to fluoridated water and who used large amounts of fluoridated toothpaste up to age eight years (Stotowski, Hunt & Levy 1995).

The use of fluoride supplements, fluoridated mouthwash use and early parent assisted tooth brushing with fluoridated toothpaste were also significantly associated with the prevalence or severity of fluorosis in 752 second grade students in a rural, non-fluoridated area of Ontario, Canada (Brothwell & Limeback 1999).

The use of fluoride supplements contributes to the decline in caries prevalence, especially tooth brushing with a fluoridated toothpaste. However, the use of fluorides should be restrictedly supervised for young children, and children exposed to multiple sources of fluorides, to avoid increased risks of fluorosis.

1.5 RATIONAL USE OF FLUORIDATION IN CARIES CONTROL

1.5.1 Population versus clinical intervention as risk strategies

Dental caries has declined dramatically in most industrialized countries and in some developing countries due to the strengths of population strategies rather than the benefits of clinical intervention (WHO 1984b; Sheiham & Joffe 1991).

Population strategies had been shown to be most effective for preventive interventions, particularly where there is a high probability of future disease. Therefore, the prevalence of disease could be reduced. Conversely, clinical interventions concentrate on curative and restorative treatment for dental caries. However, a restorative strategy is not successful in reducing future disease. This analysis has led Moller to comment 'It appears that the increase in allocation of the budget, from public and private sources, which is spent on traditional dental care has only a marginal effect on the population's oral health status' (Moller 1987). Therefore, preventive rather than curative strategies are a health promoting approach (WHO 1984b).

A further advantage is the economic rationale of population strategies. The provision of clinical intervention requires a workforce and creates a financial burden for the cost of restorative, rehabilitative treatments and services. For instance, in Britain, the cost of treating dental disease, mainly caries, and its consequences is about £1 billion a year (Sheiham, 1987b). Americans spent almost US $ 30 billion in 1986 to treat all their oral disease. A major portion of this amount was used for the treatment of decayed teeth and the consequence of caries (US Office of the Actuary 1987). Therefore, not everyone in the community can get the benefits of clinical intervention whereas population strategies which attempt to control the determinants and remove the underlying causes, have great benefits in all section of the population to which they are directed (Sheiham & Joffe 1991). Barmes and Tala stated that the continuing reduction of disease levels is due mainly to preventive action taken by individuals rather than to increased availability of dental services (Barmes & Tala 1987).

In developing countries which are burdened by oral disease and where caries is becoming more prevalent, the implementation of population intervention programs focusing on prevention is a cost-effective response to control dental caries (Pack 1998). Davies stated that dental care should be based on the principles of primary health care, with community participation and a bias towards the prevention of disease rather than the treatment of its effects (Davies 1991).

1.5.2 Fluoridation

The distribution of caries (dmf, DMF) depends on the distribution of fluoride exposure. Therefore, altering the fluoride exposure distribution may be a most effective way of reducing the prevalence of caries, both in the population as a whole and also specifically among those who are at high risk for caries (Sheiham & Joffe 1991). Among the ways of using fluoride to reduce dental caries, fluoridation, especially water fluoridation, is considered an effective, efficient, safe and inexpensive measure.

1.5.2.1 Water fluoridation

* *The effectiveness of water fluoridation:* The effectiveness of water fluoridation in reducing caries had been reviewed by Newbrun based on the surveys conducted in the previous ten years. The efficacy was greatest for the primary dentition. Studies on US children showed that children in fluoridated communities had 30 per cent lower caries prevalence than those living in non-fluoridated communities. Some studies carried out on British children reported a 40 – 60 per cent lower caries prevalence in children from fluoridated communities compared with those from non-fluoridated communities. In the mixed dentition, about 20 – 40 per cent less caries was seen in children in the fluoridated communities. In the permanent dentition, a survey of US children at age 14 – 15 years demonstrated percentage differences in caries prevalence ranging from 8 to 37 per cent between fluoridated communities and non-fluoridated communities, and the differences in British children ranged from 25 to 45 per cent (Newbrun 1989). Ripa also confirmed the

effectiveness of water fluoridation in his review and commentary of a half-century of fluoridated water in the United States (Ripa 1993).

Brunelle and Carlos observed the trend of dental caries in a Second National Survey in US children aged 5 – 17 years conducted in 1986 – 1987. The results found that the mean DMFS of children with continuous residence in fluoridated areas was about 18 per cent lower than in those with no exposure to fluoridation. This pattern was fairly consistent over age, except at 5 and 6 years old, where very little permanent dentition caries occurred in either group (Brunelle & Carlos 1990).

The association between fluoridation and dental caries experience was also investigated in Australia, where water fluoridation was implemented more than 30 years ago. Slade et al. assessed the relationship between exposure to fluoridation and dental caries experience among children in two Australian States, 9,690 South Australian children aged 5–15 years and 10,195 Queensland children aged 5–12 years. The findings showed fluoridation was associated with lower caries experience in both States (Slade et al. 1995).

A more specific comparison was made of a fluoridated area, Townsville, and an unfluoridated area, Brisbane, in the effectiveness of water fluoridation. The results revealed that caries experience was significantly lower among Townsville children than Brisbane children for both deciduous dentition and permanent dentition (Slade, Davies, Spencer & Stewart 1996).

Singapore was the first Asian country which implemented water fluoridation, in 1958, for the whole country. The 10-year study on the effects of fluoridated water showed a decrease in caries prevalence in Chinese and Malaysian children for both primary and permanent teeth (Loh 1996). Lo and Bagramian also observed data from a dental health survey of Singapore children in 1970, 1979, 1984 and 1994. The results showed that the proportion of children free of caries in permanent dentition increased from 30 per cent in 1970 to 58.7 per cent in 1994 and the DMFT index for 6 – 18-year-old children dropped from 2.98 in 1970 to 1.05 in 1994 (Lo & Bagramian 1997).

The changes in oral health in Hong Kong since the introduction of fluoridation showed similar trends. Between 1960 and 1980, the dmfs levels for children aged 6 – 8 and 9 – 11 years decreased from 9. 2 to 4.0 and from 3.8 to 1.7, respectively. Over the same period, DMFT levels for the same age groups decreased from 2.7 to 0.6 and from 4.4 to 1.3, respectively. DMFS levels for adults also decreased (Evans, Lo & Lind 1987).

The water supply of Jerusalem (Israel) was fluoridated in 1988. The mean dmfs and DMFS of children aged 6 years declined from 13.95 in 1983 to 8.09 in 1992 and from 1.64 to 0.32, respectively. The DMFS scores of children aged 9 years declined from 3.5 in 1986 to 2.5 in 1992 (Sgan-Cohen et al. 1997).

Kunzel and Fischer observed caries prevalence of 12-year-old children in Chemniz town (Germany), where fluoridated water was implemented in 1959 and was interrupted for 22 months around the year 1971. The findings showed that water fluoridation was followed by a decrease of caries, and interruptions in fluoridation were followed by increasing caries levels (Kunzel & Fischer 1997).

The effectiveness of fluoridation is enhanced by its ability to reach all sections of a community and all age groups. This is the opposite to that of topical fluorides, where exposure occurs predominantly in children in families of upper socio-economic status and who seek dental care. Dental caries is socio-economically related—, for people who are disabled or unable to afford dental care, water fluoridation is a benefit to be valued highly (Brown 1989). Spencer, Slade and Davies supported the benefit of water fluoridation in the dental health of Australian children. Water fluoridation has been found to reduce socio-economic inequalities in caries, reducing the differential between high and low socio-economic status groups (Spencer, Slade & Davies 1996).

Riley, Lennon and Ellwood conducted a study on British children aged five years. The results of the study also found that the introduction of water fluoridation substantially reduces inequalities in dental health (Riley, Lennon & Ellwood 1999).

* *The cost-effectiveness of water fluoridation:* Firstly, water fluoridation has been shown to significantly reduce dental caries. Kunzel stated that a reduction in dental caries thus enables a saving to be made either in working time or in staff, who are expensive to train. This, in turn, makes it possible for a dentist to treat more patients or to provide more comprehensive and better dental care to the same number of patients. In his review of treatment cost savings, Kunzel showed that, on the basis of fillings and extractions carried out, the cost of each child in a low fluoride district (estimated at US $33.73) was double the cost of a child of the same age in a fluoridated town (US $13.86) (Kunzel 1974).

Whittle and Downer conducted a survey on British children living in fluoridated Birmingham and non-fluoridated Salford to compare dental health and the need for treatment of children in the two areas. They found that the relative cost of providing treatment for the caries diagnosed was some 50 per cent lower in the fluoridated area (Whittle & Downer 1979).

Secondly, the cost of water fluoridation is less than other preventive methods. Horowitz and Heifetz, when assessing cost-effectiveness of systemic fluoride procedures, found that the estimated cost per person per year for community fluoridation was $0.20, for a 1 mg fluoride tablet daily at school was $0.40, and for school fluoridation was $1.50 (Horowitz & Heifetz 1979).

Garcia demonstrated the annual costs per person of a caries prevention program in the United States in 1988: water fluoridation was $0.54, fluoride supplements were $2.53, fluoride mouthrinse was $1.30, school fluoridation was $4.56 and sealant prevention was $21.17 (Garcia 1989).

The cost for implementing and maintaining fluoridation in 44 Florida communities (USA) showed that the total cost per person based on the size of the population ranged from $0.14 to $5.21 at 2 per cent interest on the initial costs and from $0.14 to $5.93 at 4 per cent (Ringelberg, Allen & Brown 1992).

Ripa stated that 'Water fluoridation is one of the most cost-effective preventive dental programs and, indeed, may be one of the most cost-effective programs in health care' (Ripa 1993).

* *The safety of water fluoridation*: The regional offices of the World Health Organization and the International Dental Federation indicated that over 130 million people in major parts of the world have used water fluoridation around 1 ppm and any health hazard with this measure is extremely improbable (Ericsson 1974).

Newbrun and NHMRC indicated that there is no evidence that water containing optimal concentrations (0.7 – 1.2 ppm) of fluoride impairs general health and no link with allergies, Down's syndrome, heart disease and cancer (Newbrun 1977; NHMRC 1991).

1.5.2.2 Salt fluoridation

Salt fluoridation can be considered as an effective caries preventive alternative to drinking water fluoridation for developing countries with high caries prevalence where water fluoridation is not possible. Salt fluoride action is, therefore, more practical in countries that lack central water supplies and in areas with low fluoride concentration in the available drinking water (Fejerskov, Ekstrand & Burt 1996; Horowitz 1990).

Toth demonstrated the effectiveness of table salt fluoridation for reducing caries in the deciduous dentition in Hungarian children aged 2–6 years. Over a 5-year period, in the experimental group, which used fluoride salt containing 250 mg fluoride per kilogram, caries was reduced 40 per cent, whereas caries was increased 12 per cent in the control group. The difference between the two groups was significant (Toth 1972).

Toth later reported on an 8-year study with 250 mg F/kg domestic salt fluoridation. During this period the dmft value in the 6 – 8-year-old children reduced by 41 per cent, in the 7–11-year-olds the DMFT index decreased by 58 per cent, and in the 12–14-year-olds mean DMFT decreased by 36 per cent. The proportion of caries-free children also increased significantly, from 23 to 60 per cent, from 4.8 to 41 per cent, and from 2.7 to 8.4 per cent, respectively (Toth 1976).

Marthaler et al. observed results of salt fluoridation used in four countries: Switzerland, Columbia, Spain and Hungary. The results confirmed the effectiveness of salt fluoridation in reducing caries (Marthaler et al. 1978). Based on analysis of the literature on the caries preventive effect of fluoridated salt, Kunzel stated that salt fluoridation containing 250 – 350 mg F/kg can be considered as equivalent to fluoridation of drinking water, and a definite caries decline can be expected from its use (Kunzel 1993). In addition, the cost of marketing fluoridated salt, based on expenditure per person per year, is low. The technology for producing fluoridated salt in now well-tested and can be applied in most countries (Burt 1984).

In conclusion, salt fluoridation is also considered to be the best method of systemic fluoridation for developing countries (FDI 1984; Fejerskov, Ekstrand & Burt 1996; Horowitz 1990). However, salt consumption varied considerably among individuals and communities so that the average of salt consumption in each community should be checked before the concentration of fluoride in salt was decided (Fejerskov, Ekstrand & Burt 1996).

1.6 RATIONALE AND OBJECTIVES FOR THE PRESENT STUDY

1.6.1. Rationale for the present study

There are indications that oral disease in Vietnam is increasing, and dental caries and dental fluorosis still remain a considerable burden. There are many factors contributing to the prevalence of dental caries and fluorosis in Vietnam. The fluoride concentration in drinking water is considered to be one of the factors strongly related to the prevalence of both dental caries and fluorosis. The relationship between fluoride concentration in drinking water and dental caries and fluorosis was discovered 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 and dental caries and fluorosis in Vietnam has never been explored.

However, the prevalence of dental caries and fluorosis is also related to other factors such as socio-economic status, dietary habits, dental behaviours and the use of fluoride supplements, which in turn confound the relationship between fluoride concentration in the drinking water and dental caries and fluorosis. Therefore, the study not only investigates the relationship between fluoride concentration in the drinking water and dental caries and fluorosis but also examines the influence of other factors on dental caries and fluorosis.

Dental caries is at a high level in Vietnamese children according to the First National Oral Health Survey conducted in 1989. Dental fluorosis is an aesthetic problem in the affected areas. Vietnam is a developing, densely populated country. Equipment, instruments and materials needed for oral health care are inadequate. The lack of dental workforce is also a problem for oral heath care. Therefore, to improve the oral health of the population, intervention programs focusing on primary care and prevention should be designed and implemented. This study will investigate fluoride and oral health as a preliminary step toward fluoridation (water, salt) as a population-based preventive strategy for Vietnam. In addition to investigating fluoride as an effective measure to reduce dental caries, this study also investigates fluoride exposure to minimise dental fluorosis in the population.

1.6.2 The objectives of the present study

1. To describe the prevalence and distribution of dental caries and dental fluorosis in children aged 6 – 17 years nationally and residing in various areas.
2. To describe the distribution of drinking water sources in Vietnam and assess the fluoride concentration in the drinking water.

3. To examine the relationship between fluoride concentration in the drinking water supply and dental caries experience and dental fluorosis in Vietnamese children.
4. To examine the influence of socio-economic status, dietary habits, dental behaviours and the use of discretionary fluoride on dental caries experience and dental fluorosis.
5. To inform policy-makers about the relationship between fluoride concentration in the drinking water and dental health so as to promote the formulation of a policy on fluoridation and dental health in Vietnam.

CHAPTER 2

RESEARCH METHODOLOGY

2.1 STUDY DESIGN

The present study used a cross-sectional design and was part of the Second National Oral Health Survey of Vietnam conducted in 1999. Cross-sectional studies are suitable for determining the distribution and prevalence of diseases and the association between risk indicators and the diseases (Leeder & Wigglesworth 1988). Therefore, the relationship between the fluoride concentration in the drinking water and dental caries and, the relationship between the fluoride concentration in the drinking water and dental fluorosis in Vietnamese children could be determined using this methodology. This cross-sectional survey was designed to provide precise comparisons among geographical areas cross-classified by age group and to provide information on oral health parameters by dental examinations linked with fluoride exposure from drinking water. This study also provided information on children's socio-economic status, dietary habits, dental behaviours and discretionary fluoride exposure by social survey.

2.2 SAMPLING STRATEGY

2. 2.1. Sampling approach

The critical requirement for survey sampling is a representative sample for the whole population. The best way to achieve representativeness is through random selection from a population. The method used in this study was a multistage stratified random sample. The areas to be sampled were based on geographical regions, which cover the whole country (Moser & Kalton 1973). Vietnam was divided into seven areas based on defined geographic features, with a total of four cities and 57 provinces. From each area, two provinces were randomly selected. Therefore, 14 provinces were selected from these seven areas. Ha Noi and Ho Chi Minh (HCM) city were both purposefully selected. These two cities are the largest economic and political centers in Vietnam. The other 12 provinces were randomly selected from within lists of the provinces in each geographical area. For Ha Noi and Ho Chi Minh City, four districts from each city were selected randomly from unstratified lists of all districts in the city. Within the 12 other provinces, districts were identified and stratified into urban and rural. Where possible, one urban and one rural district were randomly selected from each province. In total, 32 districts were selected randomly from the two cities and 12 provinces. At each stage the probability of selection was proportional to population size. The selected provinces and the selected districts in each selected province are shown in Table 2.1.

Table 2.1: The selected provinces and districts

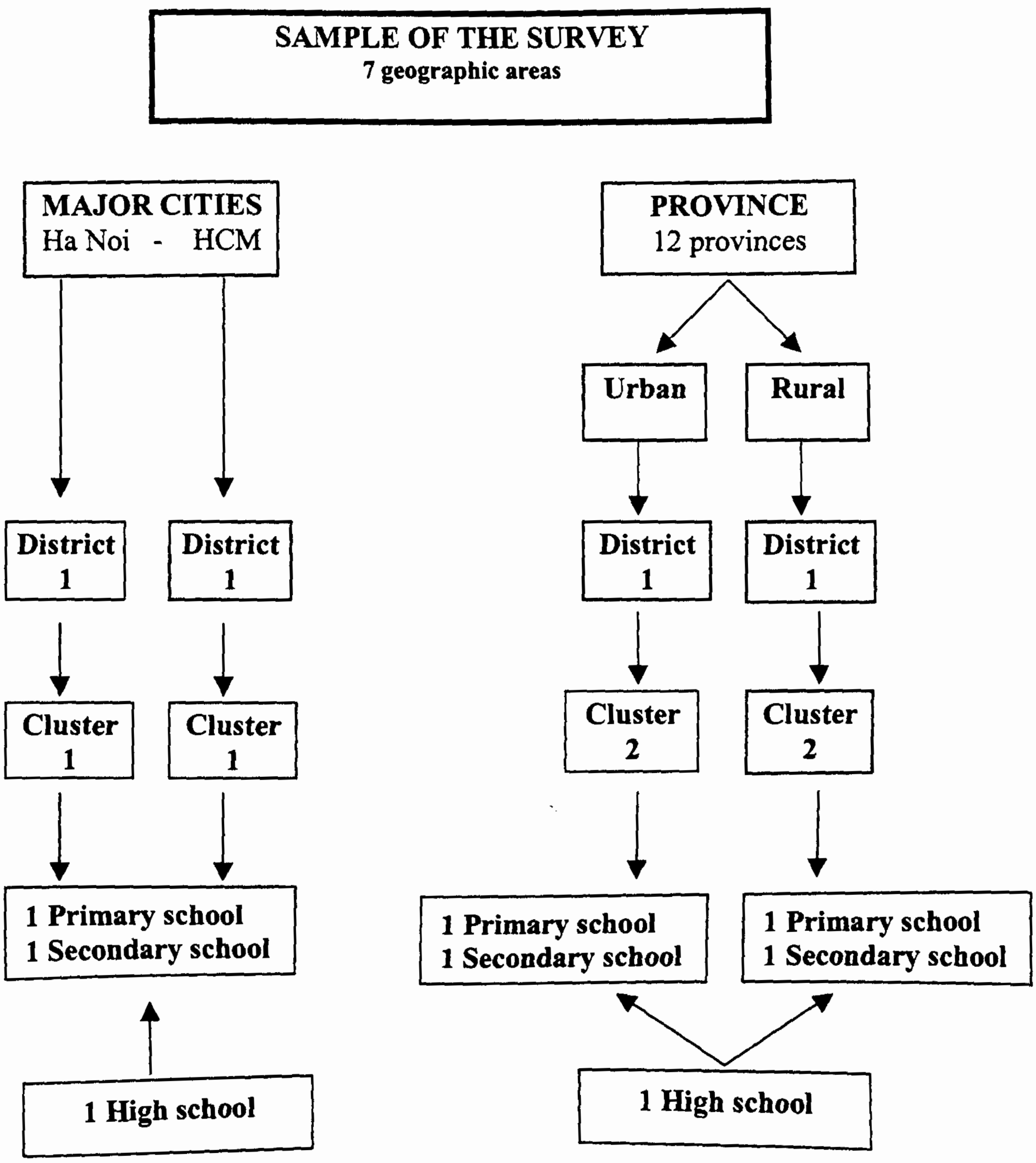
	Geographic areas	Sampled Provinces	Sampled Districts
1	**North Highland**	Lao Cai	Cam Duong Town Bao Thang District
		Ha Giang	Ha Giang Town Bac Quang District
2	**Red River Delta**	Ha Noi City	Dong Da District Gia Lam District Hai Ba Trung District Tu Liem District
		Ha Tay	Son Tay Town Ung Hoa District
3	**North Central Coast**	Quang Binh	Dong Hoi Town Quang Trach District
		TT-Hue	Hue city Phu Vang District

4	**South Central Coast**	Quang Ngai	Quang Ngai Town Nghia Hanh District
		Phu Yen	Tuy Hoa Town Dong Xuan District
5	**Central Highland**	Gia Lai	Pleiku Town A Yun Pa District
		Kon Tum	Kon Tum Town Dak Glei District
6	**North East South**	HCM city	I District IX District XI District Cu Chi District
		Baria-Vung Tau	Ba Ria Town Chau Duc District
7	**Mekong River Delta**	Tien Giang	My Tho city Cho Gao District
		Soc Trang	Soc Trang Town Dong Xuan District

The last stage in the sampling approach was selection of clusters, which were formed from the schools randomly selected from each district. Each cluster consisted of school children aged 6 – 17 years selected randomly from classes of Primary school, Secondary school and High school, who were classified into four age groups.

- Group 1 (6-8-year-olds) included first, second and third grades in Primary school.
- Group 2 (9-11-year-olds) included fourth and fifth grades in Primary school and sixth grade in Secondary school.
- Group 3 (2-14-year-olds) included seventh, eighth and ninth grades in Secondary school.
- Group 4 (15-17+ year-olds) included tenth, eleventh and twelfth grades in High school.

Within each district all schools were identified. For each selected district within Ha Noi and Ho Chi Minh City, one cluster was selected randomly, while two clusters were selected for each urban and rural district in the other provinces. This created a total of 56 clusters of selected schools. Again, at each stage the probability of selection was proportional to population size. The diagram of the selection procedure is shown below:



2.2.2. Selecting schools

The schools in the cluster were selected randomly based on the lists of schools in the selected districts, which were provided by the Institute of Odonto-Stomatology of Hanoi.

- In Ha Noi and HCM cities four districts were selected randomly and in each selected district one cluster was selected. In each cluster, one Primary school was selected randomly. Then the Secondary school, which was nearest the selected Primary school was selected. After that, one High school was randomly selected for each cluster. This created 8 clusters for Ha Noi and HCM cities.

- In the urban and rural districts of provinces two clusters were selected in each district. For each cluster, one Primary school was selected randomly. The Secondary school which was nearest the selected Primary school was then selected. One High school was randomly selected for every two clusters in each district. Therefore, the number of children to be selected in these High schools in the age group 4 years was double that of other age groups. This created 48 clusters for 12 provinces.

In the study a total of 56 clusters was formed from the two cities and 12 provinces.

2.2.3. Selecting subjects

The sample size for the study was considered to require inflating by 20 – 60 percent for the cluster design effect. This was a consequence of the relationship between the expected standard error of the survey and the standard error of a simple random sample (Levy & Lemeshow 1980; Australian Bureau of Statistics unpub). In Vietnam children aged 6–17 years represent nearly one quarter of the population, which was approximately 75 million people in 1996 (General Statistical Office 1997). Therefore, to achieve an accurate representativeness of sample size for whole the population, the number of children randomly selected was estimated with a 40 per cent design effect. It was calculated to be nearly 3,000 children (Szuster, F.S.P. 1998, pers. comm., June).

After selecting the schools for each cluster, the number of children in each class of each selected school was recorded. Based on the number of children in each class, the contacting person selected subjects according to the rules below. The selection of subjects was conducted separately for each age group.

- Step 1 - <u>choosing a random number to select subjects</u>: take the first two digits on a piece of paper money. This will be the random number. This random number indicates the position on the class list of the children to be selected in each class. For example, a school with 18 classes in the age group A (6–8-year-olds) has 18 school lists of children in the class. If the random number is 10, then the 10th child on each of the 18 class lists was selected. These children were placed on the Schedule for the survey. If the random number was not suitable because the number of children in class was limited, the last two digits were taken. If it still was not suitable, a randomly selected number from another piece of paper money was chosen until a suitable number was found.

  * For example: For group A, if the number on the paper money was: AH 8775635. The number 87 was too large; 35 was OK. Then child number 35 was selected from the list of all classes in group A and placed on the Schedule. If there were not sufficient classes to get at least 12 children, another piece of paper money was used to select another random number to select additional children.

- Step 2 - <u>choosing a random number for omitting subjects</u>: The random number denoted by month of birth was used to omit subjects if the randomly selected subjects were greater than 14. For example, there were 22 classes in age group A and 22 children were recorded on the Schedule. The number of a month of birth was chosen. This might have been 7. All of the children born in July were then excluded from the representing Schedule. If this random number was not suitable (eg no child was born in this month) or the total number of children selected was still too high, then another random number representing a month was chosen. The number of selected children in each age group required at least 12 subjects.

Finally, the number of children that should be selected in a cluster was at least 48 subjects and for the whole survey was at least 2,688.

2.3 DATA COLLECTION

2.3.1 Fieldwork processes

The Second National Oral Health Survey of Vietnam 1999 was conducted with the assistance of the Dental Statistics and Research Unit of the Australian Institute of Health and Welfare, Adelaide University, Australia. The proposal, sampling design, questionnaire form and examination form were designed at Adelaide with the assistance of two Vietnamese postgraduate dental students studying at Adelaide University (including the author). The documents and material for dental examination and water collection were sent to the Hanoi Institute of Odonto–Stomatology before commencing the survey in the second half of 1999.

In September 1999 local dentists from the selected districts gathered in the Institute of Odonto–Stomatology of Ha Noi and HCM cities to be advised about the selection process and procedures for the Survey, and plan to the schedule for the dental examinations. After the meeting these local dentists returned to their districts to prepare for the Survey. The selected schools were informed and questionnaire forms were sent to the selected children two weeks before the scheduled dental examinations.

Each Institute of Odonto-Stomatology in Ha Noi and Ho Chi Minh City selected eight dentists who were invited to participate in the survey. The participating dentists were then trained in the survey methodology over a one-week period by two oral epidemiologists. The training program was supervised by Professor AJ Spencer and Dr KR Thomson from the AIHW Dental Statistics and Research Unit of Adelaide University. The training covered dental caries, dental fluorosis and periodontal criteria discussions and calibration exercises. After training, six participants from each institute displaying the most consistency in the test-retest exercises were selected to conduct the survey and formed a team of examiners. Hence, teams were formed from the Institute of Odonto–Stomatology of Ha Noi and HCM cities, respectively. The team from Ha Noi conducted the dental examinations in the Hanoi city and six selected northern provinces and the other team from HCM city conducted the dental examinations in the HCM city and six selected southern provinces. Some mixing of the examiners occurred in TT-Hue and Quang Ngai provinces and HCM city.

2.3.2 Ethical considerations

Ethical clearance was obtained from both of Adelaide University's Committee in Experimentation with Human Subjects and the Ethics Committee of the Dental Statistics and Research Unit of the Australian Institute of Health and Welfare (AIHW).

A number of ethical issues needed to be addressed before implementing the study. The major ethical issue to be considered was the voluntary participation of children in the survey. The children in the survey and their parents had the right to ask any questions about the survey or their participation. Signing the consent form by the child's parent was not required, due to specific cultural and political imperatives in the Vietnamese community.

Therefore, local dentists and administrators in selected schools informed a selected child's parent about the aims, the procedure and the ethical issues of the survey and sought their active participation.

During the dental examination, children were informed about their dental status and recommended dental care by the examiner who conducted the oral examination. All information collected for the study was strictly confidential.

2.3.3 Social survey

Parents of selected children were asked to complete a specific parent questionnaire (Appendix A), which was sent to all parents of selected children before the children had their dental examination. In the questionnaire parents were asked to provide the following details about their child:

- Personal data: child's name, address and age.
- Social characteristics: parental education, occupation, household income, living arrangements and kind of transport and television used.
- What sources of water for drinking and cooking were used daily.
- Dental behaviours: age commenced brushing teeth and brushing with toothpaste, the kind and frequency of toothpaste and mouthrinse used.
- Dental care: the frequency of dental visits, the reason and treatment received by the child at dental visit in the last two years.
- Dietary habits: The kind and frequency of the consumption of sweets, beverages and sugar by the child and the child's family.

Before having the dental examination, the child had to have a questionnaire completed by the child's parent or guardian. The questionnaire was collected by the dental examiner when the child attended for the dental examination.

2.3.4 Dental examination

Dental examinations were conducted at a dental clinic or in a suitable room in the school at scheduled times. The children were examined according to lists arranged previously by local dentists. The children in Primary and Secondary schools were examined with the child supine, but the children in high schools sat on a chair with headrest for the dental examination. Calibrated examiners conducted all dental examinations using intra-oral fibre optic lights 'Denlite' with disposable mirror and CPI probes. All examiners used protective glasses, mask and single use examination gloves. The place and equipment for examinations were organised to ensure that all examiners used identical equipment and had the same working conditions. Infection control procedures were closely followed for the whole survey.

Each dental examination took between 10 and 20 minutes. The data for each child were recorded on an examination form (Appendix B). The completed examination form and questionnaire of each child were stapled together and stored in special boxes marked with the name of the school, district and province.

The dental examinations were conducted as scheduled except for examinations in two provinces, Phu Yen and Kon Tum, and HCM city. These provinces and HCM city were surveyed two months later than scheduled because of local flooding at the scheduled time.

2.3.4.1 Clinical assessments

At the dental examination the children were examined for caries experience, dental fluorosis and periodontal status, which included gingival and calculus status. At the examination dental fluorosis was assessed first, then the caries experience, and then the periodontal status.

♦ ***Dental fluorosis assessment:***

Dental fluorosis was assessed using Dean's index and observed on wet teeth. The indices and criteria for examination were modified from basic methods of the World Health Organization (WHO 1997). Two extra criteria, one for assessing non-fluoride enamel defects and one for teeth which could not be given a definitive diagnosis, were added to satisfy the requirement of survey. The indices and criteria of dental fluorosis are shown in Appendix C_1.

Dental fluorosis was assessed on four teeth, 12, 11, 21 and 22, and each tooth was scored. If there was any doubt in assigning a score the tooth was given a lower score. In the first instance, the examiner assessed whether or not the child had dental fluorosis by an overall view of all teeth such as the premolar and cuspid to ensure correct diagnosis. The differential diagnosis of dental fluorosis and non-fluoride enamel opacities was based on Russell's criteria (Russell 1961) and modified to include severe symptoms of dental fluorosis to improve differential diagnosis (Appendix C_1). If there was fluorosis, the criteria were followed to find out an appropriate score. If the tooth surface had plaque, gauze was used to clean the tooth surface. The codes used to assess dental fluorosis are shown in Table 2.2.

Table 2.2: The codes were used to assess dental fluorosis

Code	Assessments
Code **0** (Normal)	Tooth presents normally.
Code **1** (Questionable)	A definite diagnosis of the mildest form of fluorosis was not warranted but a classification of 'normal' was not justified.
Code **2** (Very mild)	Total of enamel affected was less than 25 per cent.
Code **3** (Mild)	Total of enamel affected was less than 50 per cent.
Code **4** (Moderate)	Entire enamel surface was affected with chalky colour, may have brown stain, a few pits and chips on incisal edges.
Code **5** (Severe)	Enamel surface was badly affected, diagnostic signs were pits, hypoplasia, brown stain, and remaining intact enamel was chalky colour.
	There is no code 6.
Code **7**	Enamel was affected by non-fluoride enamel opacities.
Code **8** (Excluded)	Tooth was not fully erupted or tooth had a crown, big filling or fixed orthodontic band.
Code **9** (Not recorded)	Examiner could not give a correct diagnosis.

- ***Dental caries experience assessment:***

The US National Institute of Dental Research criteria were used to assess caries experience for children (Appendix C_2).

Dental caries was examined following the logical process of the examination form. The examiner started with the occlusal surface of the second molar in the upper right jaw (Maxilla) through to the lingual surface of the second molar on the upper left. Then, starting with the occlusal surface of the second molar on the lower left jaw (Mandibular) through to the lingual surface of the second molar on the lower right. The examiner assessed the tooth surfaces in the following order: occlusal, mesial, buccal, distal and lingual for the posterior teeth, and mesial, labial, distal and lingual (palatal) for the anterior teeth.

A probe was used only with light pressure and to confirm visual observations. If the primary tooth and its permanent successor tooth were both present, only the permanent tooth was recorded. The 'ONE THIRD RULE' was used for restorations or carious lesions, which extended circumferentially around a tooth, while any extension from the occlusal surface was regarded as an additional surface involved. Ideally the tooth was dried before examining.

There are six possible codes for primary teeth and nine possible codes for permanent teeth, indicating the status of each surface of each tooth. Each surface of each tooth was assessed and its status recorded by one score. Third molars were not recorded. The codes used to assess dental caries are shown in Table 2.3.

Table 2.3: The codes used to assess dental caries

Code	**Assessments**
Code **A** and **0** (Code **A** for primary tooth or Code **0** for permanent tooth)	Sound surface.
Code **B** and **1** (Code **B** for primary tooth or Code **1** for permanent tooth)	Decayed surface.
Code **C** and **2** (Code **C** for primary tooth or Code **2** for permanent tooth)	Filled surface due to decay with no additional decay surface.
Code **D** and **3** (Code **D** for primary tooth or Code **3** for permanent tooth)	Surface filled due to decay with additional decay on the same surface.

Code **E** and **4** (Code **E** for primary tooth or Code **4** for permanent tooth)	Missing surface due to decay.
Code **5**	Missing surface due to other reasons not related to caries. This code was only used for permanent teeth, and the reason for extraction was not evaluated in the primary dentition.
Code **6**	Adhesive preventive sealant. If it was used as a restorative material, the surface was scored as filled (Code 2). This code was only used for permanent teeth, primary teeth were not evaluated.
Code **T** and **7** (Code **T** for primary tooth or Code **7** for permanent tooth)	Trauma to surface.
Code **U**	Unerupted tooth or congenitally absent. This code was only used for permanent teeth, primary teeth were not evaluated.
Code **X**	Surface was not assessed. This code was only used for permanent teeth, primary teeth were not evaluated.

♦ ***Periodontal status assessment:***

Periodontal status was determined using the WHO criteria.

a. **Gingival assessment:** the buccal and mesial sites of the teeth 16, 11, 26, 36, 31 and 46 were assessed. The CPI probe was inserted no more 2 mm into the gingival sulcus, starting at the distal line angle of the buccal surface, and was then moved gently toward the mesial interproximal area. Teeth were gently dried with gauze if needed and each tooth was recorded a score. The codes used to assess gingival status are shown in Table 2.4.

Table 2.4: The codes used to assess gingival status

Code	Assessments
Code **0**	Gingival bleeding does not occur when moving probe.
Code **1**	Gingival bleeding occurs at any site when moving probe.
Code **Y**	Examiner cannot assess or tooth missing.

b. **Calculus assessment:** The buccal and lingual surfaces of the teeth 16, 11, 26, 36, 31 and 46 were assessed. Examiner used the CPI probe to feel the buccal and lingual aspects of each tooth to determine the presence of either sub- or supra-gingival calculus. Teeth were gently dried with gauze if need. Each tooth was recorded a score. The codes used to assess calculus status are shown in Table 2.5.

Table 2.5: The codes used to assess calculus status

Code	Assessments
Code **0**	Calculus could not be detected at any supra- or sub-gingival site by using visual or tactile sense.
Code **1**	Calculus was detected at a supra- or sub-gingival site by using visual or tactile sense.
Code **Y**	Examiner cannot assess or tooth missing.

In the analysis of calculus, Code 1 and Code 2 were grouped as Code 1 (Appendix C_3).

2.3.4.2 Reliability of survey

There were two dental teams to conduct the survey. The dental team in the North worked in the seven northern provinces and the other team worked in the seven southern provinces. To improve the consistency of the survey, calibrated examiners in the two teams were combined in three provinces: Quang Ngai, TT-Hue and HCM city. Two examiners in the southern team examined together with the northern team in the Quang Ngai and TT-Hue provinces and conversely, two examiners from the northern team worked with the southern team in HCM City.

Approximately ten per cent of children were re-examined during the survey to assess intra- and inter-examiner reliability. The children who had a re-examination were selected randomly from the list of children. The re-examination was conducted on the same day as the dental examination with the interval between the two examinations being about two hours. The re-examination form was stapled with the questionnaire form and original examination form. The data from the re-examinations were classified separately once the data had been entered into a computer. Kappa scores were used to measure the agreement among dental examiners (Landis & Koch 1977), and the extent of examiner reliability is indicated by the scores as shown Table 2.6.

Table 2.6: Reliability statistics

Kappa Statistic	Strength of Agreement
< 0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost perfect

The questionnaire forms, examination and re-examination forms were gathered and sent to the Institute of Odonto-Stomatology of Ha Noi. All questionnaire, examination and re-examination forms were reviewed, packed and sent to the AIHW Dental Statistics and Research Unit at Adelaide University.

2.3.5 Collecting and analysing water samples

After finishing the dental examinations for children in each cluster, completed questionnaires from each school (primary, secondary and high) were checked to locate the sources of water used daily for cooking and drinking. Water samples were collected from each of the different water sources at a convenient location close to each school.

The rules of collecting water samples were:

- If the whole cluster of children used one water source for drinking and cooking, five water samples were taken from that source.
- If the whole cluster used more than one water source for drinking and cooking, three water samples were taken from each of those water sources. Water samples were collected firstly from the water sources which the primary school subjects used daily. If the secondary and high schools subjects used the same water source, these sources were recorded 'as above'. If they used a different source of water or one from a different supply, further samples were collected from these sources.
- Water samples were collected from the original water source, and were not mixed with that from any other water source.

For each water sample, 50 ml water was collected in a sterile polyethylene bottle to which several Thymol crystals had been added to prevent fungal growth and bacterial contamination. The bottles were closed firmly and clearly labelled with permanent ink showing the number of the sample, the name of the water source, the province-district-school code, the date of collection and the name of the collector.

Nearly 500 water samples were collected for the whole survey, and were sent to the Institute of Odonto–Stomatology of Ha Noi for measurement of fluoride concentration. All water samples were measured by the ORION Model 96-09 Combination Fluoride Electrode. Total Ionic Strength Adjustor Buffer II (TISAB II), used to provide constant background ionic strength, to avoid the formation of hydrogen complexes of fluoride and to adjust solution pH, was added to the water samples as well as fluoride standards (0.01, 0.1, 1.0, 10.0 and 100.0 ppm). Based on the millivolts, which was obtained from measuring fluoride standards, a calibration curve was drawn on graph paper. Fluoride concentrations in the water sample were determined by the change from millivolts, which were measured by the ORION electrode and converted to ppm according to the calibration curve of fluoride standards. The fluoride concentrations in the water samples can be seen in Appendix D. The equipment and solutions for collecting water and analysis of the water samples were provided by Adelaide University.

2.4 DATA PREPARATION

Data preparation was done after data from the survey were entered on to a computer and before being analysed.

2.4.1 Data preparation for questionnaires

Firstly, the age of survey children was calculated by year. Therefore, the age of children in the Phu Yen and Kon Tum provinces and HCM city, which were surveyed in January 2000, were re-recorded as what they would have been if they were surveyed in 1999. This was done for age to be consistent among all children in the survey.

Secondly, in validating the survey response to the question on the source of water for daily use, it was discovered that some respondents were confused between the terms used to describe well-water, bore-water and tap-water. These were corrected after site visits to validate the responses in the questionnaire. This happened in some areas of the Ha Tay, Dong Hoi, Quang Ngai, Gia Lai and Kon Tum provinces.

Finally, some questions in the questionnaire were not completed by some respondents. Where incomplete questions had a logical link with other questions that were completed, detail of the incomplete question was obtained from the completed question. This method of data cleaning was performed for the following questions of the survey:

In part C:

- Question C-2 asked about the child brushing and question C-3 asks about the age when the child started brushing teeth. If question C-3 was completed and indicated that the child did brush his/her teeth then question C-2 was assumed to be 'yes' the child did brush his/her teeth.
- Similar adjustments were performed for question C-5, which asked about the child using toothpaste, and question C-6, which asked about the age when the child started brushing with toothpaste.
- Question C-11 asked about the child using mouthrinse and question C-12 asked about the brand name of mouthrinse. Therefore, if question C-12 was completed, but not question C-11, then the response to question C-11 was assumed to be 'yes' the child did use mouthrinse.

In part D:

- Question D-3 asked about the child receiving dental treatment in the last two years and question D-4 and D-5 asked about the reason and the treatment received in the last two years. If question D-4 and D-5 were completed, but not Question D-3, then a response to question D-3 of 'yes' the child did receive dental treatment was assumed, and if question D-3 was answered 'No', the answers to questions D-4 and D-5 were excluded.

2.4.2 Data preparation for clinical assessments

The scores for fluorosis were recoded in accordance with the scores of WHO's Basic Methods 1997. To prepare for analysis, these scores were recoded to reflect the scores in Dean's index:

The score '0 – Normal'	Scored as 0
The score '1 – Questionable'	Scored as 0.5
The score '2 - Very mild'	Scored as 1
The score '3 – Mild'	Scored as 2
The score '4 – Moderate'	Scored as 3
The score '5 – Severe'	Scored as 4

2.4.3 Estimation of the fluoride exposure from water samples for the individual

According to the methods of subject selection and the collection of water samples, the estimated fluoride concentration in drinking water for individuals was:

- For children in Primary and Secondary school: The estimated fluoride concentration in drinking water was calculated as the average of the fluoride concentrations of water samples from each source collected near their Primary and Secondary schools. The assumption is that children in Primary and Secondary schools generally live close to their school.
- For children in High school: Each town or district consisted of two clusters of Primary and Secondary schools, but only one high school was selected and children in High school live anywhere in a town or district. Therefore, the fluoride

concentration of their drinking water was estimated as the average of the fluoride concentrations of all water samples from each source collected in the town or district.

- For the children using more than two sources: The fluoride concentrations of drinking water were estimated as a weighted average of the fluoride concentrations of all water sources, the weights being proportional to the percentage of children reported as using the water sources.

2.5 KEY VARIABLES

Variables from the Second National Oral Health Survey of Vietnam 1999 were used for descriptive and inferential analysis to examine the relationship of fluoride concentration in drinking water with dental caries and dental fluorosis in Vietnamese children, and other factors affecting this relationship. The variables were classified into two classes: dependent variables and independent variables.

2.5.1 Dependent variables

The oral health outcome variables recorded in the dental examinations were treated as dependent variables. These variables were calculated to describe the prevalence and extent of dental diseases at the individual and cluster level in four age groups.

2.5.1.1 Dental caries

Based on the data from the dental examinations, the frequency and mean of the number of decayed, missing and filled surfaces in primary teeth (dmfs) and permanent teeth (DMFS) were used as dependent variables to describe the prevalence and extent of dental caries in children. Dental caries in the primary teeth were only observed in the age range 6 – 11 years due to the fact that primary teeth are mostly exfoliated at age 11 years.

The dmfs and DMFS were calculated as below:

- The number of decayed surfaces (ds for primary teeth and DS for permanent teeth) included the decayed surfaces recorded as code B or 1 and the filled surfaces with decay recorded as code C or 2.
- The number of missing surfaces due to decay (ms for primary teeth and MS for permanent teeth) included the missing surfaces recorded as code E or 4.
- The number of filled surfaces (fs for primary teeth and FS for permanent teeth) included the filled surfaces without decay recorded as code C or 3.

2.5.1.2 Dental fluorosis

The percentage of children with different fluorosis scores and the mean of Community Fluorosis Index (CFI) were used to demonstrate the prevalence and severity of fluorosis in Vietnamese children.

A fluorosis score was assigned to each individual by Dean's method. Based on the score of the four teeth, the score of the worst degree of fluorosis found on at least two teeth was assigned (Horowitz 1986).

The Community Fluorosis Index (CFI) was also calculated by Dean's method (Horowitz 1986). It is the frequency of each score (normal to severe) multiplied by its numerical weighting (0 to 4) and the sum of these products is divided by the number of persons surveyed. The formula is:

$$\text{CFI} = \frac{\Sigma(\text{Weight} \times \text{Frequency})}{\text{No of persons}}$$

The Community Fluorosis Index was used to demonstrate the public health significance of fluorosis. It was classified into six levels as shown in Table 2.7.

Table 2.7: Public health significance of CFI Scores

Range of score for Community Fluorosis Index (CFI)	Public Health Significance
0.0-0.4	Negative
0.4-0.6	Borderline
0.6-1.0	Slight
1.0-2.0	Medium
2.0-3.0	Marked
3.0-4.0	Very Marked

In the opinion of Dean, CFI scores below 0.4 have no public health significance. The CFI scores of 0.4 or higher were considered as having increasing public health concern. CFI scores progressed to a maximum of 4.0.

2.5.2 Independent variables

Fluoride concentration in water samples and data from the questionnaire were considered as independent variables and their relationship with dental caries and dental fluorosis examined.

2.5.2.1 Fluoride concentration in drinking water

Fluoride concentration was estimated for each individual from water samples.

2.5.2.2 Data from the completed questionnaire

These data were also used as independent variables and were divided into four groups:

Socio-economic factors:

- Sex of survey children: According to the report of the child's parent and matched with the identification in the dental examination: Male or female.
- Residency: Urban and rural were classified by the location of the school which the child attended.
- Household crowding: The number of people who live with the child, classified into three groups: less than five people, from five to seven people and more than seven people.
- Family income: Based on Vietnamese currency, family income was categorised into three groups. The low income group ranged from one up to 400,000 DVN; the medium income group ranged from 400,001 to 800,000 DVN; and the high income group was over 800,000 DVN (US$ 1 ≈ 15,000 DVN).
- Mother's education: Based on the school the child's mother attended and was classified into three groups. Low education level was recorded if the child's mother did not attend school or only attended Primary school. Medium education level was recorded if the child's mother attended Secondary or High school. High education level was recorded if the child's mother attended TAFE trade (colleges) or a tertiary institution.
- Father's education: Based on the school the child's father attended and was classified into three groups. Low education level was recorded if the child's father did not attend school or only attended Primary school. Medium education level was recorded if the child's father attended Secondary or High school. High education level was recorded if the child's father attended TAFE trade (colleges) or a tertiary institution.

- Mother's occupation: the current occupation of the child's mother was classified by six categories: farmer, manual worker, professional and office worker, private business, home duties and other occupations.
- Father's occupation: the current occupation of the child's father was classified by six categories: farmer, manual worker, professional and office worker, private business, home duties and other occupations.

Dietary habits:

- Using fish sauce or salt: Classified by what the child's family uses: fish sauce, cooking salt, both of them, neither and other.
- Eating candy: Based on the parent's report, their child uses or not (Yes or No).
- Eating ice cream: Based on the parent's report, their child uses or not (Yes or No).
- Eating biscuits: Based on the parent's report, their child uses or not (Yes or No).
- Drinking soft drink: Based on the parent's report, their child uses or not (Yes or No).
- Drinking juice fruit: Based on the parent's report, their child uses or not (Yes or No).
- Drinking tea: Based on the parent's report, their child uses or not (Yes or No).
- Adding sugar in drinks: Classified by the child's habit: often, sometimes and never.
- Using sugar for cooking: Classified by the child's family habit: often, sometimes and never.
- Eating fruit: The frequency of eating fruit was classified into two groups. The at most once a day group consisted of children who reported they ate fruit once a day or never. The at least twice a day group consisted of children who reported they ate fruit two, three or more times per day.

Dental behaviours:

- Brushing teeth: Based on the parent's report, their child brushes her/his teeth or not (Yes or No).
- Frequency of brushing teeth: Classified into two groups. The less than twice a day group included children who reported brushing teeth once a week, several times a week or once a day. The at least twice a day group included children who reported brushing teeth twice, three times or more a day.
- Age commenced brushing teeth: Classified into three groups: at three years old or earlier, older than three years and do not know group.
- The frequency of dental visits: Classified into five groups: less than six months, between six months and 12 months, between 12 months and 24 months, more than 24 months and never.
- Dental visits: Based on the frequency of dental visits, classified into two groups. 'Yes' group consisted of children who answered the question about frequency of dental visits. 'No' group consisted of children who had not had a dental visit.

Discretionary fluoride:

- Using toothpaste: Based on the parent's report, their child uses or not (Yes or No).
- Age commenced brushing with toothpaste: Classified into three groups: at three years old or earlier, older than three years and do not know.
- Amount of toothpaste used: Classified into four groups: smear, pea size, full length and do not know.
- Using mouthrinse: Based on the parent's report, their child uses or not (Yes or No).
- The kind of mouthrinse used: Classified by the brand name of mouthrinse used.

These dependent and independent variables were regarded as key variables of this study. Key variables were fundamental data used for descriptive and inferential analysis to demonstrate the objectives of this study.

2.6 DATA ANALYSIS

The computing program d-Base on the Microsoft Access program was used to design a form for entering data and basic variables for analysis. All data were entered and transferred to SPSS for Windows 9.0 program for analysis. Before analysis, all data were checked again and cleaned to achieve logical data.

Unweighted data were used for statistical analysis. Descriptive statistics using frequencies and distributions of means were used to describe the prevalence and the distribution of dental caries and fluorosis in children at child and cluster level in four age groups. The descriptive statistics were also used to describe the social characteristics and other factors of the children.

The relationship between dental caries, dental fluorosis and fluoride concentrations in the drinking water was explored by linear regression at cluster level in four age groups. Statistical tests of association between social economic factors, dietary habits, dental behaviours and the use of discretionary fluoride and dental caries and fluorosis at the subject level were tested using analysis of variance (ANOVA). These factors were felt to independently affect the relationship of dental caries and fluorosis with the fluoride concentration in the drinking water. The potential confounding of the relationships between fluoride concentration in water and dental caries, and fluoride concentration in water and fluorosis, were controlled by using multivariate linear regression on categorical scale.

Unstandardized regression coefficients, P values (P values less than 0.05 were considered statistically significant) of dummy variables in each factor and R square, Adjusted R square and P value of the model are reported. To achieve better statistical results, the fluoride concentrations were transformed logarithmically to analyse their relationship with dental caries and confounding factors.

CHAPTER 3

RESULTS

3.1 RESPONSE RATE

The response rate for selected provinces is shown in the Table 3.1. The total number of randomly selected children in the survey was 2,805, of which 2,762 were examined and had completed questionnaires. The response rate by province ranged from 92 to 100 per cent. The overall response rate obtained was 98 per cent. The response rate by age groups and by clusters can be seen in the Appendix E.

Table 3.1: The response rate for 14 surveyed provinces

	Area	Number children expected	Number children attended	Participation percent
1	Lao Cai	202	198	98%
2	Ha Giang	210	206	98%
3	Ha Noi city	200	198	99%
4	Ha Tay	209	208	99%
5	Quang Binh	204	204	100%
6	TT- Hue	194	194	100%
7	Quang Ngai	197	197	100%
8	Phu Yen	196	196	100%
9	Gia lai	194	180	94%
10	Kon Tum	196	196	100%
11	HCM city	207	207	100%
12	Baria–Vung tau	200	185	92%
13	Tien Giang	199	197	99%
14	Soc Trang	197	196	99%
	Total	**2805**	**2762**	**98%**

3.2 RELIABILITY OF SURVEY DATA

Intra-examiner reliability was determined by re-examining four per cent of the study participants and 5 per cent of study participants were re-examined for inter-examiner reliability. Reliability was calculated using the Kappa statistic (Landis & Koch 1977), presented in Table 3.2. Intra-examiner and inter-examiner variability for the diagnosis caries in primary and permanent teeth, dental fluorosis and periodontal status were found to be minimal. The ranges of Kappa value obtained indicated substantial to almost perfect agreement between examiners and almost perfect agreement within examiners. The excellent Kappa statistics for dmfs and DMFS scores for intra-examiner reliability were 0.96 and 0.98, respectively. Excellent inter-examiner reliability scores also were obtained for dental caries, 0.91 for dmfs and 0.93 for DMFS. The excellent agreements of intra-examiner and inter-examiner in the diagnosis of dental fluorosis were 0.96 and 0.80, respectively. There were good agreements in the diagnosis of calculus status and bleeding status. However, reliability for bleeding status was more difficult to assess due to the second examination either reflecting earlier bleeding or gingival tissues becoming too sensitive to additional probing.

Table 3.2: Reliability of examinations

Kappa value		**Intra-examiner (n = 100)**	**Inter-examiner (n = 146)**
Dental caries	dmfs	0.96	0.91
	DMFS	0.98	0.93
Dental fluorosis (Dean's index)		0.96	0.80
Bleeding status	(Present = 1)	0.84	0.76
Calculus status	(Present = 1)	0.88	0.71

3.3 SOCIAL CHARACTERISTICS OF SURVEY CHILDREN

Social characteristics of surveyed children were obtained from the questionnaire completed by parents. It included details of the child, family circumstances and the child's parental education and occupations.

The total number of children examined in the survey was 2,762, divided into four age groups. The proportion of subjects in each age group is nearly equal (Table 3.3).

Table 3.3: Participation by age group

Age group	N	%
6-8 year olds	705	25.5
9-11 year olds	629	25.1
12-14 year olds	695	25.2
15-17+ year olds	670	24.3
Total	**2762**	**100.0**

The proportion of children by sex in the survey is given in Table 3.4. The proportion of males was slightly lower than females. This proportion was similar to the distribution in the population (General Statistical Office 1997).

Table 3.4: The distribution of surveyed children and population by sex

Sex	Survey		Population	
	N	%	N	%
Male	1339	48.7	36,773,300	48.8
Female	1409	51.3	38,581,900	51.2
Total	**2748**	**100.0**	**75,355,200**	**100.0**

N = 2762. Missing = 14 (0.5%)

The number of surveyed children in urban areas was higher than in rural areas, due to the fact that Ha Noi and HCM cities were purposely selected. Urban children therefore comprised 57.5 per cent and rural children only 42.5 per cent of the sample (Table 3.5).

Table 3.5: The distribution of surveyed children by residence

Residence	N	%
Urban	1588	57.5
Rural	1174	42.5
Total	**2762**	**100.0**

N = 2672

The number of people living in a household was categorized into three groups. The proportion of households with less than five people in a house was nearly equal to the proportion of households with five to seven people. Households having more than seven people were not frequent (Table 3.6).

Table 3.6: Household crowding status of surveyed children

Household crowding	N	%
< 5 people	1229	46.4
5 – 7 people	1221	44.2
> 7 people	197	7.4
Total	**2647**	**100.0**

N = 2762. Missing = 115 (4.2%)

The distribution of children's family income is represented in Table 3.7. Most was in the low-income group (40.8 per cent), and the lowest percentage was in the high-income group, only 23.1 per cent. Medium incomes were represented by 36.1 per cent.

Table 3.7: The distribution of children by family income

Family income	N	%
Low income (1-400,000 DVN)	1089	40.8
Medium income (400,001-800,000 DVN)	962	36.1
High income (> 800,001 DVN)	615	23.1
Total	**2666**	**100.0**

N = 2762. Missing = 96 (3.5%)

In order to investigate parental education, education level was evaluated by the highest level of school the children's parents had attended. The parental education level is shown in Table 3.8. It shows that the majority of both mothers and fathers had achieved the medium education level, 54.1 per cent for mothers and 59.8 percent for fathers. High education level was least common, with fewer mothers than fathers having attended trade or tertiary education, 15.4 and 18.0 per cent, respectively. In contrast, mothers had a higher percentage in the low education level than fathers did, 30.5 and 22.3 per cent, respectively.

Table 3.8: Parental education level

Parent's education	Mother		Father	
	N	%	N	%
Low education (not attended school or attended Primary school)	817	30.5	578	22.3
Medium education (attended Secondary school or High school)	1451	54.1	1552	59.8
High education (attended TAFE trade or tertiary)	414	15.4	466	18.0
Total	**2682**	**100.0**	**2596**	**100.0**

N = 2762. Missing = 80 (mother); 166 (father)

Parent's occupation was classified into six categories. Farmer was the most common occupation for both mother and father. Other occupation and manual worker were the least common mother's occupations, only 1.7 and 8.9 per cent, respectively. For fathers, home duties were lowest, only 2.5 percent, and other occupation also was low (4.9 per cent). In all social occupations, fathers had higher percentages than mothers. However, mothers had a higher percentage than fathers in home duties. (Table 3.9)

Table 3.9: Parental occupation

Parental occupation	**Mother**		**Father**	
	N	%	N	%
Farmer	1101	40.4	1140	43.4
Manual worker	242	8.9	402	15.3
Professional, office worker	506	18.6	549	20.9
Private business	327	12.0	345	13.1
Home duties	499	18.3	65	2.5
Other	47	1.7	128	4.9
Total	**2722**	**100.0**	**1629**	**100.0**

N = 2762. Missing = 40 (mother); 133 (father)

3.4 DEPENDENT VARIABLES

The dependent variables examined in this study were coronal caries experience in primary and permanent teeth, the distribution of fluorosis and the mean Community Fluorosis Index (CFI).

3.4.1. Coronal caries experiences

Dental caries was reported as the number of decayed, missing and filled surfaces of primary teeth (dmfs) and permanent teeth (DMFS).

3.4.1.1 Primary dentition

3.4.1.1a. The distribution of caries experiences in primary teeth by age group

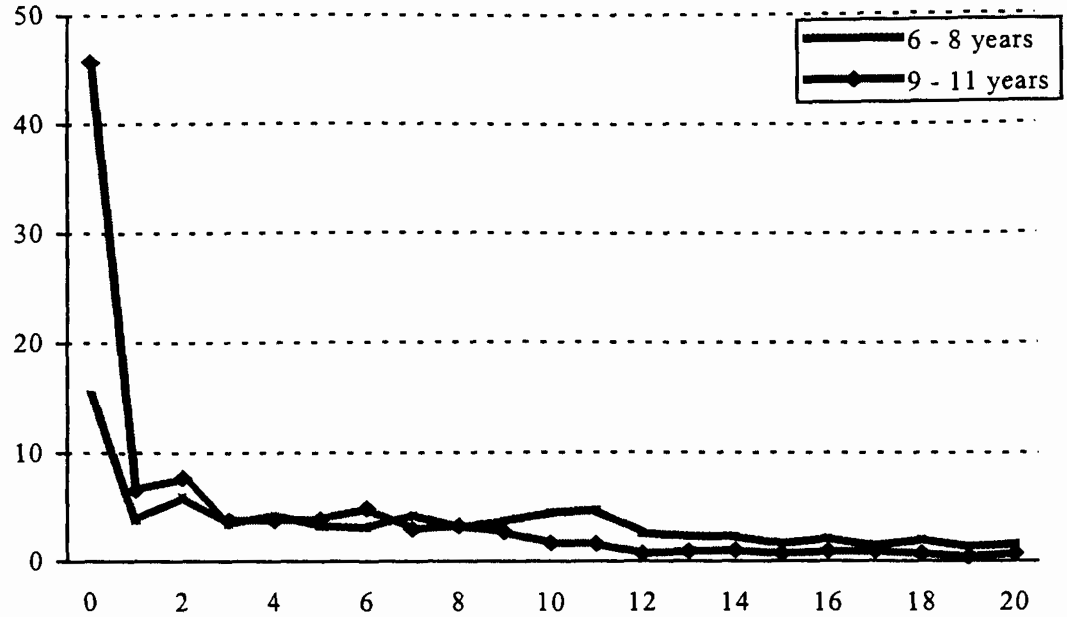
In the age group 6 – 8 years, the mean dmfs was 12.7, most of which was experienced as untreated decay. The mean dmfs was 4.3 in the age group 9 – 11 years, in which untreated decay was also the major component.

Table 3.10: The component of dmfs by age group

Age group	decayed		missing		filled		dmfs	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
6 – 8-year-olds	705	11.4 (11.6)	705	1.2 (3.6)	705	0.1 (0.5)	705	12.7 (12.7)
9 – 11-year-olds	692	3.7 (5.8)	692	0.6 (2.4)	692	0.0 (0.2)	692	4.3 (6.7)
Total	**1397**	**7.6 (10.0)**	**1397**	**0.9 (3.1)**	**1397**	**0.0 (0.4)**	**1397**	**8.5 (11.0)**

Figure 3.1 shows the distribution of dmfs by age groups. The distribution of both age groups is positively skewed. Only 15.3 percent of children had a mean dmfs of zero in the age group 6-8 years. This increased to 47.5 percent in the age group 9-11 years. The proportion of children with a dmfs value of one to eight surfaces was slightly higher in the 9 – 11-year-old age group than in the 6 – 8-year-old age group. At higher dmfs values, the percentages for 9 – 11-year-old were lower than for the age group 6 – 8 years.

Figure 3.1: The distribution of dmfs by age group



3.4.1.1b. The distribution of caries experience in primary teeth at cluster level by age group

The distribution of the mean dmfs in the 56 clusters by age group is represented in Fig. 3.2.

- In the age group 6–8 years, the mean dmfs value by cluster of children varied from 1.8 to 24.1. Children had a mean dmfs higher than 20 in five clusters.
- In the age group 9–11 years, the mean dmfs of children ranged from 0.1 to 8.8. More than half the clusters had a mean dmfs value less than five (34 clusters).

The background data of the mean dmfs by cluster can be seen in Appendix F.

Figure 3.2: The distribution of the mean dmfs at cluster level by age group

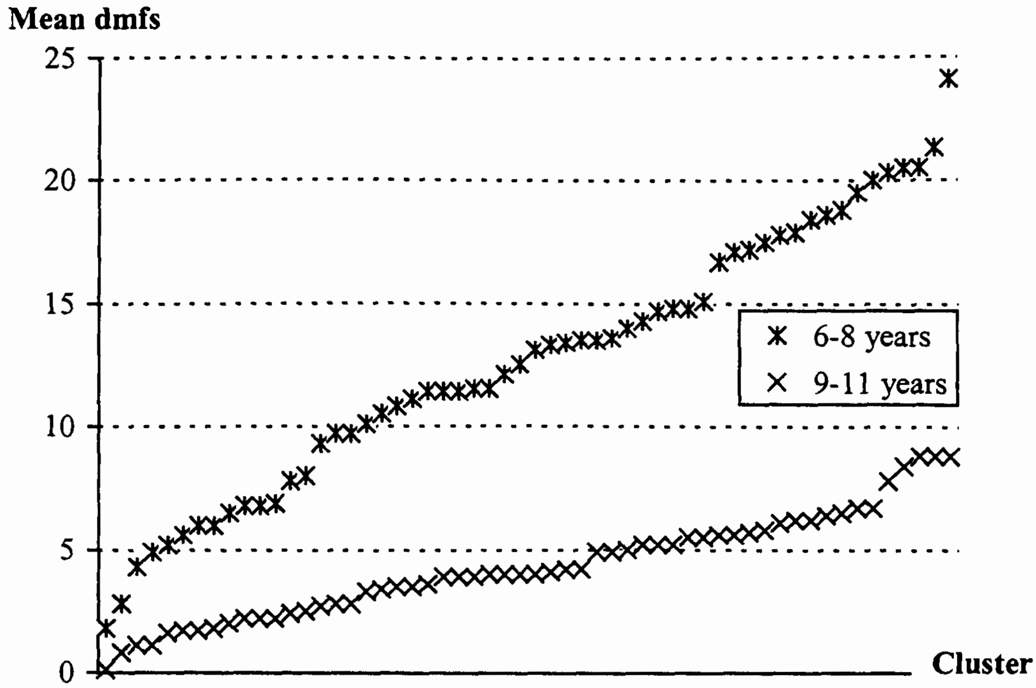
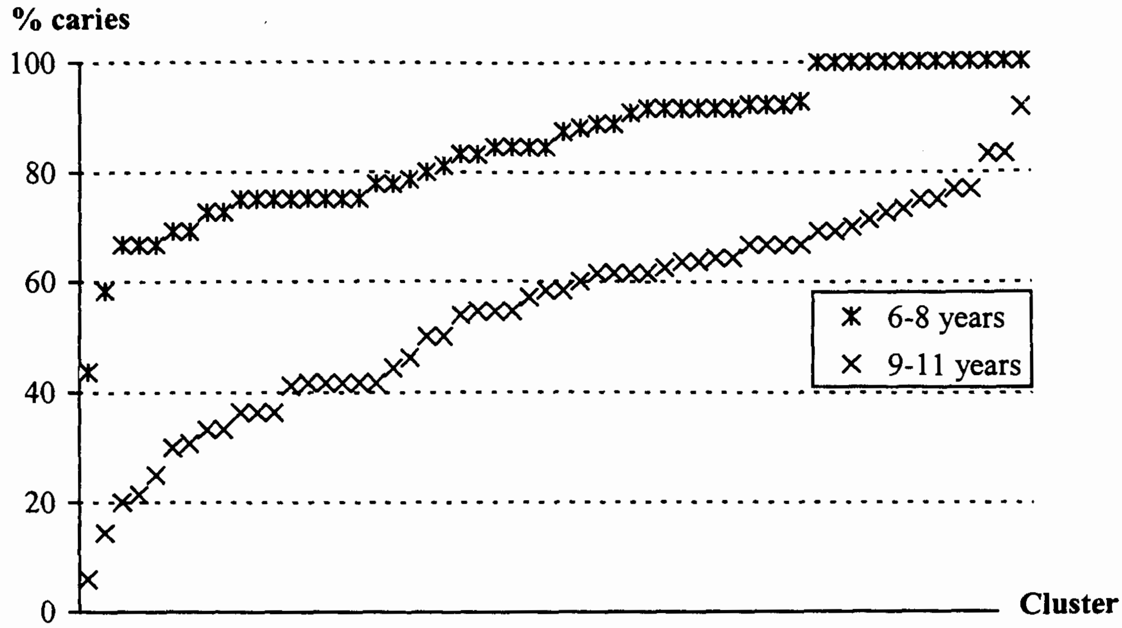


Figure 3.3 shows the distribution of the prevalence of primary caries experience (dmfs/1) in the 56 clusters by age group.

- In the age group 6–8 years, the prevalence of primary caries experience ranged from 43.7 to 100.0 percent. In 13 clusters, every child had caries experience.
- In the age group 9–11 years, the prevalence of children with primary caries experience varied from 8.3 to 94.1 per cent. More than half of the clusters had 50 per cent or more children with caries experience.

The background data of the prevalence of primary caries experience by cluster can be seen in Appendix F.

Figure 3.3: The distribution of the prevalence of primary caries experience at cluster level by age group



3.4.1.2 Permanent dentition

3.4.1.2a The distribution of caries experience in permanent teeth by age group

Table 3.11 shows there was a significant increase in caries experience of permanent teeth across age groups from a mean DMFS of 0.6 for 6 – 8-year-olds to a mean of 4.9 for 15 – 17+-year-olds. Caries experience was predominantly present as untreated decay. The mean number of missing surfaces (MS) increased from the age group 6–8 years to 12 – 14 years but the increase was greater in the age group 15 – 17+ years to 0.9 ± 2.6. Filled surfaces were low for all age groups.

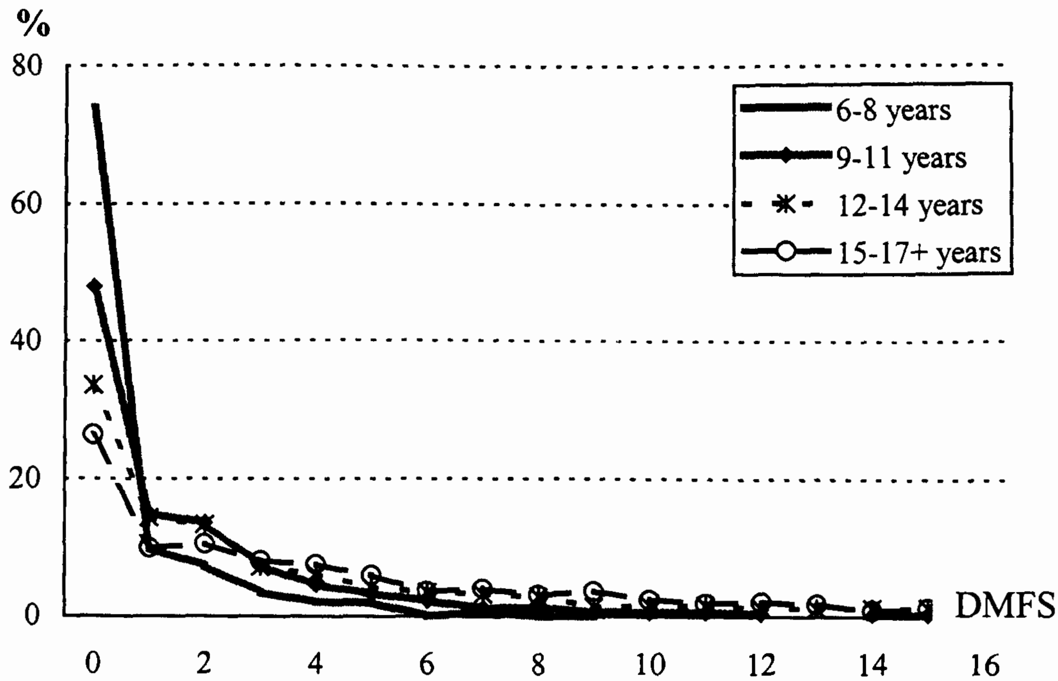
Table 3.11: The component of DMFS by age group

Age group	Decayed		Missing		Filled		DMFS	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
6 – 8-year-olds	705	0.6 (1.4)	705	0.0 (0.0)	705	0.0 (0.2)	705	0.6 (1.4)
9 – 11-year-olds	692	1.6 (2.5)	692	0.1 (0.5)	692	0.0 (0.3)	692	1.7 (2.7)
12 – 14-year-olds	695	3.1 (4.6)	695	0.2 (1.1)	695	0.1 (0.5)	695	3.4 (4.9)
15 – 17+-year-olds	670	3.8 (5.3)	670	0.9 (2.6)	670	0.2 (1.0)	670	4.9 (6.5)
Total	**2762**	**2.3 (4.0)**	**2762**	**0.3 (1.5)**	**2762**	**0.1 (0.6)**	**2762**	**2.6 (4.6)**

ANOVA table: P = 0.000

The distribution of DMFS in the four age groups is shown in Figure 3.4. All the distributions are positively skewed. The proportion of children with a DMFS of zero decreased from over two-thirds of children in the 6 – 8 years age group (73.9 per cent) to one-quarter of those in the 15 – 17+ years age group (26.3 percent). The percentage of children with a DMFS score between one to four surfaces was slightly higher in the 9 – 11-year-olds and 12 – 14-year-olds than the other age groups. The proportion of children with more than four DMFS decreased simultaneously in the four age groups. There were very few children with more than nine DMFS among the four age groups.

Figure 3.4: The distribution of DMFS by age groups



3.4.1.2b: The distribution of caries experience in permanent teeth at cluster level by age group

The distribution of caries experience in the permanent teeth by cluster (56 clusters for 6 – 8-year-olds, 9 – 11-year-olds and 12 – 14-year-olds and 32 clusters for 15 – 17+-year-olds) is demonstrated in Figure 3.5.

- In the age group 6 – 8 years, the mean DMFS of children ranged from 0.0 to 2.42. In most clusters the children had a mean DMFS less than two. In five clusters, the mean DMFS was equal to zero.
- In the age group 9 – 11 years, the mean DMFS ranged from 0.27 to 5.1. The mean DMFS score was less than four in most of the clusters.
- In the age group 12 – 14 years, the mean DMFS scores of children ranged from 0.0 to 10.75. Almost all clusters had DMFS scores less than eight. Only two clusters had DMFS scores more than 10.0.

- In the age group 15 – 17+ years, the mean DMFS of children ranged from 0.86 to 11.48. In more than half the clusters, the mean DMFS score was less than six.

The background data of the mean DMFS by cluster can be seen in Appendix F.

Figure 3.5: The distribution of the mean DMFS at cluster level by age group.

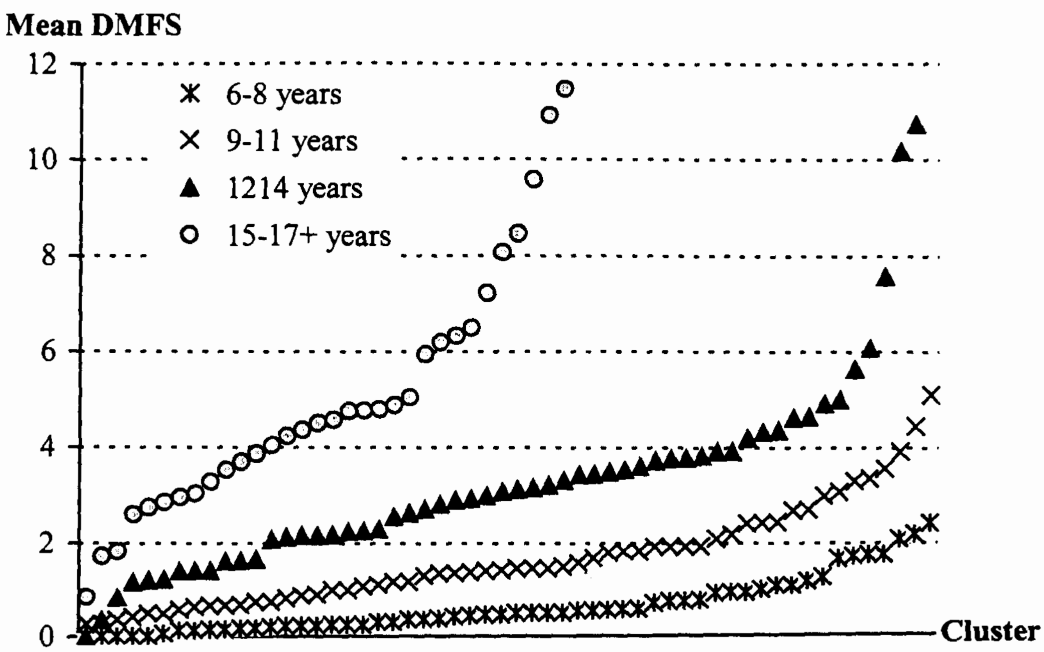


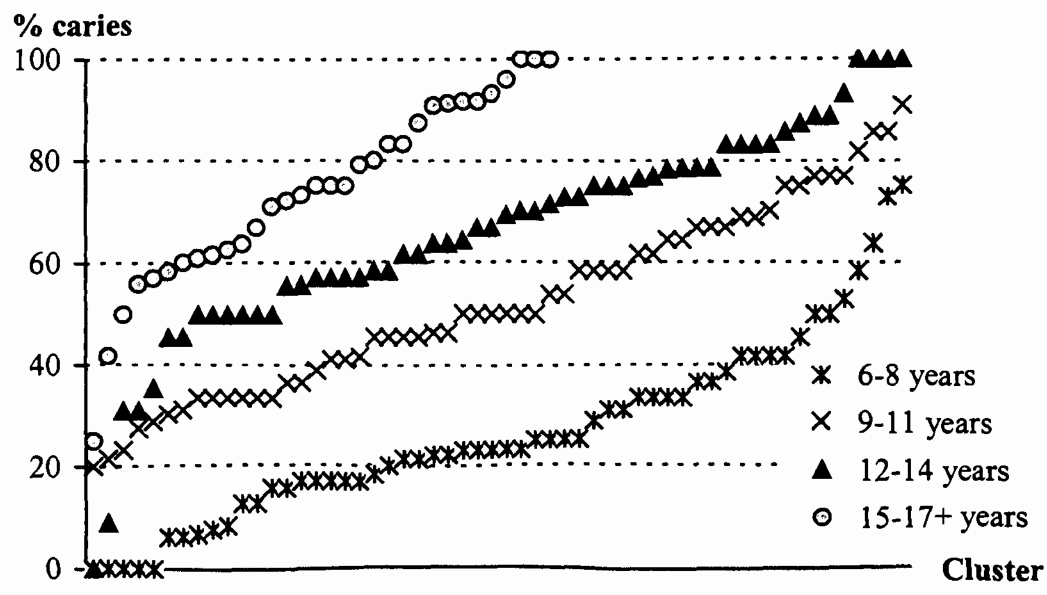
Figure 3.6 describes the distribution of prevalence of children with caries experience in the four age groups.

- In the age group 6 – 8 years, the prevalence of children with permanent caries experience varied from zero to 75 percent. The majority of the clusters had less than 56 per cent of children with caries experience.
- In the age group 9 – 11 years, the prevalence of children with permanent caries experience varied from 20 to 90.9 percent.

- In the age group 12 – 14 years, the prevalence of children with permanent caries experience varied from 0.0 to 100 percent. In one cluster no child had caries experience, and in four clusters every child had caries experience.
- In the age group 15 – 17+ years, the prevalence of children with permanent caries ranged from zero to 75 percent. In most of the clusters, the proportion of children with caries was more than 60 per cent. In three clusters, every child had caries experience.

The background data of the prevalence of permanent caries experience by cluster can be seen in Appendix F.

Figure 3.6: The distribution of the prevalence of permanent caries at cluster level by age group.



3.4.2 Dental fluorosis

3.4.2.1 The distribution of fluorosis and Community Fluorosis Index (CFI) by age group

In the 2,762 surveyed children, dental fluorosis was assessed on 2,367 children. The children not assessed for dental fluorosis included the children without fully erupted incisors, with other enamel defects and changed shape and colour of teeth (according to score 7, 8 and 9 of the diagnostic criteria for dental fluorosis). At 6-8 years upper incisors were mostly not fully erupted. This was the major reason children could not be assessed for dental fluorosis.

Dental fluorosis and CFI were not significantly different among the four age groups (ANOVA table of CFI p = 0.350). More than 80 per cent of children in each age group had no fluorosis. The two younger groups had slightly higher percentages of score 0.5. Age group 15-17+ years had higher percentages of scores 1, 2 and 4 than other groups. The lowest percentages of scores 3 and 4 were among 6 – 8-year-olds and the lowest of score 2 was in the 9 – 11-year-olds. The CFI was highest in the age group 15-17+ years. (Table 3.12)

Table 3.12: The distribution of fluorosis and CFI by age group

Age group	N of subjects	Dean's index (%)						CFI
		0	0.5	1	2	3	4	
6-8 year olds	340	80.3	11.5	6.5	1.5	0.3	0.0	0.16
9-11 year olds	673	82.0	10.5	5.8	0.4	0.9	0.3	0.16
12-14 year olds	691	84.1	8.1	5.2	1.4	0.6	0.6	0.16
15-17+ year olds	663	82.7	6.2	7.8	1.8	0.5	1.1	0.20
Total	**2367**	**82.6**	**8.7**	**6.3**	**1.3**	**0.6**	**0.5**	**1.71**

ANOVA table: P = 0.350 (CFI)

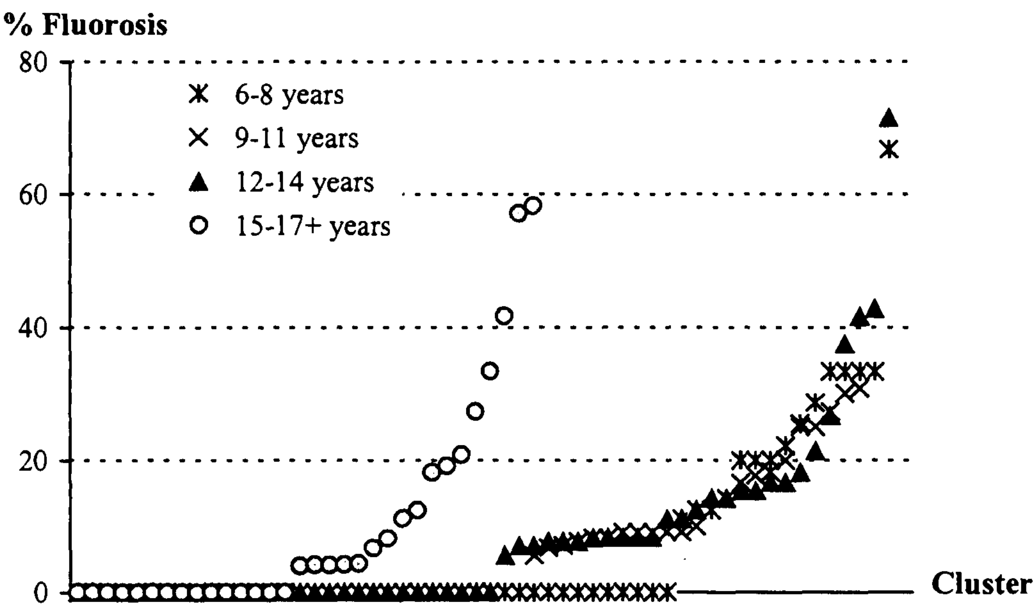
3.4.2.2 The distribution of fluorosis and Community Fluorosis Index (CFI) at cluster level by age group

To evaluate the prevalence of children with dental fluorosis, a threshold of a score of 1 or more of Dean's index was used. The score 0.5 was classified as normal. Figure 3.7 represents the prevalence of dental fluorosis in the four age groups.

- For 6 – 8-year-olds, only 15 clusters had fluorosis, the prevalence ranging from 11.1 to 33.3 per cent. In one cluster the prevalence of children with fluorosis was 66.7 per cent.
- For 9 – 11-year-olds, 25 clusters had children with fluorosis, the prevalence of fluorosis ranging from 5.6 to 33.3 per cent. One cluster had 66.7 per cent of children with fluorosis.
- For 12 – 14-year-olds, the children had fluorosis in 27 clusters, the prevalence of fluorosis varying from 5.6 to 71.5 per cent. In most clusters the prevalence of fluorosis was less than 50 per cent. One cluster had 71.5 per cent of children with fluorosis.
- For 15 – 17+-year-olds, 17 clusters had children with fluorosis, with prevalence ranging from 4.0 to 58.3 per cent.

The background data of the prevalence of fluorosis by cluster can be seen in Appendix F.

Figure 3.7: The distribution of the fluorosis prevalence at cluster level by age group

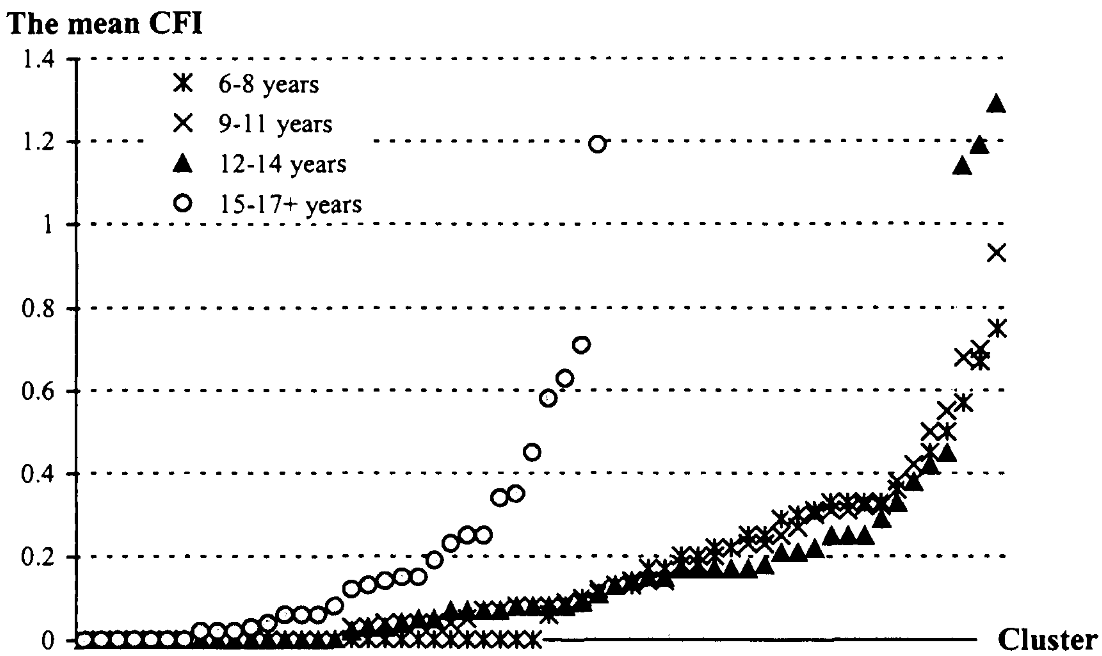


The distribution of the mean CFI scores by cluster level is demonstrated in the Figure 3.8.

- For 6 – 8-year-old children, the mean CFI varied from 0.00 to 0.75. In five clusters the mean CFI was more than 0.4.
- For 9 – 11-year-olds children, the mean CFI varied from 0.00 to 0.93, of which six clusters had the mean CFI value more than 0.60.
- For 12 – 14-year-old children, the mean CFI varied from 0.00 to 1.29. Two clusters had a mean CFI value more than 0.40 and three clusters the mean CFI was more than 1.00.
- For 15 – 17+-years-old, the mean CFI scores ranged from 0.00 to 1.19. Five clusters had a mean CFI value greater than 0.40, of which one cluster had a CFI value of 1.19.

The background data of the mean CFI by cluster can be seen in Appendix F.

Figure 3.8: The distribution of the mean CFI at cluster level by age group



3.5 INDEPENDENT VARIABLES

3.5.1 The distribution of drinking water sources

Tap-water, well-water, bore-water and rain-water are the main water sources used daily for drinking in Vietnam. The distribution of water sources used for drinking by children is shown in Table 3.13. Well-water is a water source used widely in Vietnam, mainly in rural areas. Tap-water is the next major water source (24.0 per cent) mainly in use in the cities and towns, and bore-water was used by 16.1 per cent of the sample in both urban and rural areas. Rain-water comprised 13.0 per cent of water sources. Water from rivers, lakes and streams were the least used water sources.

Table 3.13: The water sources used daily for drinking (n = 2762).

Water source	N	%
Tap-water	662	24.0
Well-water	1369	49.6
Bore-water	446	16.1
Rain-water	358	13.0
River-water	28	1.0
Lake-water	6	0.2
Stream-water	47	1.7

A single water source was used for drinking by the majority, and less than 10 per cent used two or more sources of water for drinking. One per cent of children's parents did not report their source of drinking water (Table 3.14).

Table 3.14: The quantity of water sources used daily for drinking (n = 2672)

The quantity of water sources	N	%
1 source	2559	92.7
2 sources	172	6.2
3 sources	4	0.0
No answer	27	1.0
Total	**2762**	**100.0**

Based on the reports of source of water used daily for drinking and the rules of estimation of fluoride concentration in each water source, the fluoride concentration of each water source was calculated.

The distribution and fluoride concentration of water sources in 56 clusters of children in Primary and Secondary school is shown Table 3.15 and for High school in Table 3.16.

- Tap-water was used as a major water source in four clusters, of which the use of tap-water was more than 90 per cent. In ten clusters, tap-water was used by more than 50 per cent of the sample. The fluoride concentration in the tap-water was low, and ranged from 0.01 to 0.38 ppm. Only one cluster had a water supply fluoridated at 0.55 ppm.

- Well-water was widely used except in Ha Noi and HCM City, and in Tien Giang and Soc Trang provinces. Well-water was used by more than 90 per cent of the sample in 19 clusters and by more than 50 per cent in nine other clusters. The fluoride concentrations in the well-water varied markedly (range 0.01 to 1.38 ppm). There were three clusters that had more than 1.0 ppm of fluoride and three clusters with fluoride concentrations between 0.4 and 1.0 ppm.
- Bore-water was used in the suburbs of Ha Noi and HCM cities and in the three provinces of Quang Ngai, Tien Giang and Soc Trang. In one cluster bore-water was used by more than 90 per cent of the sample. More than 50 per cent of families used bore-water in eight clusters. The fluoride concentrations in bore-water also varied from 0.01 to 1.30 ppm. One cluster had a fluoride concentration of more than 1.0 ppm and one cluster had a fluoride concentration between 0.4 and 1.0 ppm.
- Rain-water was the main source of drinking water in two clusters at 94.4 and 86.5 per cent. In ten clusters rain-water was used by around 50 per cent of the sample for drinking. In the remaining clusters only a few families used rain-water for drinking. The fluoride concentration in rain-water was mainly low. In only two clusters the fluoride concentration in the rain-water was 0.31 ppm. Rain-water samples were not collected in some clusters.
- Few families used river-water, lake-water and stream-water for drinking. In one cluster, river-water samples were collected and the fluoride concentration of the river-water samples was 0.36. Lake-water samples also were collected in one cluster and the fluoride concentration was 0.03. The fluoride concentration in the stream-

water was very low, under 0.03 ppm. There was one cluster in which 83.3 per cent of families used stream-water, but the water samples of this cluster were not collected.

Table 3.15: The distribution and fluoride concentration of water sources in each cluster for children in Primary and Secondary school

	LOCAL AREA		TAP		WELL		BORE		RAIN		RIVER		LAKE		STREAM	
			%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]
1	T-LAOCAI	1	42.1	0.18	52.6	0.18			2.6*						2.6	0.03
2		2			100.0	0.15			2.8*							
3	D-LAOCAI	1			100.0	0.09										
4		2			100.0	0.10										
5	T-HAGIANG	1	58.3	0.04	41.7	0.12										
6		2	2.4*		73.2	0.43			9.8*						22.0	0.03
7	D-HAGIANG	1			94.9	0.01			2.6*						5.1*	
8		2			97.1	0.07									2.9	0.01
9	T-HATAY	1	63.2	0.22	39.5	0.45			2.6*							
10		2	83.0	0.30	19.1	0.32			2.1*							
11	D-HATAY	1			78.9	0.20			50.0	0.14						
12		2			63.9	0.11			50.0	0.14						
13	T-QUANGBINH	1			100.0	0.02			2.7*							
14		2	7.0	0.01	93.0	0.01			2.3	0.01						
15	D-QUANGBINH	1			100.0	0.06										
16		2			100.0	0.02										
17	T-TTHUE	1	88.9	0.01	5.6*		11.1*		5.6*							
18		2	100.0	0.02					5.4	0.02						

Table 3.15: (cont.)

LOCAL AREA			TAP		WELL		BORE		RAIN		RIVER		LAKE		STREAM	
			%	[F-]	%	[F-]	%	[F-]	%	[F-	%	[F-]	%	[F-]	%	[F-]
19	D-TTHUE	1	94.4	0.01	5.6*				19.4	0.04						
20		2	55.6	0.03	25.0	0.18			52.8	0.04	2.8*		5.6	0.03		
21	T-QUANGNGAI	1	16.7	0.13			80.6	0.13								
22		2		0.17			94.7	0.09								
23	D-QUANGNGAI	1			92.1	0.01	10.5	0.01								
24		2			69.4	0.01	30.6	0.01								
25	T-PHUYEN	1	58.3	0.29	44.4	0.20										
26		2			100.0	1.25										
27	D-PHUYEN	1			84.2	0.25										
28		2			100.0	0.77										
29	T-GIALAI	1			97.2	0.05									2.8*	
30		2			100.0	0.01										
31	D-GIALAI	1			91.7	1.04			2.8*		2.8*					
32		2			88.9	1.38					11.1*					
33	T-KONTUM	1			100.0	0.03										
34		2			88.9	0.08					5.6*		5.6*			
35	D-KONTUM	1			87.5	0.29			5.0*							
36		2			13.9	0.16									83.3*	
37	T-VUNGTAU	1	62.2	0.01	29.7	0.16			10.8*							
38		2	5.3*		94.7	0.09			2.6*							

Table 3.15: (cont.)

	LOCAL AREA		TAP		WELL		BORE		RAIN		RIVER		LAKE		STREAM	
			%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]
39	D-VUNGTAU	1			92.3	0.04					3.8*		3.8*			
40		2			94.7	0.01					2.6*				2.6*	
41	T-TIENGIANG	1	52.6	0.12			10.5*		52.6*		7.9*					
42		2	48.7	0.38			12.8*		43.6*							
43	D-TIENGIANG	1	8.3	0.16			2.8	0.55	94.4	0.01	8.3	0.36			2.8*	
44		2	13.5	0.04			24.3	0.14	86.5	0.01	10.8*					
45	T-SOCTRANG	1	12.0	0.13			76.0	0.20	48.0	0.31	4.0*					
46		2	20.8	0.13			45.8	0.20	47.9	0.31	2.1*					
47	D-SOCTRANG	1					78.4	0.21	45.9	0.16						
48		2					57.9	0.21	47.4	0.13						
49	HA NOI CITY	1	97.2	0.36			2.8*									
50		2	78.9	0.27			26.3	1.30								
51		3	22.9	0.34			74.3	0.34	2.9*							
52		4	10.0*				72.5	0.33	35.0	0.20						
53	HCM CITY	1	97.3	0.55			2.7*									
54		2	30.6	0.01			66.7	0.01			2.8*					
55		3	73.0	0.27			24.3*									
56		4	14.3*				85.7	0.03								

* The bold numbers indicate that a sample of this water source could not be collected.

Table 3.16 presents the distribution and fluoride concentration of water sources in 32 clusters for children in High school.

- Tap-water was used mainly in the centre of cities and in the towns of the provinces. Tap-water was used by more than 90 per cent in three clusters and more than 50 per cent in eight other clusters. The tap-water (fluoridated) in one cluster was 0.59 ppm. Naturally occurring fluoride levels in the tap-water ranged from 0.01 to 0.37 ppm.
- Well-water was also widely used, similar to children in Primary and Secondary school. Well-water was used mainly in one third of clusters by more than 90 per cent of the sample. Of the remaining clusters, more than 50 per cent of families used the well-water. The fluoride levels in the well-water varied from 0.01 to 1.00 ppm. Most of the well-water had low fluoride concentrations. Fluoride level of well-water was 1.00 ppm in one cluster and 0.47 ppm in two clusters.
- Bore-water was used as a major water source with more than 90 per cent of the children's families using it in two clusters. More than 50 per cent using bore-water occurred in four clusters. The fluoride concentration of bore-water was found to be in the range 0.01 – 1.30 ppm. The fluoride level was more than 1.00 ppm in the cluster and under 0.35 ppm in other clusters.
- The use of rain-water was around 50 per cent in four clusters, but in other clusters rain-water was used by under 25 per cent of children. The fluoride level of rain-water was mainly low, but in one cluster the fluoride concentration was 0.31 ppm.
- Only a few families used river-water, lake-water and stream-water for drinking. The fluoride level in the stream-water was 0.03 ppm. The water samples for river-water and lake-water, unfortunately, were not collected.

Table 3.16: The distribution and fluoride concentration of water sources in each cluster for children in High school

LOCAL AREA	TAP		WELL		BORE		RAIN		RIVER		LAKE		STREAM	
	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]
1 T-LAOCAI	16.0	0.18	80.0	0.16										
2 D-LAOCAI			95.8	0.11			20.8*							
3 T-HAGIANG	59.3	0.04	44.4	0.28			7.4*						3.7	0.03
4 D-HAGIANG			100.0	0.03										
5 T-HATAY			100.0	0.30					4.0*					
6 D-HATAY			50.0	0.21			75.5	0.14						
7 T-QUANGBINH	41.7	0.01	58.3	0.01			4.2*	0.01						
8 D-QUANGBINH			100.0	0.03										
9 T-TTHUE	80.0	0.01	16.0*		8.0*									
10 D-TTHUE	62.5	0.02	29.2	0.18			25.0	0.04		0.03				
11 T-QUANGNGAI	32.0	0.16			68.0	0.11								
12 D-QUANGNGAI			66.7	0.01	33.3	0.01								
13 T-PHUYEN			95.8	0.47										
14 D-PHUYEN			95.8	0.47			4.2*							
15 T-GIALAI			100.0	0.03										
16 D-GIALAI			83.3	1.00			4.2*		12.5*					
17 T-KONTUM			100.0	0.04										
18 D-KONTUM			95.8	0.22			4.2*							
19 T-VUNGTAU	55.6	0.10	44.4	0.10			10.8*							

Table 3.16: (cont.)

LOCAL AREA			TAP		WELL		BORE		RAIN		RIVER		LAKE		STREAM	
			%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]	%	[F-]
20	D-VUNGTAU				100.0	0.07										
21	T-TIENGIANG		50.0	0.25			29.2*		20.8*							
22	D-TIENGIANG						52.2	0.35	47.8	0.01	4.3*		4.3*			
23	T-SOCTRANG		50.0	0.13			16.7	0.20	54.2	0.31						
24	D-SOCTRANG						83.3	0.21	50.0	0.15						
25	HANOI CITY	1	100.0	0.37												
26		2	91.7	0.28			8.3	1.30								
27		3					91.7	0.28	16.7*							
28		4	25.0*				75.0	0.23	8.3	0.20						
29	HCM CITY	1	80.0	0.59			20.0*									
30		2	58.3	0.01			41.7	0.02	8.3*							
31		3	92.3	0.19			7.7*									
32		4	6.7*				93.3	0.03								

* The bold numbers indicate the sample of this water source could not be collected.

3.5.2 The usage of discretionary fluoride

3.5.2.1 The use of toothpaste

Table 3.17 shows the percentage of children using toothpaste. Most of the children (94.7 per cent) used toothpaste. Only 2.6 per cent of children did not use toothpaste.

Table 3.17: The percentage of using toothpaste

Using toothpaste	N	%
Yes	2615	94.7
No	71	2.6
Total	**2686**	**100.0**

N = 2762. Missing = 76 (2.8%)

The kind of toothpaste used is presented in Table 3.18. Most of the children used fluoride toothpaste. Only 0.1 per cent of children did not use fluoride toothpaste. A few children used toothpaste which can't be identified or the parents did not know the type of toothpaste used.

Table 3.18: The kind of toothpaste used

The kind of toothpaste used	N	%
Fluoride toothpaste	2540	99.0
No fluoride toothpaste	3	0.1
Cannot identify	5	0.2
Unknown	17	0.7
Total	**2565**	**100.0**

N = 2615. Missing = 50

The age at which tooth brushing with toothpaste commenced was classified into three levels. Table 3.19 shows that half of the children started using toothpaste later than three years old (55.3 per cent).

Table 3.19: Age commenced brushing teeth with toothpaste

Age commenced brushing teeth with toothpaste	N	%
At three years old or earlier	519	20.4
Older than three years old	1407	55.3
Don't know	617	24.3
Total	**2543**	**100.0**

N = 2615. Missing = 72

The amount of toothpaste used is shown in Table 3.20. Most of the children used a pea size amount of toothpaste for brushing (64.3 per cent).

Table 3.20: Amount of toothpaste used

Amount of toothpaste used	N	%
Smear (small amount)	383	16.0
Pea size (medium amount)	1541	64.3
Full length (large amount)	288	12.0
Don't know	184	7.7
Total	**2396**	**100.0**

N = 2615. Missing = 219

3.5.2.2 The use of mouthrinses

Forty per cent of children were reported to be using a mouthrinse (Table 3.21).

Table 3.21: The percentage of use of mouthrinse

Using mouthrinse	N	%
Yes	1114	39.5
No	1309	60.5
Total	**2423**	**100.0**

N = 2762. Missing = 339 (12.3%)

Table 3.22 shows the kind of mouthrinse used. Most of the children reported using water and salt water for mouthrinse. The percentage of children who reported using fluoride mouthrinse in school was 15.7 per cent. The use of commercial mouthrinse was not popular (4.6 per cent).

Table 3.22: The kind of mouthrinse used

Name of mouthrinse	N	%
Fluoride mouthrinse in school	155	15.7
Commercial mouthrinse	45	4.6
Salt water	378	38.3
Water	403	40.9
Unknown	5	0.5
Total	**986**	**100.0**

N = 1114. Missing = 128

3.5.2.3 The use of fluoride tablets

The use of fluoride tablets was limited in Vietnam. Only 1.3 per cent of children reported they used fluoride tablets. One third of parents did not answer this question (Table 3.23).

Table 3.23: The frequency of using fluoride tablet

Using fluoride tablet	N	%
Yes	25	1.3
No	1840	98.7
Total	**1865**	**100.0**

N = 2762. Missing = 897 (32.5%)

3.5.3 Dental behaviours

Tooth brushing was performed by 96.3 per cent of children. Only 3.7 per cent of children were not brushing their teeth (Table 3.24).

Table 3.24: The percentage of brushing teeth

Brushing teeth	N	%
Yes	2603	96.3
No	101	3.7
Total	**2704**	**100.0**

N = 2762. Missing = 58 (2.1%)

The majority of children brushed at least twice a day and commenced tooth brushing after three years of age. A sizeable proportion of parents was unable to report when the child commenced tooth brushing (Table 3.25 and 3.26).

Table 3.25: The frequency of brushing teeth

Frequency of brushing teeth	N	%
Less than twice a day	1147	44.9
At least twice a day	1407	55.1
Total	**2554**	**100.0**

N = 2603. Missing = 49

Table 3.26: Age commenced brushing teeth

Age commenced brushing teeth.	N	%
At three years or earlier	744	28.6
Older than three years old	1301	50.0
Don't know	558	21.4
Total	**2603**	**100.0**

N = 2603

Table 3.27 shows the time since the last dental visit of the children. Most of the children never had a dental visit (65.2 per cent). The next highest proportion had a dental visiting more than 24 months ago, while nearly 10 per cent of children had dental visits less than six months ago. The percentage of children who visited a dentist between 6 to 12 months and 12 to 24 months prior was low.

Table 3.27: The time since dental visits

Distance of dental visit	N	%
Less than 6 months	240	9.7
Between 6 and 12 months	188	7.6
Between 12 and 24 months	107	4.3
More than 24 months	323	13.1
Never	1610	65.2
Total	**2468**	**100.0**

N = 2762. Missing = 294

Based on the reported time since the last dental visit, the children were grouped into those who had visited a dentist and those who had never visited a dentist.

Table 3.28 shows that most of the children had not received dental treatments in the last two years.

Table 3.28: Receipt of dental treatment in the last two years

Received dental treatment	N	%
Yes	722	28.7
No	1790	71.3
Total	**2512**	**100.0**

N = 2762. Missing = 250

The reasons for dental visits in the last two years are shown in Table 3.29. There were 722 children who reported they had received dental treatment in last two years, but only 693 children reported their reason for dental visit. Some children may have visited a dentist for multiple reasons. It can be seen that tooth decay, pain and loose tooth were common reasons for children to have visited a dentist. Few children visited a dentist because of bleeding gums, for a check-up or for dentures.

Table 3.29: The reason for dental visit in the last two years

Reason in last dental visit	N	%
Pain	202	29.1
Tooth decayed	319	46.0
Bleeding gum	27	3.9
Loose tooth	172	24.8
For denture	6	0.9
Check-up	3	0.4
Other	111	16.0

N = 693. Missing = 29

Table 3.30 presents the dental treatment received by children at their dental visit, if that was within the last two years. There were 722 children who reported having received dental treatment in the last two years, but only 668 children reported the treatment they received at the dental visit. The most frequent dental treatment received by children was filling. Examination and prescription, and cleaning and scaling were the next most frequently received dental treatments. A few children received prosthodontic treatment.

Table 3.30: Treatment received by the children at their last dental visit (in the last two years)

Treatment received	N	%
Examination and prescription	121	18.1
Cleaning and scaling	132	19.8
Extraction	38	5.7
Filling	440	65.9
Denture	7	1.0
Other	16	2.4

N = 668. Missing = 54

3.5.4 Dietary habits

The majority of children had both fish sauce and cooking salt in their diet. The percentage of families who used cooking salt alone was higher than the families who used only fish sauce. A few families used neither fish sauce nor cooking salt (Table 3.31).

Table 3.31: The frequency of using fish sauce or cooking salt for cooking

Fish sauce or cooking salt	N	%
Fish sauce	156	5.8
Cooking salt	367	13.6
Both of them	2151	79.9
Neither	7	0.3
Other	10	0.4
Total	**2691**	**100.0**

N = 2762. Missing = 71(2.6%)

Table 3.32 shows the percentage and the frequency of sweets eaten. The highest percentage of sweets that children used was candy (78.4 per cent). Biscuits were the second most used (75.6 per cent). A little more than half of the children used ice cream (58.2 per cent). The frequency of eating sweets was mostly once per day. Only a few children used sweets three times or more per day. Some parents reported the kind of sweets their child ate, but did not answer the frequency of their child eating sweets.

Table 3.32: The percentage and frequency of sweets used

The kind of sweets used	Candy		Ice cream		Biscuit		Other	
	N	%	N	%	N	%	N	%
Used	1752	78.4	991	58.2	1577	75.6	222	31.1
Not used	483	21.6	713	41.8	508	24.4	491	68.9
Total	**2235**		**1704**		**2085**		**713**	
Frequency of using sweets								
Sometimes	275	15.9	246	26.8	259	17.0	18	9.8
Once per day	1122	64.8	566	61.7	979	64.4	109	59.6
Twice per day	245	14.1	77	8.4	209	13.8	31	16.9
Three times/ day	58	3.3	15	1.6	48	3.2	11	6.0
More	32	1.8	13	1.4	25	1.6	14	7.7
Total	**1732**		**917**		**1520**		**183**	

N = 2762

The drinking habits of children are present in Table 3.33. Water was drunk at least once a day by the majority of children (87.8 per cent). Nearly half of the children used soft drink, fruit juice or tea daily. Soft drink and fruit juice were drunk at least once a day and tea was drunk mostly once or twice a day. Some parents reported the kind of drinks their child used, but did not answer the frequency of their child using drinks.

Table 3.33: The percentage and frequency of drinks used

The kind of drinks used	Soft drink		Fruit juice		Tea		Water	
	N	%	N	%	N	%	N	%
Used	753	49.1	597	41.9	554	41.9	1880	87.8
No used	780	50.9	827	58.1	769	58.1	262	12.2
Total	**1533**		**1338**		**1323**		**2142**	
Frequency of using drinks								
Sometimes	170	26.2	105	20.8	65	13.2	97	6.0
Once per day	419	64.7	330	65.5	195	39.5	121	7.5
Twice per day	42	6.5	53	10.5	104	21.1	117	7.2
Three times/ day	12	1.9	10	2.0	72	14.6	354	21.8
More	5	0.8	6	1.2	58	11.7	935	57.6
Total	**648**		**504**		**494**		**1624**	

N = 2762

Most of the children added sugars in their drinks sometimes, while nearly one-third often added sugar (Table 3.34).

Table 3.34: The percentage of children adding sugar in drinks

Adding sugar in drinks	N	%
Never	163	6.3
Sometimes	1618	62.7
Often	800	31.0
Total	**2581**	**100.0**

N = 2762. Missing = 181 (6.6%)

Sugar was sometimes used for cooking by the majority of families. Only one-fifth of families did not use sugar in their cooking (Table 3.35).

Table 3.35: The percentage of children's families using sugar for cooking

Using sugar for cooking	N	%
Never	529	20.4
Sometime	1678	64.6
Often	391	15.1
Total	**2598**	**100.0**

N = 2762. Missing = 164 (5.9%)

The proportion reporting eating fruit was classified into two groups. Table 3.36 shows the frequency of eating fruit. Most of children ate fruit less than two times per day.

Table 3.36: The frequency of eating fruit

Eating fruit	N	%
At most once a day	1944	79.2
At least twice a day	510	20.8
Total	**2454**	**100.0**

N = 2762. Missing = 308 (11.2%)

3.6 ASSOCIATION BETWEEN FLUORIDE AND CARIES AND FLUOROSIS

Table 3.37 presents dental caries, dental fluorosis and the mean fluoride concentration of the drinking water by age groups. Dental caries experience of the children was described by the mean dmfs and DMFS index and dental fluorosis was described by using Community Fluorosis Index (CFI). Fluoride concentration in the drinking water was determined by the mean fluoride level from water samples to which they were exposed. Primary caries experience was high in the age group 6–8 years. Permanent caries experiences increased from the youngest to the oldest age group. Dental fluorosis was nearly equal among the four age groups. The mean CFI was highest for 15-17+-year-olds. The mean fluoride levels among the four age groups were statistically significantly different (ANOVA p = 0.032).

Table 3.37: Caries experience, dental fluorosis and fluoride level in drinking water by age group

Age group	Caries			Fluorosis		Fluoride	
	N	dmfs	DMFS	N	CFI	N	F level
6-8-year-olds	705	12.7	0.6	340	0.16	642	0.22
9-11-year-olds	692	4.3	1.7	673	0.16	617	0.23
12-14-year-olds	695		3.4	691	0.16	634	0.19
15-17+-year-olds	670		4.9	663	0.20	623	0.20

To describe the association between fluoride concentration in the drinking water and dental caries and dental fluorosis, the fluoride levels were grouped into three levels of water fluoride exposure: 0.01 – 0.19 ppm, 0.20 – 0.39 ppm and 0.40 – 1.40 ppm. Few clusters had a mean fluoride concentration more than 0.4 ppm. Therefore, all clusters that had mean fluoride concentrations between 0.4 – 1.4 ppm were grouped at the same level of fluoride concentration. Associations were observed by fluoride level at the cluster level in all four age groups.

3.6.1 The age group 6 - 8 years

3.6.1.1 The relationship between fluoride concentration and dental caries

The mean dmfs and DMFS by fluoride level for the 56 clusters of children in the age group 6-8 years are presented in Table 3.38. The mean dmfs and DMFS scores decreased with increasing water fluoride levels. A significant difference in primary caries experience was observed across fluoride levels. There was no significant difference in the permanent caries experience.

Table 3.38: Mean dmfs and DMFS by fluoride level in drinking water in 56 clusters of children aged 6-8 years old.

Fluoride concentration	6–8 years		
	N of clusters	Mean dmfs (*)	Mean DMFS (#)
0.01 – 0.19 ppm	37	13.6 ± 5.7	0.7 ± 0.6
0.20 – 0.39 ppm	13	12.1 ± 3.4	0.5 ± 0.5
0.40 – 1.4 ppm	6	7.5 ± 2.5	0.3 ± 0.3

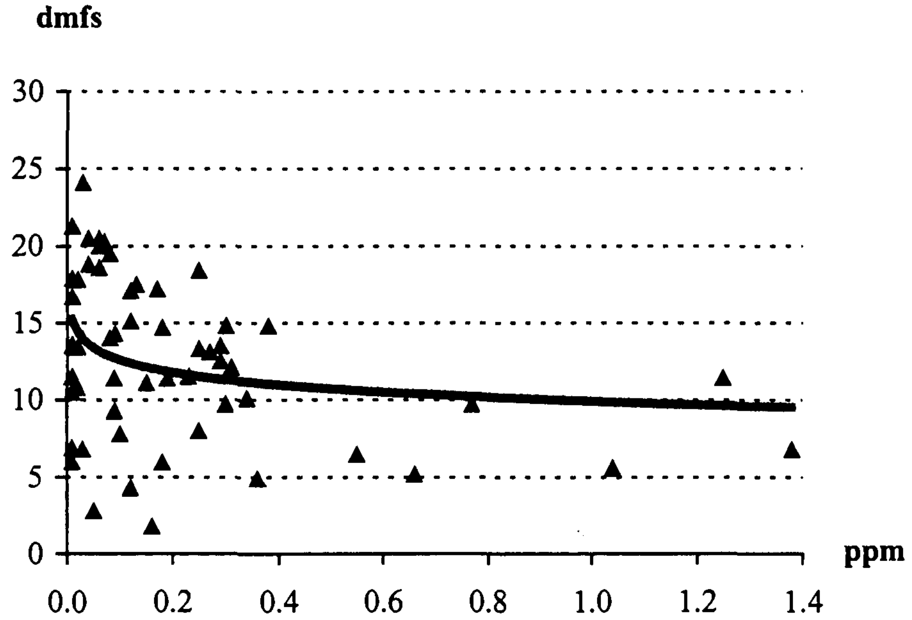
One way ANOVA table * P< 0.05; # P = NS.

Figure 3.9 shows a scatter diagram of fluoride levels and caries experience in the primary dentition with a linear regression curve fitted, in which fluoride concentration was transformed to a logarithmic scale. The relationship was:

The mean dmfs = 9.91 − 2.67 Log. fluoride concentration (ppm).

The mean dmfs had a significant inverse relationship with fluoride concentration in the drinking water (P = 0.021). The mean dmfs declined sharply from 0 ppm to 0.4 ppm of fluoride and was less sharp between 0.4 and 1.4 ppm F.

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



Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	144.65	1	5.63	0.021	0.09	0.08
Residual	1388.16	54				
Total	1532.81	55				

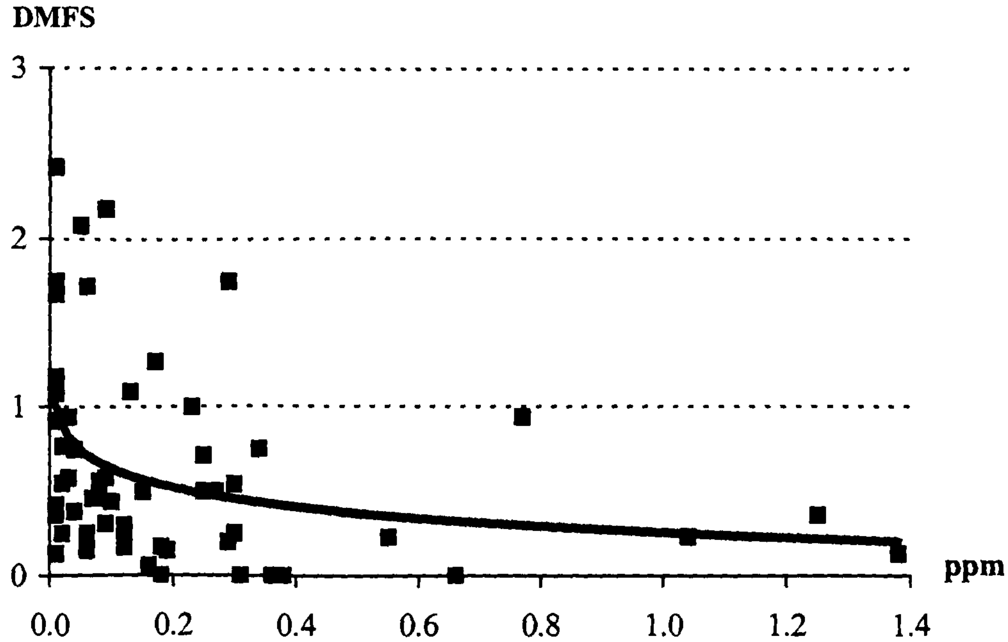
Predictors: (Constant) Log. fluoride concentration of drinking water (ppm)
Dependent Variable: The mean dmfs

Figure 3.10 shows a scatter diagram of fluoride levels and caries experience in the permanent dentition with a linear regression curve fitted, in which fluoride concentration was presented on a logarithmic scale. The relationship was:

The mean DMFS = 0.26 – 0.38 Log. fluoride concentration (ppm).

The mean DMFS had a significant negative relationship with fluoride concentration in the drinking water (P = 0.003). The mean DMFS decreased sharply from 0 ppm to 0.4 ppm of fluoride with a more gradual decline between 0.4 to 1.4 ppm F.

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.



Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	2.93	1	9.53	0.003	0.15	0.13
Residual	16.59	54				
Total	19.52	55				

Predictors: (Constant) Log. fluoride concentration of drinking water (ppm)
Dependent Variable: The mean DMFS

3.6.1.2 The relationship between fluoride concentration and dental fluorosis

Table 3.39 demonstrates the distribution of CFI with fluoride levels of the age group 6–8 years in the 56 clusters of children. The CFI index increased with increasing levels of water fluoride. The increase in CFI was statistically significant.

Table 3.39: Mean CFI by fluoride level in drinking water in 56 clusters of children aged 6-8 years

Fluoride concentration	Fluorosis	
	N of clusters	CFI (*)
0.01 – 0.19 ppm	37	0.12
0.20 – 0.39 ppm	13	0.15
0.40 – 1.6 ppm	6	0.28

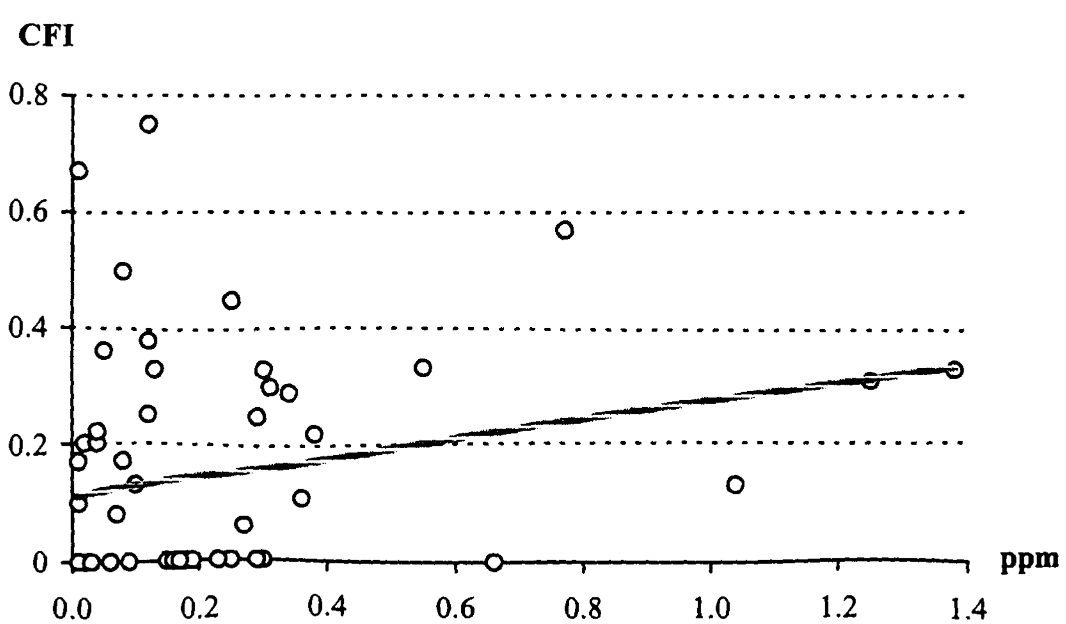
One way ANOVA table * P< 0.05

The relationship between fluoride concentration in the drinking water and dental fluorosis is described in Figure 3.11. It presents a scatter diagram of dental fluorosis and fluoride levels with a linear regression line fitted. The relationship was:

The mean CFI = 0.11 + 0.16 fluoride concentration (ppm).

The mean CFI had a borderline significant positive relationship with fluoride concentration in the drinking water (P = 0.062).

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



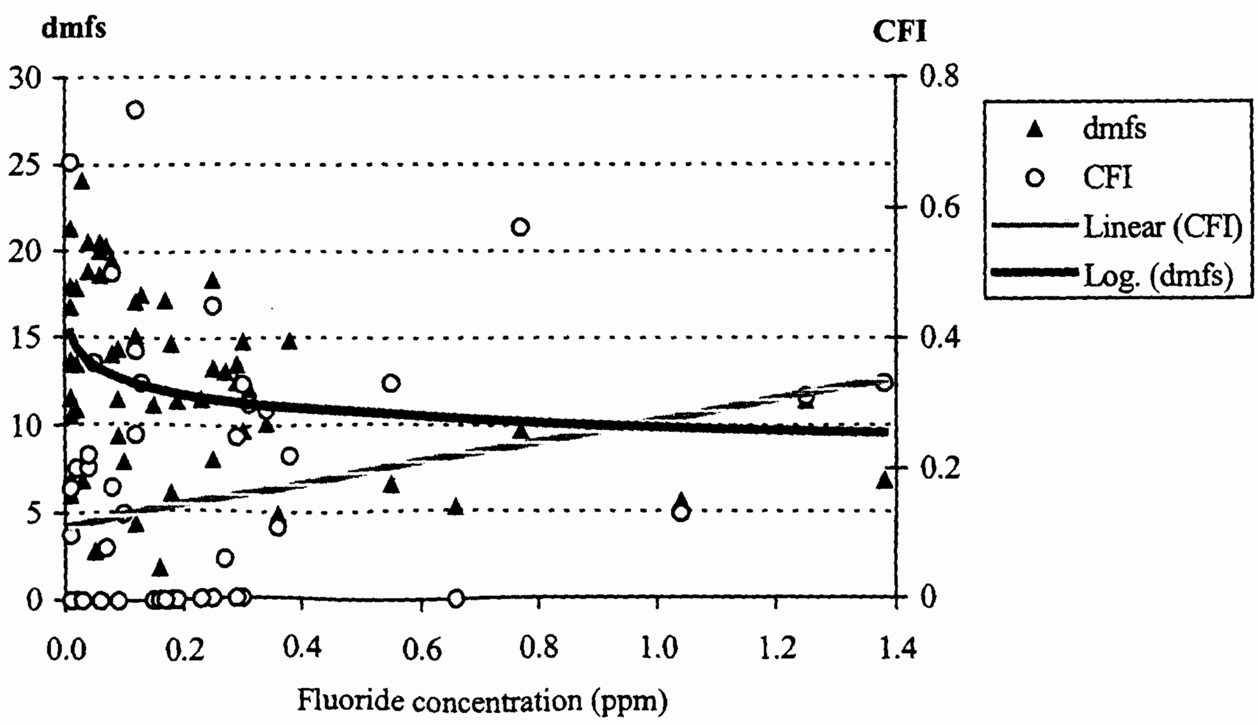
Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	0.13	1	3.64	0.062	0.06	0.05
Residual	1.87	54				
Total	2.00	55				

Predictors: (Constant) fluoride concentration of drinking water (ppm)
Dependent Variable: The mean CFI

3.6.1.3 The relationship between dental caries and fluorosis

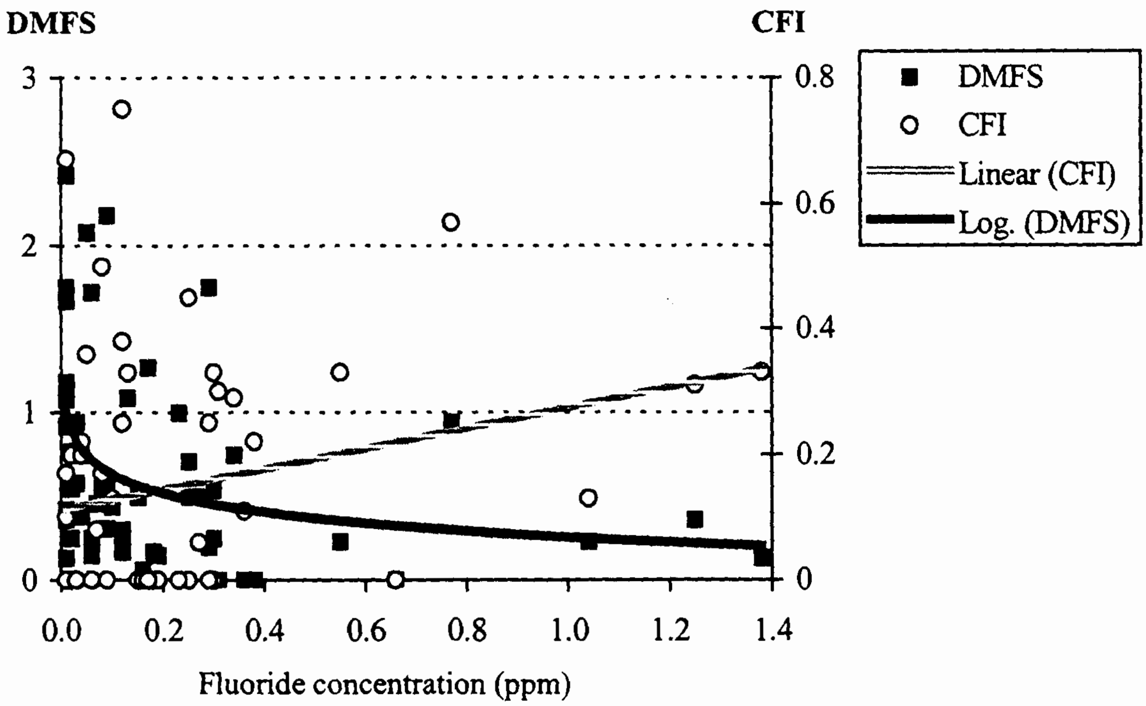
Figure 3.12 shows the intersection of the fitted regression line for dental caries for primary dentition and fluorosis in the age group 6–8 years. The intersection of the mean dmfs lines with the mean CFI was at 0.9 ppm.

Figure 3.12: The intersection of the mean dmfs and the mean CFI regression lines in the age group 6-8 years



The intersection of caries experience for permanent dentition is illustrated in Figure 3.13. It was found that the intersection of the mean DMFS and the mean CFI lines was between 0.20 to 0.30 ppm.

Figure 3.13: The intersection of the mean DMFS and the mean CFI regression lines in the age group 6–8 years



3.6.2 The age group 9-11 years

3.6.2.1 The relationship between fluoride concentration and dental caries

The relationship of dental caries with the three levels of fluoride concentration in the drinking water is presented in Table 3.40. The mean dmfs score was reduced with increasing fluoride content in the drinking water. The DMFS value decreased with increasing fluoride levels from 0.01 – 0.19 ppm to 0.20 – 0.39 ppm then increased at 0.4 – 1.4 ppm. There were no significant associations between fluoride levels and caries in either the primary or permanent dentitions in 9–11-year-olds.

Table 3.40: Mean dmfs and DMFS by fluoride level in drinking water in 56 clusters of children aged 9–11 years

Fluoride concentration	9–11 years		
	N of clusters	Mean dmfs (#)	Mean DMFS (#)
0.01 – 0.19 ppm	36	4.7 ± 2.3	1.7 ± 1.0
0.20 – 0.39 ppm	14	4.0 ± 1.2	1.5 ± 0.9
0.40 – 1.4 ppm	6	3.0 ± 2.0	1.8 ± 1.7

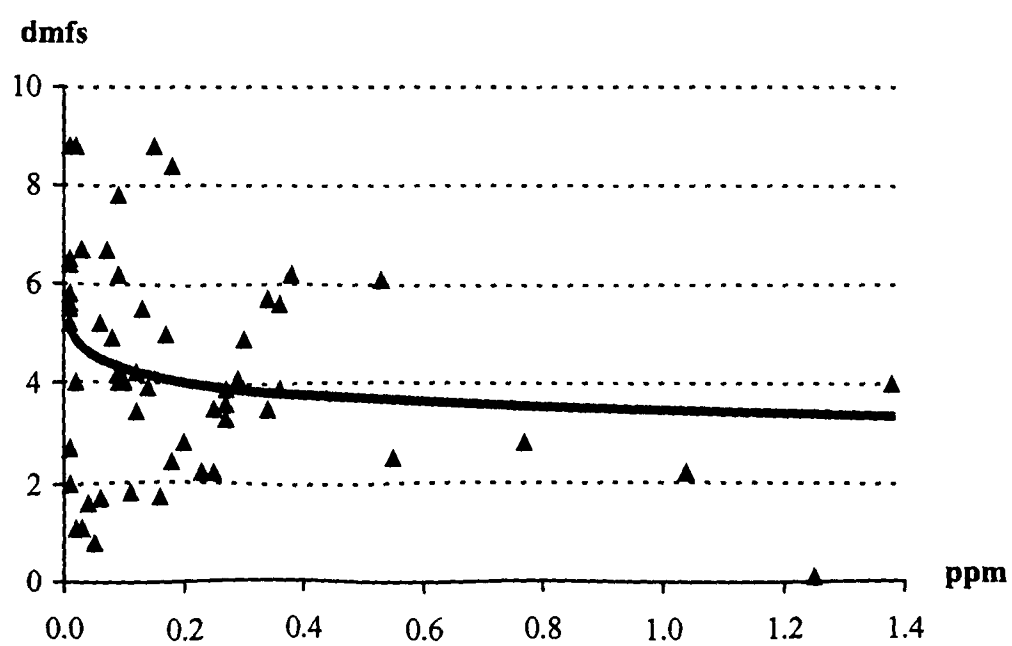
One way ANOVA table # P = NS

The relationship between fluoride concentration and primary caries experience is demonstrated by a scatter diagram in Figure 3.14 with a regression curve. Caries experience had a negative relationship with fluoride concentration when fluoride levels were transformed logarithmically. The formula of the curve is:

The mean dmfs = 3.43 – 0.85 Log. fluoride concentration (ppm).

The relationship was close to significant (P = 0.068).

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



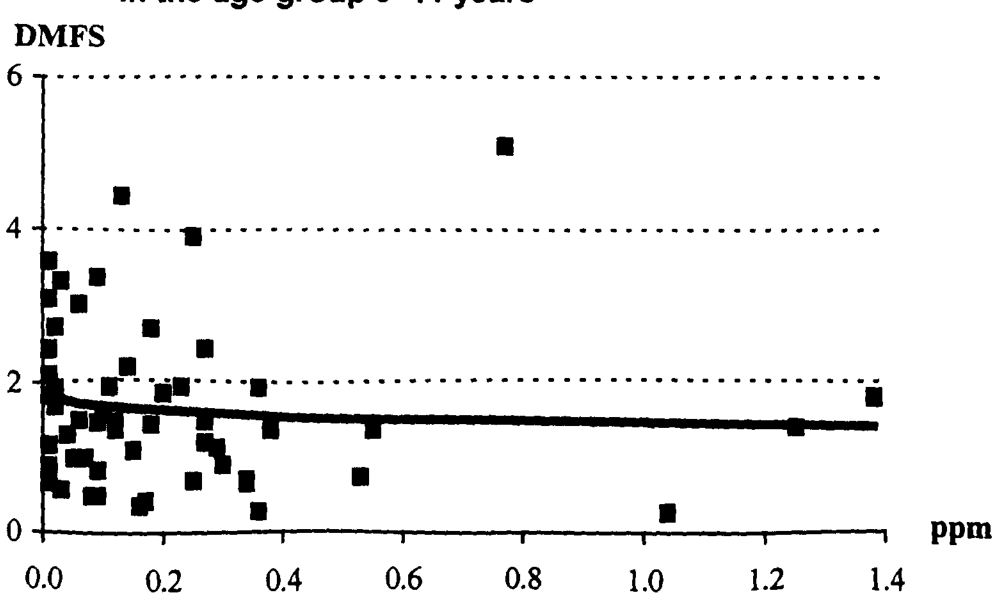
Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	15.08	1	3.47	0.068	0.06	0.04
Residual	234.41	54				
Total	249.49	55				

Predictors: (Constant) Log. fluoride concentration of drinking water (ppm)
Dependent Variable: The mean dmfs

Figure 3.15 illustrates the association of fluoride content and caries experience in the permanent dentition. A regression curve is shown for the association between fluoride concentration, which had been transformed to a logarithmic scale, and caries experience. Although fluoride concentration had a negative association with caries, there was no significant relationship between them and the curve was fairly flat. The formula of the curve is:

The mean DMFS = 1.46 – 0.21 Log. fluoride concentration (ppm).

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



Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	0.94	1	0.81	0.373	0.02	-0.004
Residual	62.65	54				
Total	63.59	55				

Predictors: (Constant) Log. fluoride concentration of drinking water (ppm)
Dependent Variable: The mean DMFS

3.6.2.2 The relationship between fluoride concentration and dental fluorosis

The distribution of CFI with fluoride concentration in drinking water in 56 clusters is presented in Table 3.41. The mean CFI index increased with increasing water fluoride levels. The increase in CFI was significant across the three fluoride level groups (P = 0.000).

Table 3.41: Mean CFI by fluoride level in drinking water in 56 clusters of children aged 9–11 years old

Fluoride concentration	Fluorosis	
	N of clusters	CFI (*)
0.01 – 0.19 ppm	36	0.10 ± 0.12
0.20 – 0.39 ppm	14	0.14 ± 0.14
0.40 – 1.6 ppm	6	0.57 ± 0.25

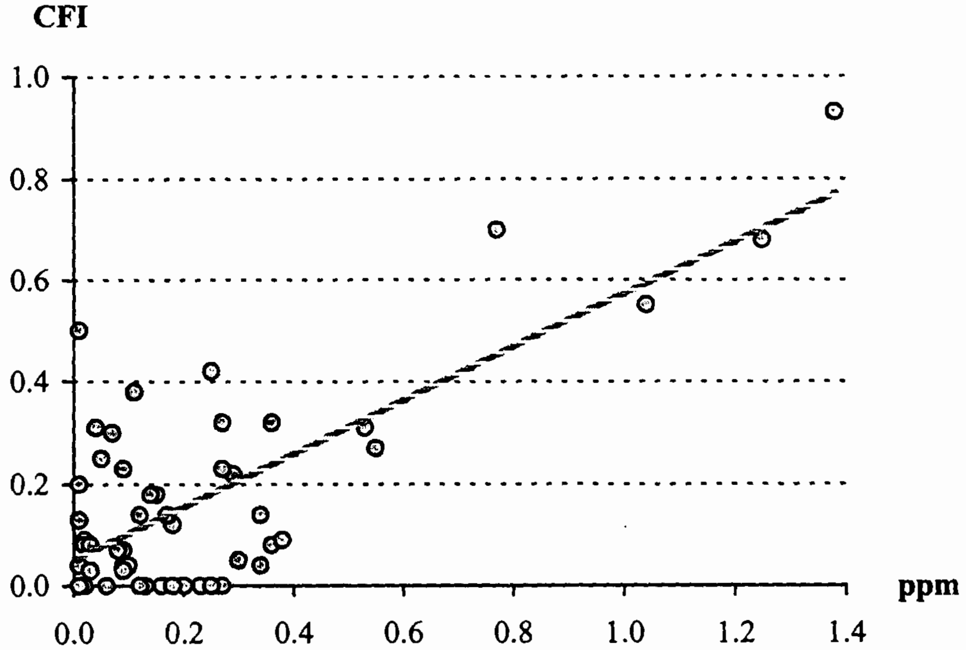
One way ANOVA table * P = 0.000

The relationship between fluoride concentration in the drinking water and dental fluorosis is described in Figure 3.16. It presents a scatter diagram of dental fluorosis against fluoride levels with a linear regression line fitted. The line was:

The mean CFI = 0.05 + 0.53 fluoride concentration (ppm).

A significant linear correlation was found between fluoride concentration in the drinking water and dental fluorosis of children (P = 0.000).

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



Model	**Sum of squares**	**df**	**F**	**Sig.**	**R^2**	**Adjusted R^2**
Regression	1.28	1	70.21	0.000	0.57	0.56
Residual	0.99	54				
Total	2.27	55				

Predictors: (Constant) Fluoride concentration of drinking water (ppm)
Dependent Variable: The mean CFI

3.6.2.3 The relationship between dental caries and dental fluorosis

The intersection of the regression lines for caries for deciduous dentition and fluorosis is shown in Figure 3.17. At 0.6 ppm of fluoride in drinking water, the curve of dental caries crossed the line of dental fluorosis.

Figure 3.17: The intersection of mean dmfs and mean CFI regression lines in the age group 9–11 years

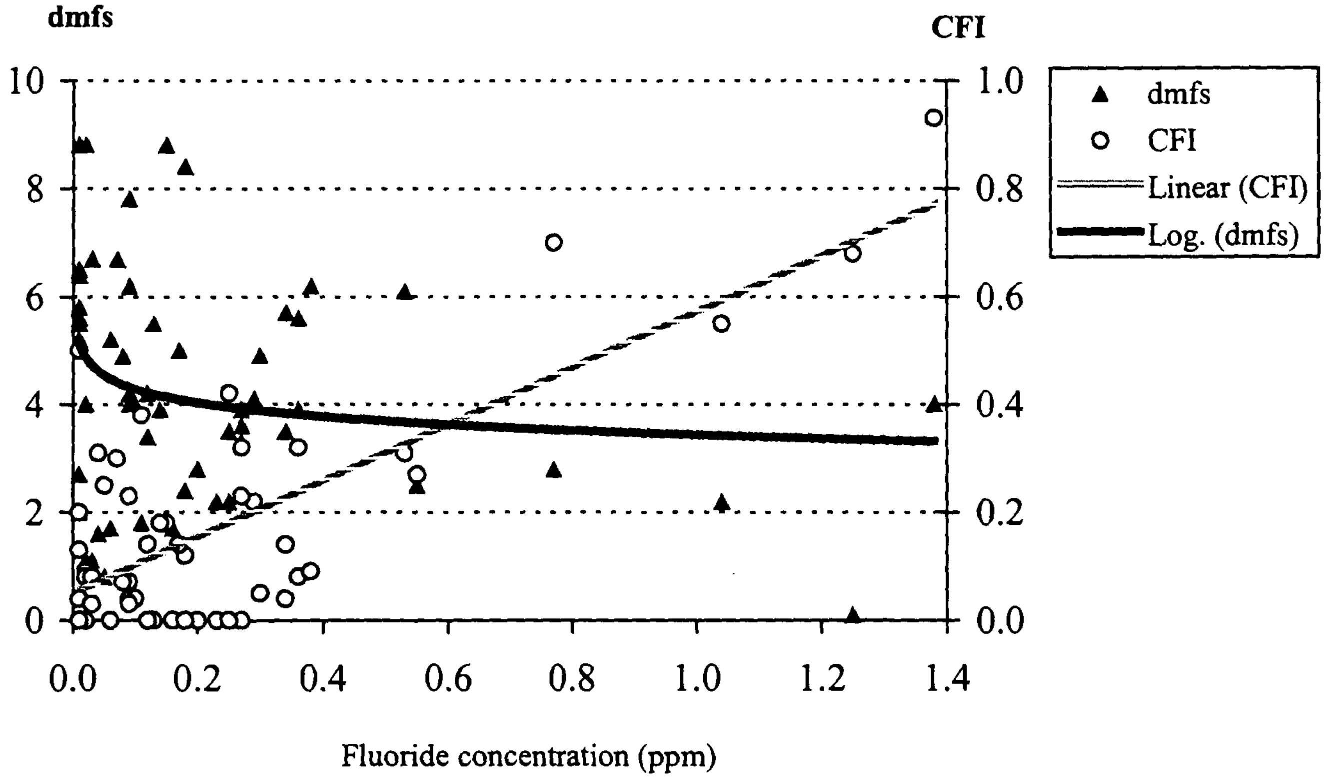
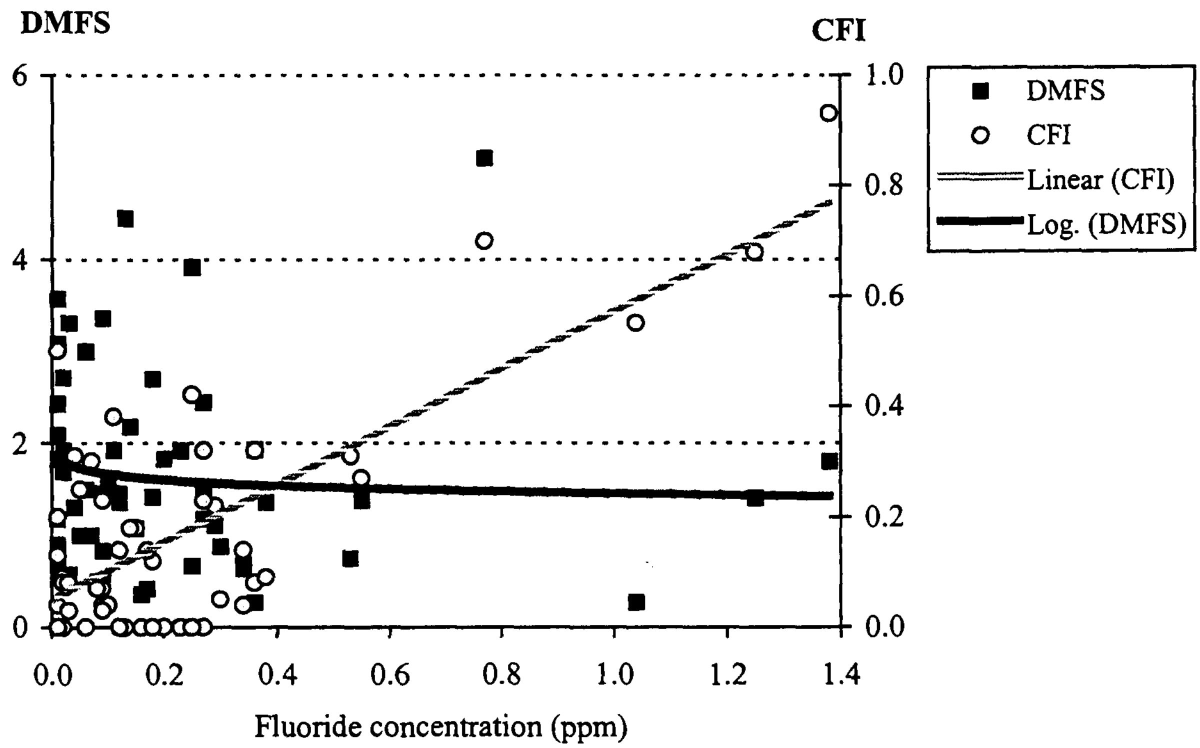


Figure 3.18 shows the curve of dental caries for permanent dentition intersecting the line for dental fluorosis at 0.4 ppm of fluoride in the drinking water.

Figure 3.18: The intersection of mean DMFS and mean CFI regression lines in the age groups 9–11 years.



3.6.3 The age group 12-14 years

3.6.3.1 The relationship between fluoride concentration and dental caries

Table 3.42 presents the relationship between dental caries and fluoride in 56 clusters of children aged 12–14 years. The mean DMFS index reduced with increasing fluoride content in the drinking water. However, the relationship was not significant.

Table 3.42: Mean DMFS by fluoride level in drinking water in 56 clusters of children aged 12–14 years old.

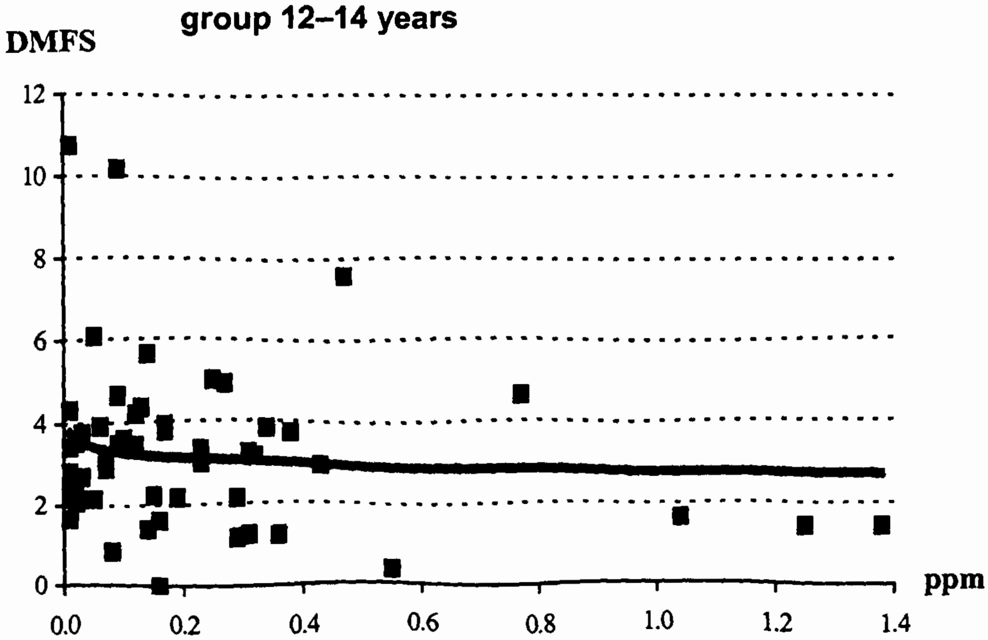
Fluoride	12–14 years	
concentration	N of clusters	Mean DMFS (#)
0.01 – 0.19 ppm	37	3.4 ± 2.1
0.20 – 0.39 ppm	12	3.0 ± 1.3
0.40 – 1.6 ppm	7	2.9 ± 2.5

One way ANOVA table #P = NS

Figure 3.19 shows the scatter diagram of mean fluoride level in drinking water and the mean DMFS for 12–14-year-olds with a regression curve fitted, in which fluoride concentration is transformed to a logarithmic scale. The curve of the mean DMFS showed a negative relationship with fluoride concentration in the drinking water, but it was reasonably flat. The relationship was not significant. The curve was:

The mean DMFS = 2.78 – 0.49 Log. fluoride concentration (ppm).

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



Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	4.69	1	1.19	0.280	0.02	0.03
Residual	212.95	54				
Total	217.64	55				

Predictors: (Constant) Log. fluoride concentration of drinking water (ppm)
Dependent Variable: The mean DMFS

3.6.3.2 The relationship between fluoride concentration and fluorosis

Table 3.43 describes the mean CFI scores across the three mean levels of fluoride in the drinking water. There was a significant positive relationship between fluoride concentration in drinking water and fluorosis (P = 0.000).

Table 3.43: Mean CFI by fluoride level in drinking water in 56 clusters of children aged 12–14 years

Fluoride concentration	12–14 years	
	N of clusters	Mean CFI (*)
0.01 – 0.19 ppm	37	0.09 ± 0.10
0.20 – 0.39 ppm	12	0.23 ± 0.32
0.40 – 1.6 ppm	7	0.50 ± 0.52

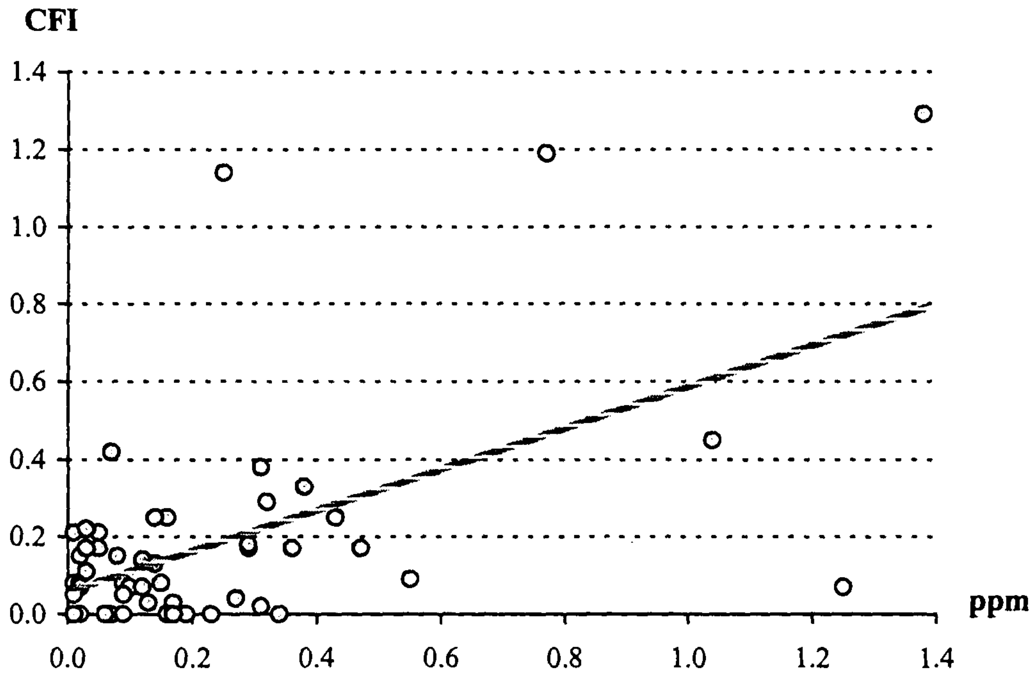
One way ANOVA table *P = 0.000

The association of mean fluoride concentration in the drinking water and dental fluorosis in 56 clusters of children aged 12–14 years was demonstrated by a regression line fitted on a scatter diagram. The positively sloped line established following the formula:

The mean CFI = 0.05 + 0.53 fluoride concentration (ppm).

A significant relationship was found between fluoride concentration in the drinking water and fluorosis (Figure 3.20).

Figure 3.20: The relationship between fluoride concentration in drinking water and dental fluorosis in 56 clusters of children age group 12–14 years



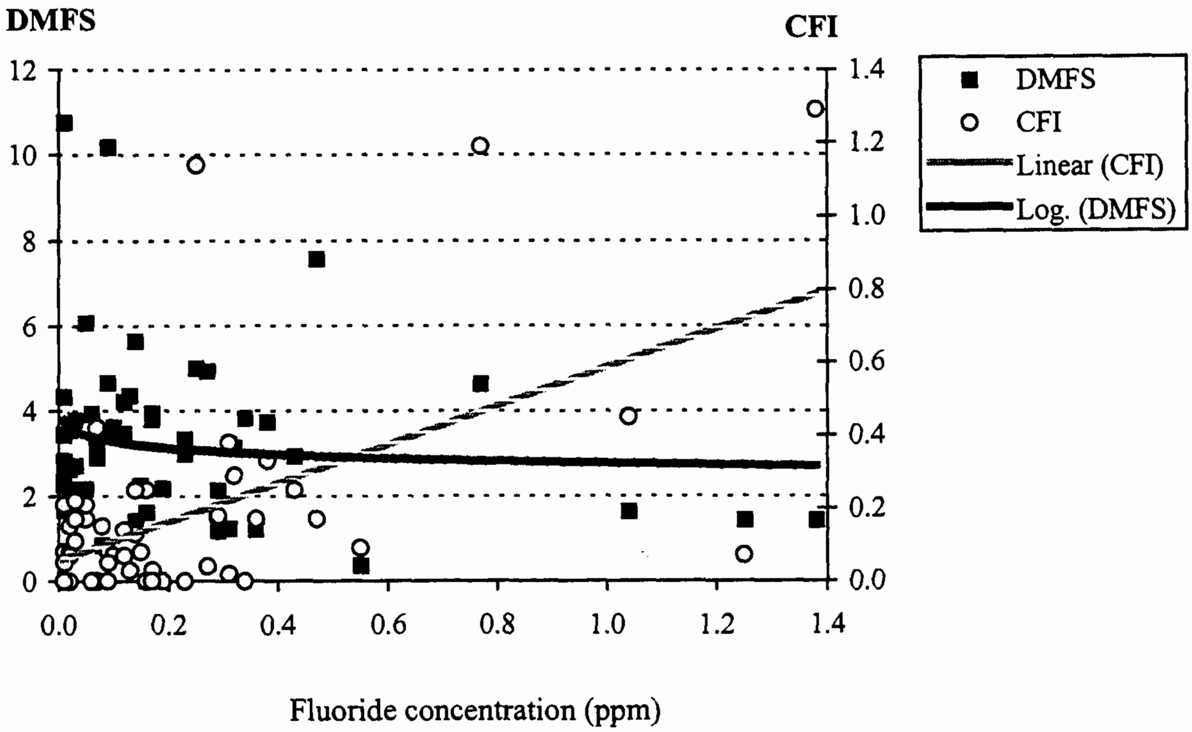
Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	1.32	1	25.19	0.000	0.32	0.31
Residual	2.82	54				
Total	4.14	55				

Predictors: (Constant) Fluoride concentration of drinking water (ppm)
Dependent Variable: The mean CFI

3.6.3.3 The relationship between dental caries and fluorosis

Figure 3.12 presents the intersection of the curve of the mean DMFS with the line of the mean CFI at 0.5 ppm of fluoride concentration for the 56 clusters of 12–14-year-olds.

Figure 3.21: The intersection of mean DMFS and mean CFI regression lines in the age group12–14 years



3.6.4 The age group 15-17+ years

3.6.4.1 The relationship between dental caries and fluoride concentration

The mean of DMFS in 32 clusters of 15-17+-years-olds by fluoride concentration is presented in Table 3.44. The mean DMFS reduced with increasing fluoride concentration from 0.01 – 0.19 ppm to 0.20 – 0.39 ppm, then increased at 0.40 – 1.00 ppm of fluoride. There was no significant association of the mean DMFS with fluoride level.

Table 3.44: Mean DMFS by fluoride level in drinking water in 32 clusters of children aged 15–17+ years

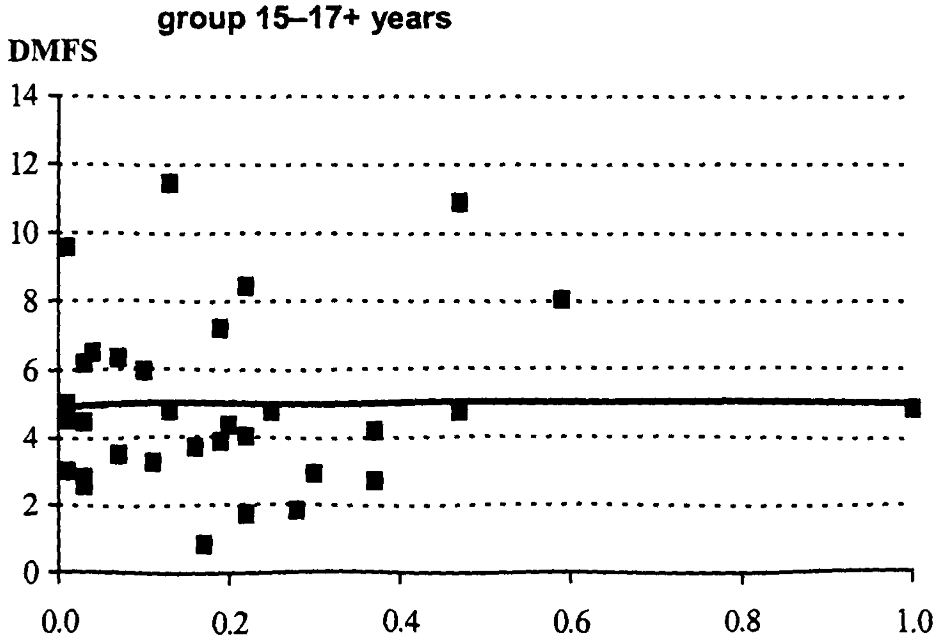
Fluoride concentration	15–17+ years	
	N of clusters	Mean DMFS (#)
0.01 – 0.19 ppm	19	5.0 ± 2.5
0.20 – 0.39 ppm	9	3.9 ± 2.0
0.40 – 1.00 ppm	4	7.2 ± 2.9

One way ANOVA table #P = NS

Figure 3.22 shows the scatter diagram of fluoride concentration in drinking water and caries experience for children aged 15–17+ years with a regression curve fitted, in which fluoride concentration was transformed logarithmically. Dental caries was not significantly related with fluoride concentration in the drinking water (P = 0.965). The formula of the curve was:

The mean DMFS = 5.03 + 0.04 Log. fluoride concentration (ppm).

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



Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	0.01	1	0.00	0.965	0.00	-0.03
Residual	202.58	30				
Total	202.60	31				

Predictors: (Constant) Log.fluoride concentration of drinking water (ppm)
Dependent Variable: The mean DMFS

3.6.4.2 The relationship between dental fluorosis and fluoride concentration

The mean CFI of 32 clusters of children aged 15-17+ years by fluoride concentration is presented in Table 3.45. The mean CFI value increased with increasing fluoride concentration in the drinking water, but no significant relationship was found between them.

Table 3.45: Mean CFI by fluoride level in drinking water in 32 clusters of children aged 15–17+ years

Fluoride concentration	15–17+ years	
	N of clusters	Mean CFI (#)
0.01 – 0.19 ppm	19	0.13 ± 0.19
0.20 – 0.39 ppm	9	0.25 ± 0.37
0.40 – 1.6 ppm	4	0.36 ± 0.30

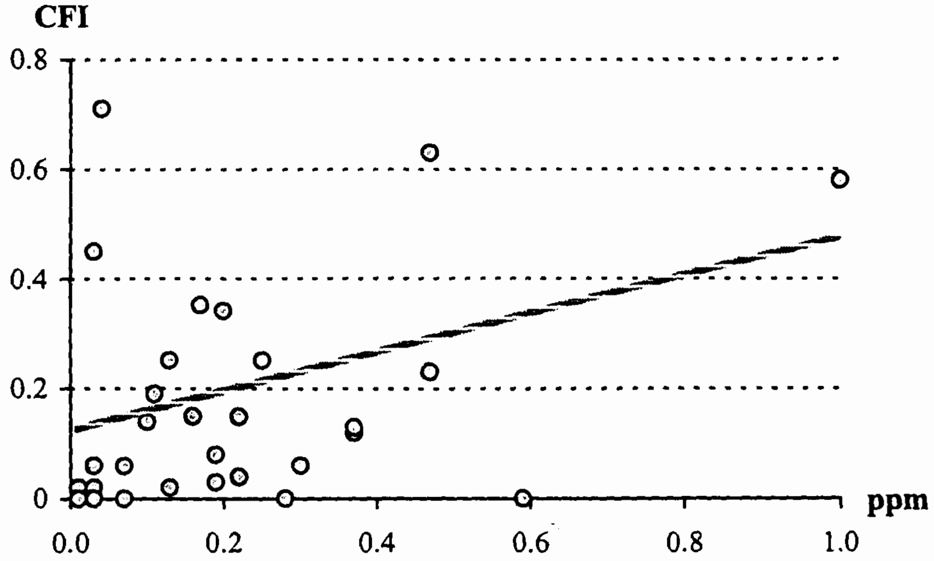
One way ANOVA table #P = NS

A regression line fitted in the scatter diagram presented for the association between fluoride level in the drinking water and fluorosis is demonstrated in Figure 3.23. The slope of the mean CFI was calculated as:

The mean CFI = 0.12 + 0.36 Fluoride concentration (ppm).

The relationship was not significant.

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



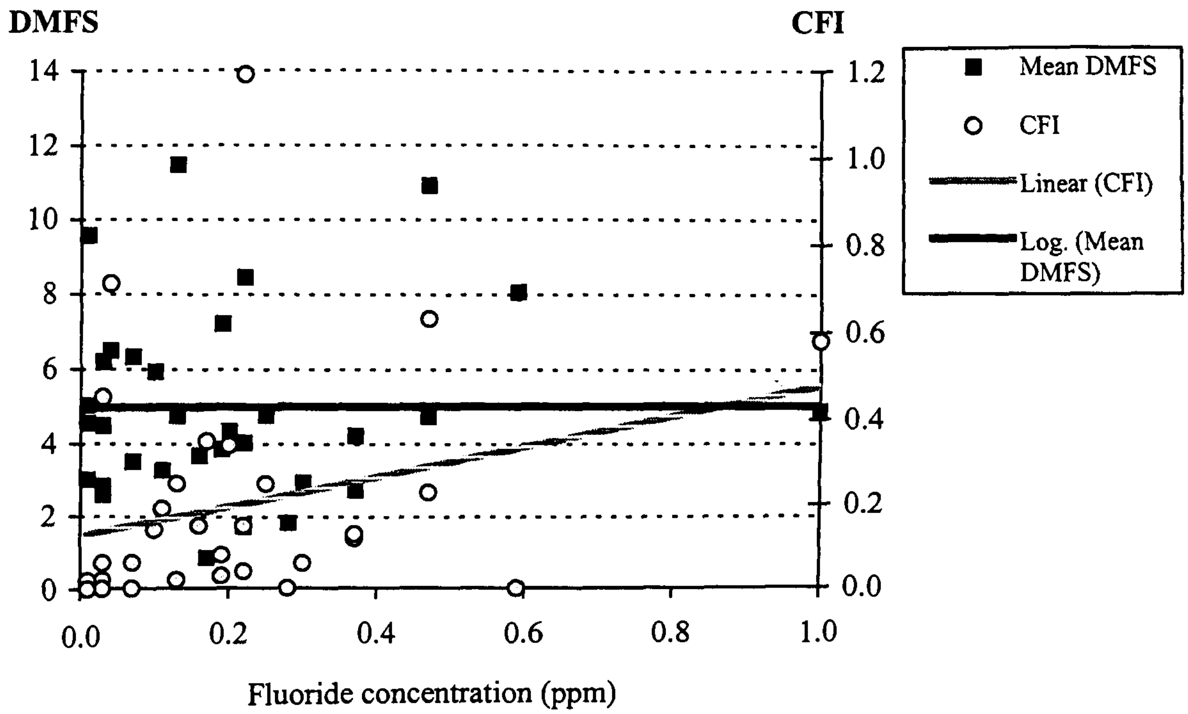
Model	Sum of squares	df	F	Sig.	R^2	Adjusted R^2
Regression	0.17	1	2.56	0.120	0.08	0.05
Residual	2.03	30				
Total	2.20	31				

Predictors: (Constant) Fluoride concentration of drinking water (ppm)
Dependent Variable: The mean CFI

3.6.4.3 The relationship between dental caries and fluorosis

Figure 3.24 shows the intersection of dental caries and fluorosis for 32 clusters of children aged 15–17+ years was between 0.8 and 0.9 ppm of fluoride.

Figure 3.24: The intersection of mean DMFS and mean CFI regression lines in the age group 15–17+ years



3.7 CONFOUNDING ASSOCIATIONS

Dental caries and fluorosis are influenced not only by the fluoride concentration in the drinking water, but also by other factors. The comparison of the mean dmfs, DMFS and CFI among groups with different water fluoride exposure without consideration of the other factors may confound the relationship between fluoride concentration in the drinking water and dental caries and fluorosis. The statistical procedure ANOVA was used to measure the relationships between these other factors and dental caries and fluorosis.

3.7.1 The influence of socio-economic and demographic factors on dental caries and fluorosis

In this study, eight factors of socio-economic and demographic status were examined in relation to dental caries and fluorosis. The factors were sex, residence, household crowding, family income, mother's education, father's education, mother's occupation and father's occupation.

3.7.1.1 Socio-economic and demographic factors with dental caries

3.7.1.1.a The influence of socio-economic and demographic factors on caries experience of the primary dentition

Table 3.46 lists the mean dmfs of each level of the socio-economic and demographic factors and the statistical significance of the differences between the levels. The results indicate that:

- In the age group 6-8 years, the factors showing significant associations were household crowding, mother's education, father's education, mother's occupation and father's occupation. Children who were in a more crowded family, whose parents had low education and were farmers, had lower dental caries experience than their counterparts.
- In the age group 9–11 years there were statistically significant differences in dmfs scores between groups for sex, mother's education level and mother's occupation. Female children had lower caries experience than male children. Children whose mothers had low education levels and children whose mothers worked as farmers had lower primary caries experience.

Table 3.46: Mean dmfs in each level of socio-economic and demographic status by age group

Socio-economic and demographic status	6–8 years		9–11 years	
	N	Mean (SD)	N	Mean (SD)
Sex	P = 0.067		**P = 0.007***	
Male	362	13.5 (13.3)	344	5.0 (7.0)
Female	339	11.8 (11.8)	344	3.6 (6.3)
Residence	P = 0.923		P = 0.269	
Urban	403	12.7 (12.5)	409	4.1 (6.4)
Rural	303	12.8 (12.8)	282	4.6 (7.1)
Household crowding	**P = 0.029***		P = 0.146	
< 5 people	379	13.8 (13.2)	299	4.6 (6.5)
5 – 7 people	255	11.6 (12.1)	316	4.1 (6.6)
7 + people	42	9.6 (8.9)	53	2.8 (6.9)
Family income	P = 0.192		P = 0.068	
Low income	293	11.5 (11.5)	273	3.6 (6.2)
Medium income	271	13.3 (13.4)	245	4.4 (6.8)
High income	120	12.8 (11.5)	144	5.2 (7.1)
Mother's education	**P = 0.016***		**P = 0.047***	
Low education	219	10.6 (12.1)	222	3.4 (5.6)
Medium education	368	13.7 (13.3)	352	4.8 (7.3)
High education	94	13.1 (11.2)	94	4.5 (6.9)
Father's education	**P = 0.020***		P = 0.330	
Low education	165	10.3 (11.2)	160	3.7 (6.3)
Medium education	395	13.5 (13.3)	394	4.7 (7.0)
High education	93	13.2 (11.9)	93	4.8 (7.1)
Mother's occupation	**P = 0.002***		**P = 0.026***	
Farmer	282	10.5 (11.3)	293	3.5 (5.7)
Manual worker	60	12.7 (13.0)	50	5.1 (8.3)
Professional, office worker	122	13.6 (11.5)	129	5.1 (7.6)
Private business	86	15.7 (15.4)	89	3.8 (6.1)
Home duties	129	14.9 (13.8)	108	5.7 (7.8)
Other	10	16.4 (15.1)	13	4.9 (6.9)

Father's occupation	**P = 0.020***		P = 0.330	
Farmer	294	10.9 (11.4)	302	3.8 (6.2)
Manual worker	117	13.1 (13.2)	94	4.7 (7.1)
Professional, office worker	118	13.8 (13.1)	116	4.7 (6.8)
Private business	86	14.9 (14.2)	97	4.7 (7.2)
Home duties	21	17.8 (16.8)	17	7.1 (9.2)
Other	28	13.9 (10.3)	31	4.0 (6.9)

*Statistical significance P< 0.05

3.7.1.1.b The influence of socio-economic and demographic factors on caries experience of the permanent dentition

The mean DMFS at each level of various socio-economic factors are shown in Table 3.47 for the four age groups. The results show caries experience was significantly influenced by family income, mother's education and father's occupation in the age group 6–8 years. The highest caries experience was found in children who had low family income, whose mother had low education level and whose father was a farmer. In the age group 9–11 years, only sex had a statistically significant association with caries experience. Females had higher caries experience than males. The findings were in contrast to that observed for primary teeth, probably reflecting the earlier dental development of girls. No factors had a statistically significant effect on caries experience among the 12–14-year-olds or the 15–17+-year-olds.

Table 3.47: Mean DMFS in each level of socio-economic and demographic status by age group

Socio-economic and demographic status	6–8 years		9–11 years		12–14 years		15–17+ years	
	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)
Sex	P = 0.575		**P = 0.048***		P = 0.167		P = 0.342	
Male	362	0.6 (1.4)	344	1.5 (2.4)	352	3.1 (4.6)	281	4.7 (6.8)
Female	339	0.7 (1.4)	344	1.9 (2.8)	342	3.6 (5.1)	384	5.2 (6.4)
Residence	P = 0.570		P = 0.845		P = 0.101		P = 0.107	
Urban	403	0.6 (1.4)	409	1.7 (2.5)	392	3.1 (4.3)	358	5.3 (6.2)
Rural	303	0.7 (1.4)	282	1.7 (2.8)	303	3.7 (5.5)	285	4.5 (6.9)
Household crowding	P = 0.447		P = 0.673		P = 0.107		P = 0.587	
< 5 people	379	0.6 (1.4)	299	1.6 (2.4)	277	3.3 (4.7)	274	4.7 (6.9)
5 – 7 people	255	0.7 (1.4)	316	1.8 (2.8)	327	3.5 (5.2)	323	5.1 (6.4)
7 + people	42	0.7 (1.4)	53	1.7 (3.4)	57	2.9 (4.5)	45	4.4 (5.3)
Family income	**P = 0.000***		P = 0.097		P = 0.535		P = 0.956	
Low income	293	0.8 (1.6)	273	1.8 (2.7)	302	3.3 (5.0)	220	4.9 (7.4)
Medium income	271	0.5 (1.2)	245	1.7 (2.8)	214	3.7 (5.4)	232	4.8 (5.8)
High income	120	0.3 (0.8)	144	1.3 (2.2)	161	3.2 (3.9)	191	4.9 (5.9)
Mother's education	**P = 0.020***		P = 0.726		P = 0.418		P = 0.106	
Low education	219	0.7 (1.5)	222	1.6 (3.0)	221	3.7 (5.4)	154	5.8 (7.0)
Medium education	368	0.6 (1.4)	352	1.7 (2.4)	363	3.3 (4.8)	369	4.9 (6.7)
High education	94	0.3 (0.8)	94	1.5 (2.4)	97	2.9 (3.7)	129	4.1 (5.4)
Father's education	P = 0.235		P = 0.253		P = 0.240		P = 0.073	
Low education	165	0.6 (1.3)	160	1.5 (2.6)	152	3.0 (4.4)	101	6.0 (7.7)
Medium education	395	0.7 (1.5)	394	1.8 (2.8)	397	3.6 (5.3)	366	4.7 (5.3)
High education	93	0.4 (1.0)	93	1.4 (2.0)	111	2.9 (3.7)	169	4.3 (5.4)
Mother's occupation	P = 0.282		P = 0.653		P = 0.792		P = 0.095	
Farmer	282	0.7 (1.5)	293	1.6 (2.6)	297	3.5 (5.8)	229	4.4 (6.0)
Manual worker	60	0.4 (1.0)	50	1.7 (3.2)	58	2.8 (3.5)	74	4.1 (4.7)
Professional, office worker	122	0.5 (1.1)	129	1.5 (2.2)	110	3.0 (3.8)	145	4.9 (7.9)
Private business	86	0.7 (1.6)	89	2.1 (3.3)	75	3.2 (4.6)	77	6.2 (7.4)
Home duties	129	0.6 (1.4)	108	1.5 (2.3)	142	3.6 (4.2)	120	6.0 (6.3)
Other	10	0.5 (1.1)	13	2.2 (3.1)	7	4.3 (5.1)	17	3.6 (4.0)

Father's occupation	P = 0.046*		P = 0.700		P = 0.867		P = 0.059	
Farmer	294	0.8 (1.6)	302	1.7 (2.6)	312	3.4 (5.4)	232	5.1 (7.5)
Manual worker	117	0.4 (1.1)	94	1.7 (2.6)	97	3.6 (4.5)	94	4.8 (5.8)
Professional, office worker	118	0.5 (1.1)	116	1.5 (2.3)	124	3.0 (3.8)	191	3.9 (4.8)
Private business	86	0.5 (1.2)	97	1.8 (2.9)	82	3.4 (4.7)	80	6.0 (6.8)
Home duties	21	0.6 (1.1)	17	1.0 (1.9)	17	2.2 (2.5)	10	6.1 (3.7)
Other	28	0.7 (1.5)	31	2.1 (3.3)	28	3.7 (4.7)	41	6.5 (6.5)

*Statistical significance P< 0.05

3.7.1.2 Socio-economic and demographic factors with dental fluorosis

Table 3.48 describes the relationship between the mean CFI and socio-economic and demographic factors. Children at least 12 years old living in a rural area are associated with a higher CFI score. Parent's occupation was also significantly related to fluorosis in the 15-17+ years age group. The mean CFI was higher in the group of children whose parents were farmers, professionals or office workers and lower in the group of children with parents running private businesses.

Table 3.48: Mean CFI in each level of socio-economic and demographic status by age group

Socio-economic and demographic status	6–8 years		9–11 years		12–14 years		15–17+ years	
	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)
Sex	P = 0.078		P = 0.372		P = 0.436		P = 0.401	
Male	156	0.20 (0.48)	333	0.17 (0.48)	351	0.18 (0.54)	278	0.22 (0.65)
Female	182	0.13 (0.29)	336	0.14 (0.42)	340	0.15 (0.45)	380	0.18 (0.52)
Residence	P = 0.333		P = 0.052		**P = 0.001***		**P = 0.004***	
Urban	191	0.18 (0.39)	399	0.13 (0.38)	390	0.11 (0.38)	382	0.15 (0.50)
Rural	150	0.14 (0.40)	273	0.20 (0.54)	301	0.23 (0.61)	281	0.28 (0.67)
Household crowding	P = 0.659		P = 0.422		P = 0.123		P = 0.054	
< 5 people	173	0.18 (0.45)	291	0.14 (0.43)	277	0.13 (0.44)	272	0.15 (0.40)
5 – 7 people	138	0.14 (0.33)	306	0.19 (0.51)	324	0.18 (0.52)	320	0.23 (0.69)
7 + people	17	0.15 (0.34)	52	0.13 (0.31)	56	0.28 (0.72)	43	0.35 (0.69)

Family income	P = 0.441		P = 0.219		P = 0.675		P = 0.413	
Low income	145	0.20 (0.48)	263	0.18 (0.49)	300	0.18 (0.50)	219	0.17 (0.48)
Medium income	126	0.14 (0.33)	242	0.17 (0.52)	212	0.15 (0.50)	228	0.23 (0.63)
High income	56	0.13 (0.31)	139	0.10 (0.25)	161	0.15 (0.53)	189	0.24 (0.65)
Mother's education	P = 0.301		P = 0.358		P = 0.97		P = 0.185	
Low education	115	0.19 (0.46)	215	0.20 (0.57)	219	0.18 (0.51)	151	0.26 (0.72)
Medium education	171	0.16 (0.38)	345	0.14 (0.39)	361	0.16 (0.49)	367	0.19 (0.56)
High education	43	0.08 (0.24)	89	0.14 (0.39)	97	0.06 (0.33)	127	0.14 (0.43)
Father's education	P = 0.097		P = 0.266		P = 0.078		P = 0.103	
Low education	83	0.17 (0.45)	158	0.22 (0.63)	152	0.20 (0.58)	99	0.14 (0.36)
Medium education	179	0.18 (0.39)	382	0.15 (0.40)	393	0.18 (0.53)	362	0.24 (0.67)
High education	51	0.05 (0.18)	88	0.14 (0.39)	111	0.07 (0.21)	169	0.14 (0.47)
Mother's occupation	P = 0.066		P = 0.204		P = 0.353		**P = 0.027***	
Farmer	146	0.21 (0.50)	287	0.21 (0.53)	295	0.21 (0.58)	227	0.31 (0.69)
Manual worker	24	0.13 (0.27)	46	0.12 (0.26)	58	0.16 (0.51)	73	0.18 (0.64)
Professional, office worker	56	0.04 (0.13)	123	0.15 (0.49)	110	0.12 (0.46)	143	0.19 (0.58)
Private business	38	0.22 (0.36)	88	0.12 (0.39)	73	0.13 (0.40)	76	0.09 (0.26)
Home duties	61	0.13 (0.29)	107	0.11 (0.29)	142	0.11 (0.37)	120	0.13 (0.47)
Other	5	0.00 (0.00)	13	0.00 (0.00)	7	0.29(0.49)	16	0.13 (0.29)
Father's occupation	P = 0.185		P = 0.381		P = 0.478		**P = 0.006***	
Farmer	152	0.21 (0.48)	296	0.19 (0.50)	310	0.20 (0.54)	229	0.29 (0.66)
Manual worker	41	0.11 (0.26)	89	0.16 (0.40)	96	0.13 (0.42)	92	0.06 (0.19)
Professional, office worker	59	0.07 (0.21)	110	0.12 (0.36)	124	0.13 (0.54)	190	0.22 (0.68)
Private business	37	0.16 (0.33)	96	0.10 (0.27)	81	0.17 (0.50)	79	0.08 (0.29)
Home duties	12	0.08 (0.19)	17	0.18 (0.35)	17	0.00 (0.00)	10	0.20 (0.63)
Other	17	0.15 (0.34)	31	0.26 (0.88)	28	0.11 (0.32)	41	0.10 (0.26)

*Statistical significance P< 0.05.

It can be seen that more socio-economic and demographic factors had statistically significant associations with primary dental caries than with permanent dentition. Caries experience in the age groups 12–14 years and 15–17+ years was not significantly associated with any of the social factors. Dental fluorosis was significantly associated with area of residence of children and parental occupation.

3.7.2 The influence of dietary habits on dental caries and fluorosis

Based on the report by the child's parent about dietary habits of the child and the rest of the family, ten dietary habits were examined to determine their association with dental caries and fluorosis in the four age groups.

3.7.2.1 Dietary habits with dental caries

3.7.2.1a The influence of dietary habits on caries experience of the primary dentition

The use of fish sauce or cooking salt significantly influenced the deciduous caries experience for children 11 years old or younger. Children in families using only cooking salt had lower mean dmfs than children in families using fish sauce or both fish sauce and cooking salt. Children who ate candy had higher caries experience than those who did not. Other factors such as kind of sweets, drinks and sugar consumption demonstrated that the children who used sweets, soft drinks, juice fruit, tea and added sugar in drinks or their family often used sugar for cooking had higher caries than their counterparts. Using soft drinks, adding sugar in drinks and using sugar for cooking were significantly related with higher caries experience in the 6–8-year-olds. Eating fruit at least twice a day is associated with reduced caries experience among 6–8-year-olds (Table 3.49).

Table 3.49: Mean dmfs in each level of dietary habit by age group

Dietary habit	6–8 years		9–11 years	
	N	Mean (sd)	N	Mean (sd)
Using fish sauce or salt	**P = 0.002***		**P = 0.015***	
Fish sauce	32	13.8 (12.9)	39	3.2 (4.9)
Cooking salt	117	8.9 (11.8)	103	2.7 (4.4)
Both of them	536	13.5 (12.7)	529	4.7 (7.0)

Eating candy	**P = 0.026***		**P = 0.042***	
Yes	456	13.4 (13.2)	462	4.5 (7.0)
No	109	10.3 (10.6)	122	3.1 (6.0)
Eating ice-cream	P = 0.805		P = 0.824	
Yes	244	13.5 (12.8)	249	4.3 (7.4)
No	165	13.2 (13.3)	184	4.1 (6.6)
Eating biscuits	P = 0.272		P = 0.133	
Yes	411	13.3 (13.3)	406	4.6 (7.2)
No	117	11.8 (11.5)	126	3.5 (5.7)
Drinking soft drink	**P = 0.037***		P = 0.244	
Yes	187	14.6 (14.3)	176	4.9 (7.5)
No	179	11.8 (11.6)	214	4.1 (6.9)
Drinking juice fruit	P = 0.372		P = 0.756	
Yes	159	14.3 (12.8)	141	4.7 (7.4)
No	169	13.1 (13.0)	217	4.5 (7.1)
Drinking tea	P = 0.111		P = 0.771	
Yes	87	16.2 (13.6)	116	5.0 (7.7)
No	179	13.4 (13.1)	214	4.7 (7.5)
Adding sugar in drinks	**P = 0.010***		P = 0.940	
Often	42	15.5 (14.5)	32	4.5 (6.5)
Sometimes	405	13.5 (12.6)	403	4.3 (6.6)
Never	202	10.6 (12.1)	211	4.1 (7.1)
Using sugar for cooking	**P = 0.021***		P = 0.094	
Often	116	13.6 (13.4)	137	4.6 (7.9)
Sometimes	430	13.3 (12.4)	407	4.5 (6.8)
Never	108	9.7 (11.9)	107	3.0 (4.4)
Eating fruit	**P = 0.005***		P = 0.495	
At most once a day	494	13.8 (13.3)	512	4.2 (6.8)
At least twice a day	119	10.1 (9.8)	92	4.7 (6.7)

*Statistical significance P< 0.05.

3.7.2.1.b The influence of dietary habits on caries experience of the permanent dentition

Table 3.50 shows that eating biscuits was associated with lower caries experience, while drinking tea was associated with higher caries experience among 6–8-year-olds. Adding sugar in drinking and in cooking was associated with increased caries experience among 9–11-year-olds and 15–17+-year-olds. Eating fruit at least twice a day was associated with more permanent teeth caries among 15–17+-year-olds.

Table 3.50: Mean DMFS in each level of dietary habit by age group

Dietary habits	6–8 years		9–11 years		12–14 years		15–17+ years	
	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)
Using fish sauce or salt	P = 0.965		P = 0.262		P = 0.965		P = 0.160	
Fish sauce	32	0.7 (1.8)	39	1.9 (3.0)	46	2.7 (3.6)	39	3.5 (3.7)
Cooking salt	117	0.6 (1.4)	103	1.3 (2.2)	99	2.8 (3.6)	48	3.8 (3.9)
Both of them	536	0.6 (1.4)	529	1.7 (2.7)	520	3.5 (5.2)	566	5.1 (6.8)
Eating candy	P = 0.727		P = 0.195		P = 0.295		P = 0.846	
Yes	456	0.6 (1.3)	462	1.7 (2.7)	422	3.4 (5.3)	412	5.1 (6.2)
No	109	0.6 (1.3)	122	1.4 (2.4)	96	2.8 (3.4)	156	5.2 (7.6)
Eating ice-cream	P = 0.672		P = 0.960		P = 0.844		P = 0.518	
Yes	244	0.6 (1.2)	249	1.7 (2.7)	235	3.0 (4.0)	263	5.5 (6.9)
No	165	0.6 (1.3)	184	1.7 (2.6)	146	2.9 (4.6)	218	5.1 (7.0)
Eating biscuits	**P = 0.008***		P = 0.383		P = 0.512		P = 0.672	
Yes	411	0.5 (1.2)	406	1.8 (2.8)	375	3.3 (4.7)	385	5.3 (6.4)
No	117	0.8 (1.6)	126	1.5 (2.4)	109	2.9 (3.9)	156	5.1 (7.8)
Drinking soft drink	P = 0.173		P = 0.711		P = 0.761		P = 0.334	
Yes	187	0.5 (1.1)	176	1.8 (2.7)	173	3.0 (3.9)	217	5.9 (7.2)
No	179	0.6 (1.4)	214	1.6 (2.6)	169	3.2 (5.4)	218	5.2 (7.2)
Drinking juice fruit	P = 0.062		P = 0.663		P = 0.789		P = 0.694	
Yes	159	0.5 (1.0)	141	1.9 (3.2)	149	3.0 (3.9)	148	5.4 (6.5)
No	169	0.7 (1.5)	217	1.8 (2.5)	177	3.1 (5.1)	264	5.6 (7.2)

Drinking tea	**P = 0.017***		P = 0.081		P = 0.580		P = 0.550	
Yes	87	1.0 (1.8)	116	2.1 (3.3)	153	2.9 (4.3)	198	5.7 (8.0)
No	179	0.5 (1.1)	214	1.6 (2.3)	172	3.2 (4.6)	204	5.3 (5.7)
Adding sugar in drinks	P = 0.066		P = 0.157		P = 0.466		**P = 0.001***	
Often	42	0.9 (1.8)	32	2.5 (4.4)	34	4.2 (5.6)	55	8.1 (11.8)
Sometimes	405	0.7 (1.5)	403	1.6 (2.3)	412	3.4 (5.3)	398	4.8 (6.1)
Never	202	0.4 (1.1)	211	1.5 (2.7)	202	3.1(4.0)	185	4.3 (5.0)
Using sugar for cooking	P = 0.250		**P = 0.000***		P = 0.670		P = 0.000	
Often	116	0.6 (1.3)	137	2.4 (3.8)	126	3.7 (5.0)	150	6.9 (9.1)
Sometimes	430	0.7 (1.5)	407	1.6 (2.3)	428	3.4 (4.9)	413	4.7 (5.7)
Never	108	0.5 (1.0)	107	1.2 (1.9)	97	3.1 (4.6)	79	2.9 (3.6)
Eating fruit	P = 0.122		P = 0.069		P = 0.531		**P = 0.008***	
At most once a day	494	0.7 (1.4)	512	1.8 (2.7)	484	3.3 (4.7)	454	4.6 (5.8)
At least twice a day	119	0.4 (1.0)	92	1.2 (2.2)	126	3.6 (5.7)	173	6.2 (8.4)

*Statistical significance P< 0.05

3.7.2.2 Dietary habits with dental fluorosis.

Table 3.51 presents the relationship between dietary habits and dental fluorosis. Ice-cream was significantly associated with a lower level of fluorosis in 6–8-year-olds. In the age group 9–11-years, the use of ice-cream, biscuits and soft drinks were associated with lower levels of fluorosis. In the age group 15–17+-years, the use of soft drinks and more frequent consumption of fruit juice and fruit were significantly associated with reduced occurrence of fluorosis.

Table 3.51: Mean CFI in each level of dietary habits by age group.

Dietary habits	**6–8 years**		**9–11 years**		**12–14 years**		**15–17+ years**	
	N	**Mean (sd)**	**N**	**Mean (sd)**	**N**	**Mean (sd)**	**N**	**Mean (sd)**
Using fish sauce or salt	P = 0.252		P = 0.539		P = 0.174		P = 0.826	
Fish sauce	13	0.15 (0.38)	38	0.14 (0.31)	46	0.10 (0.27)	39	0.17 (0.53)
Cooking salt	49	0.07 (0.25)	101	0.20 (0.46)	99	0.10 (0.31)	48	0.17 (0.43)
Both of them	271	0.16 (0.37)	514	0.15 (0.45)	517	0.18 (0.55)	559	0.21 (0.60)

Eating candy	P = 0.142		P = 0.500		P = 0.442		P = 0.177	
Yes	214	0.14 (0.36)	448	0.16 (0.49)	419	0.18 (0.57)	408	0.20 (0.56)
No	64	0.22 (0.43)	120	0.19 (0.43)	95	0.13 (0.32)	153	0.28 (0.74)
Eating ice-cream	**P = 0.031***		**P = 0.005***		P = 0.285		P = 0.432	
Yes	113	0.10 (0.26)	241	0.12 (0.37)	235	0.12 (0.38)	259	0.21 (0.60)
No	89	0.20 (0.42)	183	0.25 (0.60)	144	0.16 (0.40)	216	0.25 (0.62)
Eating biscuit	P = 0.359		**P = 0.000***		P = 0.648		P = 0.063	
Yes	182	0.11 (0.31)	392	0.13 (0.41)	373	0.15 (0.46)	381	0.19 (0.54)
No	72	0.15 (0.32)	124	0.31 (0.66)	108	0.17 (0.42)	153	0.29 (0.71)
Drinking soft drink	P = 0.140		**P = 0.050***		P = 0.423		**P = 0.034***	
Yes	83	0.12 (0.27)	171	0.11 (0.37)	173	0.13 (0.44)	216	0.14 (0.45)
No	89	0.20 (0.43)	210	0.19 (0.48)	166	0.17 (0.45)	215	0.25 (0.64)
Drinking juice fruit	P = 0.771		P = 0.190		P = 0.341		**P = 0.024***	
Yes	75	0.17 (0.39)	137	0.13 (0.33)	148	0.13 (0.42)	147	0.11 (0.32)
No	93	0.15 (0.33)	213	0.19 (0.47)	174	0.18 (0.46)	260	0.23 (0.63)
Drinking tea	P = 0.546		P = 0.688		P = 0.667		P = 0.786	
Yes	51	0.17 (0.33)	113	0.17 (0.41)	152	0.18 (0.42)	195	0.21 (0.62)
No	90	0.13 (0.31)	212	0.15 (0.41)	170	0.16 (0.50)	203	0.20 (0.54)
Adding sugar in drinks	P = 0.882		P = 0.342		P = 0.618		P = 0.060	
Often	21	0.14 (0.28)	30	0.07(0.22)	34	0.12 (0.25)	54	0.08 (0.25)
Sometimes	200	0.15 (0.39)	392	0.16 (0.44)	408	0.18 (0.56)	398	0.19 (0.54)
Never	97	0.18 (0.40)	208	0.19 (0.53)	202	0.14 (0.42)	179	0.28 (0.74)
Using sugar for cooking	P = 0.567		P = 0.102		P = 0.739		P = 0.055	
Often	66	0.17 (0.42)	132	0.11 (0.31)	126	0.15 (0.41)	148	0.10 (0.37)
Sometimes	205	0.15 (0.36)	397	0.16 (0.50)	426	0.17 (0.50)	408	0.24 (0.64)
Never	53	0.10 (0.28)	103	0.24 (0.47)	96	0.20 (0.65)	79	0.23 (0.58)
Eating fruit	P = 0.616		P = 0.213		P = 0.725		**P = 0.000***	
At most once a day	242	0.16 (0.41)	498	0.16 (0.47)	480	0.15 (0.46)	448	0.26 (0.67)
At least twice a day	297	0.19 (0.35)	91	0.22 (0.51)	126	0.17 (0.51)	172	0.06 (0.23)

*Statistical significance $P < 0.05$

In summary, dietary habits were strongly associated with dental caries in all age groups, especially in the 6–8 years age group for primary dentition and in the 15–17+ years age group for permanent dentition, whereas they were not related consistently with dental fluorosis.

3.7.3. The influence of dental behaviours on dental caries and fluorosis

3.7.3.1 Dental behaviours with dental caries

Four dental behaviours were examined to determine the influence of the child's dental behaviours on dental caries and dental fluorosis.

3.7.3.1 a The influence of dental behaviours on the primary dentition

Among dental behaviours of children, only the factor of previous dental visiting had a significant relationship with primary caries experience. It showed that the children who had a dental visit had higher caries experience than those who had not had a dental visit (Table 3.52).

Table 3.52: Mean dmfs in each level of dental behaviour by age group

Dental behaviours	6–8 years		9–11 years	
	N	Mean (sd)	N	Mean (sd)
Brushing teeth	P = 0.192		P = 0.323	
Yes	638	12.3 (12.6)	644	4.2 (6.7)
No	51	10.5 (12.9)	34	5.4 (7.4)
Frequency of brushing teeth	P = 0.625		P = 0.719	
Less than twice a day	323	12.7 (12.8)	291	4.4 (6.9)
At least twice a day	303	13.2 (12.5)	341	4.2 (6.5)
Age commenced brushing teeth	P = 0.565		P = 0.112	
Three years old or earlier	209	12.3 (11.5)	197	4.6 (6.7)
After three years old	380	13.1 (13.0)	346	4.0 (6.1)
Don't know	66	14.1 (14.3)	102	5.6 (9.2)

Dental visit	P = 0.000*		P = 0.004*	
Yes	229	15.4 (13.1)	224	5.4 (7.6)
No	389	10.8 (11.9)	378	3.8 (6.0)

*Statistical significance P< 0.05

3.7.3.1 b The influence of dental behaviours on the permanent dentition

In the permanent teeth a similar trend of dental caries experience was seen in relation to dental visiting patterns. For all age groups, except for 6–8-year-olds, dental attendance was associated with higher caries experience (Table 3.53).

Table 3.53: Mean DMFS in each level of dental behaviour by age group

Dental behaviours	6-8 years		9-11 years		12-14 years		15-17+ years	
	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)
Brushing teeth	P = 0.812		P = 0.313		P = 0.204		P = 0.195	
Yes	638	0.6 (1.4)	644	1.7 (3.0)	670	3.4 (4.9)	651	4.8 (6.4)
No	51	0.6 (1.5)	34	1.3 (2.1)	12	1.6 (2.7)	4	9.0 8.0)
Frequency of brushing	P = 0.754		P = 0.925		P = 0.483		P = 0.095	
Less than twice a day	323	0.7 (1.5)	291	1.7 (2.7)	302	3.4 (5.3)	231	4.4 (6.7)
At least twice a day	303	0.6 (1.3)	341	1.7 (2.7)	347	3.2 4.1)	416	5.3 (6.5)
Age commenced brushing	P = 0.606		P = 0.954		P = 0.167		P = 0.764	
Three years old or earlier	209	0.6 (1.3)	197	1.7 (2.6)	181	3.4 (4.2)	157	4.9 (5.5)
After three years old	380	0.7 (1.5)	346	1.7 (2.6)	339	3.7 (5.6)	236	4.6 (6.1)
Don't know	66	0.7 (1.5)	102	1.7 (3.2)	151	2.8 (3.9)	239	4.9 (5.9)
Dental visit	P = 0.692		**P = 0.036***		**P = 0.002***		**P = 0.000***	
Yes	224	0.7 (1.4)	187	2.0 (2.8)	182	4.3 (5.9)	223	7.3 (7.3)
No	376	0.6 (1.4)	440	1.5 (2.5)	443	2.9 (4.4)	402	3.7 (5.7)

* Statistical significance P< 0.05

3.7.3.1 Dental behaviours with dental fluorosis

A relationship between dental behaviours and dental fluorosis was only found for dental visiting. Children who had visited a dental clinic had a lower mean CFI than those who had not been. The significant effect of dental visiting was seen in all the age groups except for 6–8-year-olds (Table 3.54).

Table 3.54: Mean CFI in each level of dental behaviour by age group

Dental behaviours	6–8 years		9–11 years		12–14 years		15–17+ years	
	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)
Brushing teeth	P = 0.338		P = 0.169		P = 0.732		P = 0.876	
Yes	311	0.17 (0.40)	627	0.15 (0.45)	666	0.16 (0.50)	644	0.20 (0.59)
No	23	0.09 (0.25)	32	0.27 (0.60)	12	0.21 (0.58)	4	0.25 (0.50)
Frequency of brushing	P = 0.197		P = 0.879		P = 0.822		P = 0.772	
Less than twice a day	154	0.19 (0.44)	285	0.16 (0.45)	300	0.16 (0.48)	228	0.21 (0.50)
At least twice a day	155	0.14 (0.37)	332	0.15 (0.44)	346	0.17 (0.54)	412	0.20 (0.63)
Age commenced brushing	P = 0.284		P = 0.477		P = 0.981		P = 0.282	
Three years old or earlier	104	0.19 (0.48)	192	0.14 (0.35)	181	0.17 (0.48)	157	0.20 (0.51)
After three years old	179	0.17 (0.37)	338	0.17 (0.51)	336	0.16 (0.57)	233	0.25 (0.68)
Don't know	41	0.07 (0.24)	99	0.12 (0.39)	150	0.17 (0.39)	237	0.16 (0.55)
Dental visit	P = 0.074		**P = 0.014***		**P = 0.004***		**P = 0.002***	
Yes	119	0.11 (0.27)	218	0.11 (0.30)	181	0.07 (0.21)	221	0.11 (0.45)
No	186	0.19 (0.47)	366	0.20 (0.55)	440	0.19 (0.56)	398	0.27 (0.66)

*Statistical significance P< 0.05

The behaviour of dental visiting was strongly associated with dental caries for both primary and permanent teeth and dental fluorosis. Other dental behaviours had no significant relationship with dental caries or dental fluorosis.

3.7.4 The influence of discretionary fluoride on dental caries and fluorosis

The use of toothpaste and mouthrinsing were examined in relation to dental caries and fluorosis in four age groups.

3.7.4.1 Discretionary fluoride with dental caries.

3.7.4.1.a The influence of discretionary fluoride on the primary dentition

Table 3.55 shows no statistically significant association between caries experience in primary teeth and discretionary fluoride exposure.

Table 3.55: Mean dmfs in each level of discretionary fluoride by age group

Discretionary fluoride	6–8 years		9–11 years	
	N	Mean (sd)	N	Mean (sd)
Using toothpaste (tp)	P = 0.387		P = 0.356	
Yes	643	13.0 (12.7)	648	4.3 (6.8)
No	25	10.8 (10.5)	19	2.9 (4.3)
Age commenced brushing with tp	P = 0.977		P = 0.524	
Three years old or earlier	154	12.6 (12.0)	139	4.7 (7.1)
After three years old	406	12.6 (12.7)	381	4.1 (6.2)
Don't know	71	14.2 (13.3)	115	4.7 (7.9)
Amount of toothpaste used	P = 0.883		P = 0.154	
Smear (small amount)	164	12.4 (12.4)	117	4.9 (7.4)
Pea size (medium amount)	333	13.1 (12.5)	371	4.0 (6.3)
Full length (large amount)	26	12.0 (13.3)	50	3.8 (5.9)
Don't know	43	11.9 (12.0)	53	6.0 (8.4)
Using mouthrinse	P = 0.068		P = 0.408	
Yes	313	13.6 (13.3)	276	4.4 (6.0)
No	298	11.7 (12.0)	329	4.0 (7.2)

Kind of mouthrinse used	P = 0.513		P = 0.640	
Fluoride mouthrinse in school	73	15.7 (12.4)	64	4.9 (7.0)
Commercial mouthrinse	6	13.0 (15.4)	9	2.9 (4.5)
Salt water	94	12.6 (13.9)	94	4.8 (6.1)
Water	85	13.8 (12.9)	94	4.0 (5.3)

3.7.4.1.b The influence of discretionary fluoride on the permanent dentition

Only using toothpaste was significantly associated with permanent caries experience for 9–11-year-olds. The children who used toothpaste had lower caries experience than those who did not (Table 3.56).

Table 3.56: Mean DMFS in each level of discretionary fluoride by age group

Discretionary fluoride	**6–8 years**		**9–11 years**		**12–14 years**		**15–17+ years**	
	N	**Mean (sd)**	**N**	**Mean (sd)**	**N**	**Mean (sd)**	**N**	**Mean (sd)**
Using toothpaste (tp)	P = 0.123		**P = 0.010***		P = 0.485		P = 0.817	
Yes	643	0.6 (1.4)	648	1.7 (2.7)	666	3.3 (4.9)	658	5.0 (6.6)
No	25	1.1 (1.8)	19	3.3 (2.9)	18	2.6 (3.1)	9	4.4 (3.7)
Age commenced brushing with tp	P = 0.818		P = 0.500		P = 0.499		P = 0.098	
Three years old or earlier	154	0.6 (1.3)	139	1.9 (3.2)	134	3.3 (4.1)	92	4.8 (6.2)
After three years old	406	0.6 (1.4)	381	1.7 (2.6)	364	3.6 (5.5)	256	4.3 (5.5)
Don't know	71	0.7 (1.5)	115	1.5 (2.0)	154	3.0 (3.9)	277	5.5 (7.4)
Amount of tp used	P = 0.910		P = 0.900		P = 0.131		P = 0.434	
Smear (small)	164	0.6 (1.4)	117	1.6 (2.8)	68	2.6 (3.4)	34	5.1 (8.1)
Pea size (medium)	333	0.7 (1.5)	371	1.8 (2.7)	416	3.7 (5.4)	420	4.6 (5.5)
Full length (large)	26	0.5 (1.1)	50	1.5 (2.2)	92	2.8 (3.8)	120	5.5 (6.5)
Don't know	43	0.7 (1.1)	53	1.6 (2.8)	47	4.2 (4.6)	41	5.7(12.2)
Using mouthrinse	P = 0.534		P = 0.343		P = 0.098		P = 0.810	
Yes	313	0.6 (1.3)	276	1.8 (2.7)	282	3.7 (5.8)	243	4.9 (7.6)
No	298	0.7 (1.5)	329	1.6 (2.7)	328	3.1 (4.1)	354	5.1 (6.0)

Kind of mouthrinse used	P = 0.916		P = 0.747		P = 0.692		P = 0.975	
Fluoride mouthrinse in school	73	0.5 (1.1)	64	1.8 (3.1)	11	2.2 (2.4)	7	4.1 (4.5)
Commercial mouthrinse	6	0.3 (0.8)	9	2.7 (3.6)	6	1.8 (2.2)	24	5.4 (4.6)
Salt water	94	0.5 (1.3)	94	1.7 (2.6)	97	3.5 (5.3)	93	4.8 (8.9)
Water	85	0.6 (1.2)	94	2.0 (2.7)	143	3.8 (6.1)	81	4.8 (6.6)

*Statistical significance P< 0.05

3.7.4.2 Discretionary fluoride with dental fluorosis

Table 3.57 shows that the use of mouthrinse was significantly associated with dental fluorosis for all age groups except 12–14-year-olds. The children who used mouthrinse had a lower mean CFI. Age commenced brushing with toothpaste was a significant factor among 9–11-year-olds for the occurrence of fluorosis. The children who started brushing with toothpaste early had a lower mean CFI than children who started late.

Table 3.57: Mean CFI in each level of discretionary fluoride exposure by age group

Discretionary fluoride	6–8 years		9–11 years		12–14 years		15–17+ years	
	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)	N	Mean (sd)
Using toothpaste (tp)	P = 0.856		P = 0.075		P = 0.835		P = 0.815	
Yes	314	0.16 (0.39)	632	0.15 (0.45)	662	0.16 (0.51)	652	0.20 (0.58)
No	14	0.14 (0.53)	19	0.34 (0.75)	18	0.14 (0.29)	8	0.25 (0.71)
Age commenced brushing with tp	P = 0.122		**P = 0.011***		P = 0.830		P = 0.063	
Three years old or earlier	73	0.21 (0.45)	134	0.07 (0.18)	134	0.14 (0.41)	92	0.11 (0.35)
After three years old	187	0.15 (0.36)	372	0.20 (0.52)	361	0.17 (0.55)	254	0.27 (0.65)
Don't know	48	0.07 (0.23)	113	0.12 (0.38)	153	0.15 (0.38)	272	0.18 (0.60)
Amount of tp used	P = 0.249		P = 0.633		P = 0.401		P = 0.146	
Smear (small)	76	0.11 (0.38)	116	0.16 (0.52)	68	0.16 (0.41)	34	0.29 (0.75)
Pea size (medium)	170	0.19 (0.38)	361	0.17 (0.48)	413	0.18 (0.53)	416	0.20 (0.56)
Full length (large)	9	0.00 (0.00)	50	0.13 (0.30)	92	0.10 (0.45)	119	0.09 (0.30)
Don't know	24	0.23 (0.66)	52	0.09 (0.24)	47	0.09 (0.24)	40	0.20 (0.66)

Using mouthrinse	**P = 0.041***		**P = 0.017***		P = 0.281		**P = 0.002***	
Yes	145	0.10 (0.33)	265	0.11 (0.28)	280	0.14 (0.48)	242	0.12 (0.35)
No	160	0.19 (0.40)	326	0.20 (0.58)	326	0.18 (0.53)	349	0.27 (0.69)
Kind of mouthrinse used	P = 0.552		P = 0.585		P = 0.285		P = 0.407	
Fluoride mouthrinse in school	37	0.05 (0.16)	62	0.09 (0.23)	11	0.14 (0.32)	7	0.07 (0.19)
Commercial mouthrinse	1	0.00 (0.00)	8	0.13 (0.23)	6	0.08 (0.20)	24	0.13 (0.30)
Salt water	44	0.16 (0.49)	89	0.15 (0.33)	96	0.08 (0.35)	92	0.06 (0.19)
Water	34	0.08 (0.23)	91	0.10 (0.25)	142	0.20 (0.59)	81	0.12 (0.32)

*Statistical significance P< 0.05.

Assessment of the relationship between discretionary fluoride and dental caries and fluorosis found that only using toothpaste was significantly associated with dental caries in the age group 9–11 years. Other factors had no relationship with caries. Using mouthrinsing was related strongly with fluorosis.

3.7.5 Summary

Table 3.58 shows a 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.

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

Factors	**dmfs**		**DMFS**				**CFI**			
Socio-economic and demographic status	**6–8**	**9–11**	**6–8**	**9–11**	**12–14**	**15–17**	**6–8**	**9–11**	**12–14**	**15–17**
Sex		✓		✓						
Residence									✓	✓
Household crowding	✓									
Family income			✓							
Mother's education	✓	✓	✓							
Father's education	✓									
Mother's occupation	✓	✓								✓
Father's occupation	✓		✓							✓
Dietary habits										
Using fish sauce or salt	✓	✓								
Eating candy	✓	✓	✓							
Eating ice-cream							✓	✓		
Eating biscuits			✓					✓		
Drinking soft drink	✓							✓		✓
Drinking juice fruit										✓
Drinking tea			✓							
Adding sugar in drinks	✓					✓				
Using sugar for cooking	✓			✓		✓				
Eating fruit	✓					✓				✓
Dental behaviours										
Brushing teeth										
Frequency of brushing										
Age commenced brushing										
Dental visit	✓	✓		✓	✓	✓		✓	✓	✓

Factors	**dmfs**		**DMFS**				**CFI**			
Socio-economic and demographic status	**6–8**	**9–11**	**6–8**	**9–11**	**12–14**	**15–17**	**6–8**	**9–11**	**12–14**	**15–17**
Discretionary fluoride										
Using toothpaste				✓						
Age commenced brushing with toothpaste								✓		
Amount of toothpaste used										
Using mouthrinse							✓	✓		✓
Kind of mouthrinse										

✓: a statistically significant association

3.8 MULTIVARIATE MODELS FOR CONTROLLING THE RELATIONSHIP BETWEEN FLUORIDE CONCENTRATION IN DRINKING WATER AND DENTAL CARIES AND FLUOROSIS

According to bivariates analyses of socio-economic and demographic status, dietary habits, dental behaviours and discretionary fluoride exposure with dental caries and fluorosis, some factors were determined to have strong associations with caries and fluorosis at the individual child level. Multivariate models included fluoride concentration in drinking water. The factors which had a strong and consistent association with dental caries and fluorosis in the bivariable models were analysed by linear regression to investigate the confounding of these factors with the relationship of fluoride concentration in drinking water with dental caries and fluorosis. Dummy variables of each factor were created and used in multivariable models. Linear regression analyses were used to determine their relationships with dental caries and fluorosis. The unstandardized coefficients, P value of dummy variables in each factor, and R square, adjusted R square and P value of model were reported.

3.8.1 Multivariate models for caries experience

Mother's education, using sugar for cooking and dental visiting determined in bivariate analyses were strongly statistically significant in their association with caries experience. The dummy variables of these factors and fluoride concentration of drinking water, which was transformed logarithmically, were examined in the multivariate linear regression model for both primary and permanent dentition. Table 3.59 presents the relationship of factors with caries experience in primary dentition. The result shows that fluoride concentration in drinking water was significantly associated with reduced primary caries experience in the age group 6-8 years. Dental visit patterns were associated significantly with increased primary dental caries for both age groups. Sometimes using sugar for cooking was associated significantly with high primary caries experience among 6–8-year-old children. P value of model was statistically significant.

Table 3.59: Multivariable models for caries experience in primary teeth (dmfs)

Variables	6–8 years		9–11 years	
	Coefficients	**Sig.**	**Coefficients**	**Sig.**
Mother's education				
Low education level	0.05	0.976	-0.91	0.369
Medium education level	1.42	0.369	0.05	0.960
High education level	-	-	-	-
Using sugar for cooking				
Often	2.80	0.135	1.14	0.300
Sometimes	3.48	**0.020**	0.75	0.416
Never	-	-	-	-
Dental visit				
Yes	3.04	**0.009**	1.29	0.055*
No	-	-	-	-
Log. fluoride concentration in drinking water	- 2.69	**0.001**	-0.62	0.211
	$R2 = 0.05$ Adj. $R2 = 0.04$ Model: $P = 0.000$		$R2 = 0.02$ Adj. $R2 = 0.01$ Model: $P = 0.072$*	

* a closely significant association

The model for permanent teeth caries experience is shown in Table 3.60. The fluoride levels in drinking water also had a negative association with permanent caries, but the association was statistically significant only among 6–8-year-old children. Mother's education also had a negative association with permanent caries experience. Children whose mothers had a lower education level had higher caries experience. The relationship was significant for all age groups except 9–11 years. The frequency of using sugar for cooking was significantly associated with an increase in permanent caries experience in the age groups 9–11 years and 15–17+ years. Dental visit patterns were related significantly with an increase in permanent caries experience. Children who had been to a dental clinic had higher caries experience from 12 years of age and older. Mother's education, using sugar for cooking and dental visit patterns were associated significantly with increased permanent caries experience for 15–17+ years age group. P value of model was statistically significant in the age groups 6–8 years and 15–17+ years.

Table 3.60: Multi-variables models for caries experience in permanent teeth (DMFS)

Variables	6-8 years		9-11 years		12-14 years		15-17+ years	
	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Mother's education								
Low education level	0.64	**0.002**	0.06	0.881	1.28	0.072*	1.87	**0.031**
Medium education level	0.41	**0.026**	0.18	0.633	0.95	0.143	1.31	0.081
High education level	-	-	-	-	-	-	-	-
Using sugar for cooking								
Often	-0.01	0.949	0.94	**0.033**	0.44	0.545	3.15	**0.001**
Sometimes	0.27	0.126	0.26	0.479	0.59	0.329	1.38	0.110
Never	-	-	-	-	-	-	-	-
Dental visit								
Yes	0.12	0.391	0.25	0.350	1.19	**0.014**	3.50	**0.000**
No	-	-	-	-	-	-	-	-
Log. fluoride levels in drinking water	- 0.33	**0.001**	-0.24	0.221	-0.38	0.328	-0.27	0.570
	R2 = 0.05 Adj. R2 = 0.04 Model: P = 0.000		R2 = 0.02 Adj. R2 = 0.01 Model: P = 0.101		R2 = 0.02 Adj. R2 = 0.01 Model: P = 0.136		R2 = 0.09 Adj. R2 = 0.08 Model: P = 0.000	

* a closely significant association

3.8.2 Multivariate model for dental fluorosis

In bivariates analyses residence, dental visiting and using mouthrinse were found to have consistent significant relationships with fluorosis. The result of the examination of these factors and fluoride levels in drinking water is presented in Table 3.61. The analyses found that fluoride concentration in drinking water had a positive relationship with dental fluorosis in children. The association was significant in all age groups except 6–8 years. Children who live in rural areas were related significantly with an increased mean CFI for 9–11-year-olds and 12–14-year-olds. Dental visiting patterns were associated significantly with a reduced mean CFI in the age groups 12–14 years and 15–17+ years. A significant relationship was seen in the age group 15–17+ years for using mouthrinse. The use of mouthrinse was related significantly with a reduced mean CFI. P value of models was significant for all age groups.

Table 3.61: Multivariables models for Community Fluorosis Index (CFI)

Variables	6–8 years		9–11 years		12–14 years		15–17+ years	
	Coeff.	**Sig.**	**Coeff.**	**Sig.**	**Coeff.**	**Sig.**	**Coeff.**	**Sig.**
Residence								
Urban	-	-	-	-	-	-	-	-
Rural	-0.08	0.131	0.10	**0.037**	0.10	**0.021**	0.06	0.266
Dental visit								
Yes	-0.09	0.107	-5.55	0.238	-0.10	**0.031**	-0.13	**0.027**
No	-	-	-	-	-	-	-	-
Using mouthrinse								
Yes	-0.09	0.099	-2.11	0.650	-0.03	0.494	-0.14	**0.009**
No	-	-	-	-	-	-	-	-
Fluoride concentration in drinking water	0.12	0.124	0.58	**0.000**	0.45	**0.000**	0.22	**0.039**
	R2 = 0.05 Adj. R2 = 0.03 Model: P = 0.019		R2 = 0.17 Adj. R2 = 0.16 Model: P = 0.000		R2 = 0.09 Adj. R2 = 0.08 Model: P = 0.000		R2 = 0.04 Adj. R2 = 0.04 Model: P = 0.000	

After controlling the relationship of the factors with dental caries and dental fluorosis by using multivariable models, it was seen that fluoride concentration in drinking water had a negative relationship with caries experience for all age groups except 15-17+ years. However, the relationship was only significant among 6–8-year-old children for both primary and permanent dentitions. Mother's education level, using sugar for cooking and dental visit patterns were risk factors for permanent caries experience, especially in the 15-17+ years age group. Fluoride concentration in the drinking water had a positive association with dental fluorosis for all age groups, but the relationship was not significant in the 6–8 years age group. Residential location of children was a risk factor for fluorosis. Dental visit patterns and the use of mouthrinse had a negative relationship with dental fluorosis in some age groups.

CHAPTER 4

DISCUSSION

4.1 OVERVIEW OF THE STUDY

The present study has met its objectives, which were to determine the relationships between fluoride concentration in drinking water and dental caries and fluorosis in Vietnamese children. This cross-sectional study based on a multistage stratified random sample of 2762 school children aged 6–17 years provided information on the distribution and prevalence of dental caries and dental fluorosis in Vietnamese children. Fluoride exposure was determined by measuring the fluoride concentration of the drinking water samples, which were collected from drinking water sources located close to selected schools. In addition, the parents of each child participant completed a questionnaire, which provided information about the child's social economic status, dietary habits, dental behaviours and discretionary fluoride intake.

The relationships between fluoride concentration in drinking water and dental caries and fluorosis were examined at cluster level for four age groups. The influence of socio-economic status, dietary habits, dental behaviours and discretionary fluoride intake on dental caries and fluorosis was reported using bivariate analyses. Subsequently, the association at an individual child level between fluoride levels in drinking water and dental caries and fluorosis was further explored by a multivariate model.

The results of the study will inform policy development of appropriate strategies for the prevention of dental caries at the same time as minimising the occurrence of dental fluorosis, both of which are public health concerns for the Vietnamese population.

4.2 THE STRENGTHS AND THE LIMITATIONS OF THE STUDY

4.2.1 The strengths of the study

4.2.1.1 Design

The study was part of the Second National Oral Health Survey of Vietnam, 1998. This survey used a cross-sectional design which is useful for determining the distribution and prevalence of disease (Leeder & Wigglesworth 1988). The multistage stratified random sampling, with each stage having a probability of selection proportional to population size, enabled a representative sample to be achieved (Moser & Kalton 1973). Therefore, the study design is suitable for evaluating the distribution and prevalence of dental caries and dental fluorosis of Vietnamese children as well as assessing the association between risk factors and dental caries and dental fluorosis.

4.2.1.2 Response rate of the study

The response rate of the study was high with the total number of participants being 2,762 school children aged 6–17 years (98 per cent response rate). Hence, estimates of caries and fluorosis prevalence are unlikely to be biased by non-participation.

4.2.1.3 Social survey

A parent of each child in the study completed a questionnaire detailing the child's daily drinking water source, socio-economic and demographic status, dietary habits, dental care behaviours and use of discretionary fluoride. The comprehensive information obtained from the questionnaire allowed assessment of the association of socio-economic and demographic factors, dietary habits, dental care behaviours and discretionary use of fluoride with dental caries and fluorosis.

4.2.1.4 Dental examinations

Dental examinations were conducted using the criteria of the NIDR for dental caries and Dean's Index for dental fluorosis. The criteria have been widely used in oral epidemiological studies for caries and fluorosis (Nanda et al. 1974; de Muniz 1985; Evans 1989; Brunelle & Carlos 1990; Heller, Eklund & Burt. 1997; Ibrahim, Bjorvatn & Birkeland 1997). Furthermore, all the examiners in the survey were trained and calibrated in the use of these criteria. Assessment of intra- and inter-examiner reliability indicated a high level of consistency within examiners and between examiners (Kappa scores for dmfs, DMFS scores and fluorosis for intra-examiner reliability were 0.96, 0.98 and 0.96, respectively; Kappa scores for dmfs, DMFS scores and fluorosis for inter-examiner reliability were 0.91, 0.93 and 0.80, respectively). Examiners had good agreement in assessing dental caries and dental fluorosis.

4.2.1.5 Drinking water samples

Other studies have used fluoride levels in school water sources as an indicator of exposure to fluoride (Sathananthan, Vos & Bango 1996; Heller, Eklund & Burt 1997; de Muniz 1985). These studies found that the use of fluoride concentration in the drinking water located close to the schools was a reliable method to determine fluoride exposure of children from their drinking.

Water samples were collected from almost all drinking water sources, which were reported by the child's parent. From each water source, at least three water samples were collected. This resulted in 500 different water samples from different sources. Therefore, these water samples were reasonable to represent the drinking water sources reported by the children's parents. After the water samples were collected, they were maintained in a secure store and precautions taken to prevent bacterial and fungal contamination. The TISAB II method was used to measure fluoride concentration in the water samples. The advantage of this method is that a constant background ionic strength was maintained, avoiding the formation of hydrogen complexes of fluoride, and the pH of the solution was able to be adjusted. Hence, fluoride concentrations obtained from the measuring procedure were likely to be valid.

4.2.2 The limitations of the study

The limitations of this study stem from study design, reliability and validity of self-reported information from questionnaires, attribution of fluoride exposure to an individual from fluoride levels in the sampled water and the minimal variation in fluoride concentration between the water samples.

4.2.2.1 Study design

The study was a cross-sectional design and part of the Second National Oral Health Survey of Vietnam. The relationship between fluoride concentration in drinking water and dental caries and dental fluorosis was examined for the time of the survey on all survey children. The history of fluoride exposure of children was not obtained in the study.

4.2.2.2 The reliability and validity of questionnaire response

A questionnaire was completed by the self-reporting of each child's parent. Difficulties were encountered by respondents in completing questionnaires and some questionnaires were not fully completed. Non-response to certain items may reduce the internal validity of the study. Even though the questionnaire was pilot-tested among selected Vietnamese students, some questions may have been too difficult for some parents to comprehend. A substantial portion of the sample, who lived in rural or remote areas, had a low level of education. Responses to the questions were adjusted if responses to other related questions provided information that allowed for such adjustments. Confusion over the use of particular terms to describe water sources used was also examined by site visits to confirm the responses. The methodology adapted for cleaning the questionnaire data has been explained in Chapter 2.

4.2.2.3 The attribution of fluoride exposure

The fluoride concentration of the water samples collected at a location close to the surveyed schools was used as an indicator of fluoride exposure of children. This was based on the assumption that children attending a local school would live close to the school and the water source used at home would be similar in composition to that of water sources near the school. Hence, the fluoride estimation for children in the Primary and Secondary schools is likely to be a valid indicator for fluoride exposure. However, the majority of children in High schools did not reside close to the selected Primary and Secondary schools. Therefore, the fluoride levels estimated for collected samples, which was an average of all water samples in each town or district, may be a less valid indicator of the fluoride level of drinking water consumed by High school children. The misclassification of the level of exposure to fluoride among children in High schools is likely to be non-differential and the effect of this is to move the estimate of effect towards the null.

4.2.2.4 The selecting sampled areas

Fluoride concentrations in the collected water samples from the selected provinces in the study were generally low and did not vary greatly between provinces. The lack of variation is likely to affect detection of differences in caries and fluorosis between individuals. However, the plots of fluoride concentration in the samples and the mean caries experience and CFI of the areas was still useful for determining the relationship between fluoride concentration in the drinking water and dental caries and fluorosis.

4.3 THE DISTRIBUTION AND PREVALENCE OF DENTAL CARIES AND DENTAL FLUOROSIS IN VIETNAMESE CHILDREN

4.3.1 The distribution and prevalence of dental caries in Vietnamese children

4.3.1.1 Primary dentition

This study reported deciduous caries experience among children in two age groups (6-8 and 9-11 years). The prevalence of dental caries in children aged 6–8 years was high (83.7 per cent) with a mean dmfs in excess of 12.7. Some areas had a high prevalence of caries (100 per cent). Untreated decay, which comprised approximately 89.4 per cent of the component of primary caries experience, was a major contributor to the total dmfs score for both age groups, indicating a very low caries treatment capacity in Vietnam. The dental caries prevalence and experience in 9–11-year-old children was lower than the caries experience of 6–8-year-old children, probably due to the exfoliation of the primary teeth among the older age group.

The prevalence of primary dental caries in Vietnamese children was similar to the levels prevailing in other developing countries. Among aboriginal children in Malaysia, 87.3 per cent of children had primary teeth caries (Kadir & Yassin 1990) and among 6-year-old children from Quangdong province in China, 74.1 per cent of them had primary teeth caries (Wang, Shen & Schwarz 1994). In Thailand, the primary teeth caries prevalence of 6-year-old children was between 60 and 81 per cent (Sonpaisan & Davies 1989).

4.3.1.2 Permanent dentition

The prevalence of permanent caries increased across older age groups (from 26.1 to 73.7 per cent). Some areas had a high prevalence of caries in the age groups 12–14 years and 15–17 years. Caries experience was also predominantly present as untreated decay in all age groups. The number of missing teeth, while low, also increased across older age groups.

Caries experience of Vietnamese children aged 6–17+ years (DMFS = 2.6) was lower than that of the aboriginal children in Malaysia aged 6–15year-olds (DMFS = 3.22) (Kadir and Yassin 1990). The prevalence of permanent caries in Vietnamese children for 15–17+ year-olds (73.7 per cent) was higher than that of Thailand children, who had approximately 30 per cent of caries at 15-16 years (Songpaisan and Davies 1989). The prevalence of permanent teeth caries in Vietnamese children for 12–14 year-olds (66.5 per cent) also was higher than that of Quangdong children, for whom the prevalence of caries was 43.7 per cent of caries at 12-14 years (Wang, Shen and Schwarz 1994). Compared with more developed Asian populations such as Singapore and Hong Kong, the prevalence of permanent caries was much higher in Vietnamese children. The difference may be due to the fact that both Singapore and Hong Kong have fluoridated water supplies (0.7 ppm of fluoride) (Loh 1996; Evans, Lo and Lind 1987).

4.3.2 The distribution and prevalence of dental fluorosis in Vietnamese children

This study found 8.7 per cent of children had fluorosis (questionable score was considered as normal). The CFI score of children was low (0.17). However, in some areas children had a more severe form of fluorosis and the level of fluorosis was slight or medium in terms of public health concern according to Dean's CFI index.

In relative comparison, using CFI scores, Vietnamese children had lower CFI scores than Thai children who had a CFI of 0.35 (Sonpaisan & Davies 1989). The prevalence of fluorosis in Lucknow children (India) was 24 per cent, which also was a higher prevalence of fluorosis than Vietnamese children (Nanda et al. 1974). According to the data from the Oral Health Survey of Jakarta (Indonesia), the prevalence of dental fluorosis in Vietnamese children was higher than the prevalence of dental fluorosis in Indonesian children (3.6 per cent of fluorosis at 12 years and 2.7 per cent at 15 years) (Morgan et al. 1992).

4.3.3 The comparison with First National Oral Health Survey of Vietnam

It is recognized that the methodology used in the First National Oral Health Survey conducted in 1989 was different in both sampling strategy and criteria for dental caries. Therefore, the previous data are not suitable for a direct comparison with the data of the

Second National Oral Health Survey. However, a relative comparison between the prevalence of caries by key ages included in the first survey (57 per cent among 12 – year olds and 60 per cent among 15 - year-olds) and the prevalence of caries by age group of the second survey (66.5 per cent of caries among 12-14 - year-olds and 73.7 per cent among 15-17 - year-olds) suggests that the prevalence of dental caries among Vietnamese children still remains high or may be on the increase. In addition, the second survey reinforce that the low caries treatment capacity for children was still a problem of dental public health in Vietnam (Tran 1990).

No previous data of dental fluorosis were available for comparison with the data of dental fluorosis in the second survey.

4.4 THE FLUORIDE CONCENTRATION OF DRINKING WATER SOURCES IN VIETNAM

Drinking water sources used in Vietnam were mainly well-water, tap-water and bore-water. Stream-water, river-water and lake-water were rarely used, only occasionally being used in the mountainous or remote areas.

Tap-water, which was supplied from a central source, was available mostly in the central cities and in the towns of provinces. The fluoride level in most of the tap-water sources was low. Tap-water was generally not fluoridated except in one district of HCM city, which had 0.7 ppm of fluoride.

Well-water and bore-water were the main water sources in the rural areas and in the suburbs of the cities. As in other developing Asian countries well-water and bore-water are located in each household and show variations in fluoride concentration across the water sources (Songpaisan & Davies 1989). Water sources from some provinces had a low concentration of fluoride in the water, other provinces had some fluoride in the water, but the fluoride levels varied across the samples even though the samples were collected from the same area. This occurred in Tu Liem district of Ha Noi city (in the range 0.01-0.64 ppm of fluoride), Ung Hoa district of Ha Tay province (ranged from 0.18 to 0.62 ppm F), Dong Xuan district of Phu Yen province (in the range 0.20-1.50 ppm F) and Ayun Pa district of Gia Lai province (in the ranges 0.50-1.70 and 0.19-2.00 ppm F) (Appendix D).

Rain-water was mainly used in combination with other water sources for drinking. The fluoride level in rain-water was mainly low (around and under 0.10 ppm of fluoride), only one area having 0.31 ppm of fluoride in the rain-water. Other sources such as stream-water and lake-water had a low fluoride content (under 0.1 ppm of fluoride). Only one cluster had river-water sample with 0.36 ppm of fluoride.

4.5 THE INFLUENCE OF SOCIO-ECONOMIC AND DEMOGRAPHIC INDICATORS, DIETARY HABITS, DENTAL BEHAVIOURS AND DISCRETIONARY FLUORIDE ON DENTAL CARIES AND FLUOROSIS

Based on the bivariate analyses, socio-economic and demographic status, dietary habits, dental behaviours and discretionary fluoride were associated with caries experience and fluorosis.

4.5.1 Association with caries

4.5.1.1 Socio-economic and demographic indicators

The association between caries and socio-economic and demographic status was not consistent for all the various indicators of socio-economic and demographic status in this study. The children whose parents had low education, were farmers and who lived in crowded households had lower caries experience for primary dentition than their counterparts. A similar trend had been reported for Nigerian children (Enwonwu 1974).

However, the findings for caries in the permanent dentition were opposite to that observed in the primary dentition. Children aged 6-8 # years whose families had low income, whose mothers had low education level and whose fathers were farmers, had higher caries experience than their counterparts. This finding was similar to other studies in Australia, America and England (Slade Spencer Davies & Stewart. 1996; Vargas, Crall & Schneider 1998; Gratrix and Holloway 1994; Cleaton-Jones et al. 1994).

Sex was also associated with caries experience, but its association was not consistent for all age groups and the effect was opposite between primary and permanent dentition. Boys had higher primary teeth caries experience than girls among the 9–11- year-olds, but girls had higher permanent teeth caries experience than boys. Other studies also found girls has higher permanent teeth caries experience than boys, which may be as a result of earlier dental development among girls than boys (Kadir & Yassin 1990; Rowe et al. 1976; Irigoyen & Szpunar 1994).

4.5.1.2 Dietary habits

The findings showed a similar influence on caries experience of sugar confectionery and sugar consumption in the 6–8 years age group for primary teeth and in the 15–17 years age group for permanent teeth (Arnadottir et al. 1998; Akizawa et al. 1990; Murray 1989; Burt et al. 1988).

The consumption of soft drinks was associated with increased primary caries experience in 6-8-year-old children, which was similar to a finding in Japanese children (Akizawa et al. 1990).

The findings from some studies suggest consumption of tea is associated with low levels of caries or high levels of fluorosis due to tea being high in fluoride (Mann et al. 1985; Levy 1994). However, in this study drinking tea is associated with increasing levels of caries for 6–8-year-old children in the primary dentition. A similar finding was reported in a study of Ethiopian children. It was felt that the children added sugar to the tea and the amount of fluoride intake from tea drinking was not enough to reduce caries (Olsson 1978).

This study found that cooking salt was related with lower primary caries experience, but no estimates of fluoride concentration in cooking salt or fish sauce were available so this needs further investigation.

4.5.1.3 Dental behaviours

An association of dental hygiene behaviours, such as the brushing of teeth, the frequency of brushing teeth and the age commenced brushing teeth, with caries was not found in this study. Dental hygiene behaviours of children in the study showed that the majority of children started brushing teeth and brushing with toothpaste after three years of age. Moreover, most of the children reported they brushed their teeth. It may be possible that children gave a 'false' answer to please the investigator or appear to have 'good dental behaviours'. This could explain why dental hygiene did not show its effectiveness in reducing dental caries for children as other studies did (Fosdick 1950; Berenie, Ripa & Leske 1973; Tucker, Andlaw & Burchell 1976). However, the findings of the study were also similar with the findings and reviews of other studies (Ashley & Sainsbury 1981; Andlaw 1978; Sutton & Sheiham 1974).

Dental visiting patterns showed a consistent association with dental caries. This may be more a reflection of dental attendance associated with a problem. Children visited because they needed dental treatment rather than for a preventive visit. The result was similar to the findings of previous studies (Nainar 1998; Barrette et al. 1981).

4.5.1.4 Discretionary fluorides

The study did not find a statistically significant association between the use of discretionary fluoride and dental caries. The effectiveness of using toothpaste in reducing dental caries experience was only found among 9–11-year-old children (Hesselgren & Thylstrup 1982; Blinkhorn, Hollaway & Davies 1983; Kerebel et al. 1985). This study did not find a strong relationship between the use of discretionary fluoride with dental caries as in other studies due to the fact that the majority of children reported they brushed with toothpaste later than three years old. Some children may be misclassified due to giving what were presumed to be as desirable responses to some of the questions.

4.5.2 Association with fluorosis

4.5.2.1 Socio-economic and demographic indicators

The study found that the residential location of children aged at least 12 years (those who live in rural areas) and parental occupation among 15-17+ - year-old children (those whose parents were farmers) were associated with the occurrence of fluorosis. This may be a reflection of the distribution of water sources in Vietnam. Well- and bore-water are used mainly in rural areas and only these water sample sources contained high levels of fluoride. Being a farmer is the most common occupation in rural areas.

4.5.2.2 Dietary habits

Children aged 6-11 years who ate ice-cream and biscuits had lower mean CFI than those who did not. The reasons for these findings are difficult to explain. No estimates of fluoride concentration in ice-cream or biscuits were available, or of the fruit juices and fruits consumed. It is also possible that in bivariate analysis some factors may be statistically significant simply due to chance because of the multiple testing of factors.

The consumption of soft drink also had an inverse relationship with fluorosis in children aged 9-11 and 15-17 years. Children who consumed soft drinks had a lower mean CFI. The finding was the opposite observation from other studies, which found that soft drinks contained a high fluoride concentration (Levy 1994; Fejerskov, Ekstrand & Burt 1996). The cause of the difference between this and other studies may be that the children did not use soft drinks as often as they reported.

4.5.2.3 Dental behaviours

This study found that the children who had a dental visit had a lower mean CFI than those who had not had a dental visit. It may be possible that the group of children who had negligible fluorosis had high caries experience. This was similar to Dean's studies, which found that dental fluorosis had an inverse relationship with caries (Dean 1938; Dean et al. 1939; Dean, Arnold & Evolve 1942).

4.5.2.4 Discretionary fluoride

Using mouthrinse was found in this study to have a negative relationship with fluorosis. The reasons for the relationship are difficult to explain. The number of children reported using mouthrinse was low and the kinds of mouthrinse used were mainly water and salt water. Therefore, the use of mouthrise did not relate to fluoride ingestion by children. Another reason, which may be possible, is that children gave a 'false' answer to appear to have good dental behaviours.

In summary, various indicators of socio-economic and demographic status, dietary habits and dental visiting were strongly associated with dental caries, especially for primary dentition and for permanent dentition in the age group 15–17 + years. Dental fluorosis was not strongly related with socio-economic and demographic status, dietary habits, dental behaviours and discretionary fluoride. Only residential location of children and the occupation of the child's parent were risk factors for fluorosis.

4.6 THE RELATIONSHIP BETWEEN FLUORIDE CONCENTRATION IN DRINKING WATER AND DENTAL CARIES AND DENTAL FLUOROSIS IN VIETNAMESE CHILDREN

4.6.1 Fluoride concentration in the drinking water and dental caries

An inverse relationship between fluoride concentration in drinking water and dental caries in deciduous teeth was found in this study, similar to the findings of other studies (de Muniz 1985; Hawew et al. 1996; Sathananthan, Vos & Bango 1996; Cortes, Mullane & Bastos 1996; Heller, Eklund & Burt 1997; Ibrahim, Bjorvatn & Birkeland 1997).

The regression curve presented showed that increasing fluoride concentration was strongly associated with lower mean dmfs in the 6–8 years age group. In the 9–11 years age group the relationship was nearly significant (P = 0.068). It is likely that the exfoliation of primary teeth may have affected the relationship for 9–11-year-olds. In this study the mean dmfs declined sharply between 0.0 and 0.4 ppm of fluoride in water. At higher concentrations (0.4 en 1.4 ppm) of fluoride, there was a more gradual decline in caries experience. The fluoride concentration at which caries declined rapidly in this study was lower than the levels observed in a study of US school children, where a sharp decline of caries occurred from 0.0 to 0.7 ppm of fluoride (Heller, Eklund & Burt. 1997). The difference between the studies might be due to different climatic conditions (The Vietnamese climate is tropical while the American climate is temperate) leading to differences in water consumption (Galagan & Vermillion 1957; Richards et al. 1967).

A negative association between fluoride concentration in drinking water and dental caries in the permanent dentition was found in this study for children in the 6–8, 9–11 and 12–14 year age groups. The findings were similar to those reported in previous studies (Dean 1938; Dean et al. 1939; Dean et al. 1941; Dean, Arnold & Evolve 1942; Thylstrup, Bille & Bruun 1982; Eklund & Striffler 1980; de Muniz 1985; Angelillo et al. 1990; Al-Khateeb et al. 1990; Hawew et al. 1996; Sathananthan, Vos & Bango 1996; Cortes, Mullane & Bastos. 1996; Heller, Eklund & Burt 1997; Ibrahim, Bjorvatn & Birkeland 1997; Aleksejuniene, Arneberg & Eriksen 1996). However, there was no statistically significant association among 9–11 or 12–14 - year-olds and no relationship between fluoride concentration in the drinking water and permanent dental caries experience in the 15–17+ years age group.

Multiple linear regression was used to control for possible confounding of the relationship between fluoride concentration in drinking water and dental caries in permanent teeth.

Firstly, some factors of socio-economic and demographic status, dietary habits and dental behaviours such as parent's education, use of sugar for drinking and cooking, and dental visit patterns showed significant bivariate associations with dental caries. After controlling these factors and fluoride concentration in drinking water with permanent teeth caries in a multivariate model, the use of sugar for cooking was associated with increasing permanent caries experience among 9-11 - year-olds children. High permanent caries experience among 12-14 - year-old children was associated with having made a dental visit in the last two years. In the 15-17+ year-old children, mother's education, the use of sugar for cooking and dental visit patterns were significantly associated with permanent caries experience. Multivariate analysis provided adjustments of potential confounders to the relationships between fluoride concentration in drinking water and permanent caries experience. However, the R square of the multivariate model was low, indicating that a large proportion of permanent caries experience was unexplained.

Secondly, fluoride exposure measured by fluoride concentration in the source of drinking water located close to children's schools may have caused some misclassification of the children's fluoride exposure. This could affect the association between fluoride concentration in drinking water and caries experience.

Finally, in other studies, the relationship between fluoride concentration in drinking water and dental caries was examined among populations exposed to a wide range of fluoride levels in drinking water (Dean et al. 1939; Dean et al. 1941; Dean, Arnold & Evolve 1942; Thylstrup, Bille & Bruun 1982; Eklund & Striffler 1980; Angelillo et al. 1990; Al-Khateeb et al. 1990; Hawew et al. 1996; Sathananthan, Vos & Bango 1996; Heller, Eklund & Burt 1997; Ibrahim, Bjorvatn & Birkeland 1997). In the present study, there were only six clusters with fluoride levels in drinking water that were more than 0.4 ppm (approximately

72 children). This may create a lack of statistical power. Therefore, the relationship between fluoride concentration in drinking water and dental caries was not demonstrated as clearly as in other studies.

The relationship between fluoride concentration in drinking water and caries experience was more strongly evident and consistent for primary teeth than for permanent teeth. This finding is similar to other studies.

4.6.2 Fluoride concentration in drinking water and dental fluorosis

The scatter plot with fitted regression lines suggests a positive linear relationship between fluoride concentration in drinking water and dental fluorosis. This finding is in agreement with other studies (Dean & Evolve 1936; Dean & Evolve 1937; Angelillo et al. 1990; Sathananthan, Vos & Bango 1996; Ibrahim, Bjorvatn & Birkeland 1997; Heller, Eklund & Burt 1997; Angelillo et al. 1999). This relationship was statistically significant for all age groups in the multivariate models except for 6–8 - year-olds. The lack of a significant relationship among the 6-8 - year-olds may be due to too few children available with fully erupted upper incisors for assessment of fluorosis.

According to the results of the bivariate analysis, the prevalence of fluorosis was not influenced by socio-economic and demographic status, dietary habits, dental behaviours and discretionary fluoride. Residence and dental visiting were the only other risk factors for fluorosis but these associations were not consistent. The findings were different to the findings of other studies, which found that dietary habits and discretionary fluoride contributed partly to the prevalence of dental fluorosis (Levy 1994; Fejerskov, Ekstrand & Burt 1996; Mascarenhas & Burt 1998). The reasons, which may result in the difference between this study and other studies, were, firstly, the majority of children in the study started brushing teeth with toothpaste later than three years of age. This is past the age of risk of fluorosis for the upper anterior teeth. Secondly, children whose parents reported them brushing with toothpaste earlier than three yeas of age may not have correctly reported their age of initiation of brushing.

The data illustrated that the prevalence of dental fluorosis in Vietnamese children was mostly dependent on the fluoride concentration in the drinking water, which was similar with the findings of Dean's studies (Dean & Evolve 1935; Dean & Evolve 1936; Dean& Evolve 1937).

4.6.3 The relationship between fluoride concentration in drinking water, caries and fluorosis

The relationship between fluoride concentration in drinking water, caries and fluorosis may be presented by the intersection of dental caries with dental fluorosis based on fluoride concentration in drinking water. The intersection point indicates a trade-off of the level where fluoride concentration in drinking water can achieve near maximum reduction of dental caries and minimum production of dental fluorosis. In this study the intersection between dental caries and fluorosis ranged from 0.2 to 0.9 ppm of fluoride in the drinking water. The average of intersected points was around 0.6 ppm of fluoride. The annual average maximum daily air temperatures of the surveyed provinces in the study in 5-10 years was reported in the range 27.4 to 32.5oC (Nguyen et al. 1989). If 0.6 ppm was considered as an optimal fluoride concentration of fluoride in drinking water in Vietnam, it would be consistent with the climatic guidelines of Galagan & Vermillion (1957) and the United States Public Health Service (Galagan & Vermillion 1957; Dunning 1977).

In summary, the study found an association between fluoride concentration in drinking water found in the study was associated and dental caries and fluorosis. The optimum fluoride concentration in the drinking water was considered to be 0.6 ppm.

4.7 POSSIBLE IMPLICATIONS FOR DENTAL HEALTH POLICY

Data presented in this study are from a National Oral Dental Health Survey of Vietnamese children. The survey was designed so that its results would be representative of the country's total child population. The main purpose of this study was to examine the factors associated with dental caries and dental fluorosis in Vietnamese children. The study provides fundamental information to assist government in the establishment of appropriate strategies to prevent dental caries and manage dental fluorosis to improve the oral health of children in Vietnam.

The findings of the study demonstrated that dental caries in Vietnamese children is at a moderate to high level but increases reasonably quickly with age. The majority of caries experience presented as untreated decay and, without intervention, it is likely to lead to tooth extraction in the future. Moreover, the children who had had a dental visit sought only 'symptomatic' rather than 'preventive' dental care and the percentage of children who received dental care was low. While Vietnam is a developing country and is densely populated, resources available to manage dental problems are limited. Therefore, the implementation of an appropriate preventive strategy for the whole population is necessary (Pack 1998; Davies 1991; Sheiham & Joffe 1991).

This study investigated the use of fluoride as a population-based preventive strategy for Vietnam. Water fluoridation is considered to be a highly cost-effective preventive strategy (Ripa 1993; Ringelberg, Allen & Brown 1992; Garcia 1989; Horowitz & Heifetz 1979). However, this study also found that water sources used by the majority of the population were not from a central source. The lack of wide-spread availability of centrally treated and supplied water acts against the use of water fluoridation as a means of providing a population-based caries preventive programme.

An alternative to water fluoridation is the use of fluoride. Salt fluoridation is considered to be an effective caries preventive alternative to drinking water fluoridation for countries where water fluoridation is not practical. (Fejerskov, Ekstrand & Burt 1996; Horowitz 1990). The effectiveness of fluoridated salt in reducing dental caries was demonstrated by the studies of Toth (1972 and 1976), and experiences in four countries, Switzerland, Columbia, Spain and Hungary, of using salt fluoridation has shown the procedure to be safe and highly effective (Marthaler et al. 1978; Kunzel 1993).

The study found that high level of caries experience is associated with the frequency of the family's sugar consumption and the consumption of sweet foods and drinks. The traditional diet in Vietnam contains a high amount of fermentable carbohydrates and sugar. The addition of fluoride to salt to enhance the ability of the tooth structure to resist caries may be easier than changing the dietary habits. It was also observed in this study that children whose parents had a low education level or were farmers had higher levels of caries than their counterparts. It has been shown that water fluoridation can reduce the socio-economic inequalities in caries (Spencer, Slade & Davies 1996; Riley, Lennon and Ellwood 1999). The use of fluoridated salt may have similar effects on socio-economic differentials in caries occurrence.

The study found that more than 90 per cent of families used salt for cooking. Thus a high proportion of the population is likely to benefit. In addition, the implementation of fluoridated salt is suitable for Vietnamese economic situations due to the low cost of marketing fluoridated salt and the technology for producing fluoridated salt is now well-tested and could be applied to most countries (Burt 1984).

If the proposal to promote salt fluoridation were to be adapted, its implementation would have to take into consideration geographical differences to fluoride exposure from drinking water.

This study found that well-water and bore-water in some areas contains high fluoride concentration and there is considerable variation between areas. The findings in this study support earlier research on the association between dental fluorosis with fluoride concentration in the drinking water (Dean & Elvolve 1936; Dean & Elvolve 1937; Heller, Eklund & Burt 1997; Angelillo et al. 1999). Therefore, in the areas which had high a prevalence of fluorosis, further investigation about fluoride concentration in the drinking water should be undertaken, and if the fluoride concentration is found to be optimum (0.6 ppm) or higher, the use of fluoridated salt should be discouraged, especially for children younger than six years of age, to minimise dental fluorosis in these areas.

This study supports the findings of other studies of decreasing caries experience with increasing fluoride exposure (Dean et al. 1941; Dean, Arnold & Evolve 1942; Eklund & Striffler 1980; Heller, Eklund & Burt 1997) and of increasing occurrence of fluorosis with increasing fluoride exposure (Dean & Elvolve 1936; Dean & Elvolve 1937; Heller, Eklund & Burt 1997; Angelillo et al. 1999). The level of fluoride at which caries reduction is maximal and occurrence of fluorosis is minimal provides valuable information to assist government in determining strategies to combat a major oral health problem of the Vietnamese people.

CHAPTER 5

CONCLUSION

This study is a cross-sectional study and a part of the Second National Oral Health Survey of Vietnam 1999. The sampling of the study was conducted using a multistage stratified random sample strategy with a probability of selection proportional to population size. The survey achieved a high response rate. Hence, a representative sample of the population was obtained.

The conclusions drawn from the objectives of the study are addressed below:

1. The prevalence of dental caries was high compared with developed and developing countries and may be on the increase, especially in primary teeth. Untreated decay was a main component of caries experience. This indicated insufficient caries treatment capacity in Vietnam.

2. 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.

3. Well-water, tap-water and bore-water were the main water sources used for daily drinking. Tap-water was a primary water source in cities and towns. However, the water sources used by most of the population were not centrally supplied. Most of the tap-water sources had low fluoride concentration, except one tap-water source

in HCM city which was fluoridated at a level of 0.7 ppm. Well- and bore-water sources had high fluoride concentration in some areas.

4. Fluoride concentration in the drinking water supply was associated negatively with dental caries experience, especially in deciduous dentition. The relationship between fluoride concentration in the drinking water and permanent caries experience differed among the age groups. Multivariate models all had low R square values indicating a relative lack of explanatory power of the variables in the model.

5. Fluoride concentration in the drinking water supply was associated positively with dental fluorosis.

6. Mother's education level, sugar consumption and dental visiting patterns were also associated with dental caries experience.

7. Children who lived in a rural area or whose parents were farmers had a higher risk of having dental fluorosis.

8. The results provide fundamental information to assist policy makers to formulate strategies for improving oral dental health in Vietnamese children.

APPENDIX A: QUESTIONNAIRE FORM

CONFIDENTIAL

QUESTIONNAIRE

FOR CHILDREN SAMPLE

Office use only
Name school : .... District: ....
Province :................... .... Date : ....
Child ID : ....Collector : ....

INSTRUCTION : Please read each question and answer as best you can. Answers are either written on the dotted line or tick the appropriate box.

A. PERSONAL DATA

1. What is your child's full name : ....

2. What is your child's age: .... (in year)

3. What is your child's sex: Male : ☐ Female: ☐

4. What is your home address: ....
....

5. Has your child ever lived at another address in a different city/town/ village:
Yes : ☐ No: ☐

6. What educational level did each parent/ guardians (who is currently living with child) achieve:

	Mother/Guardian	**Father/Guardian**
No schooling :	☐	☐
Primary school :	☐	☐
Lower secondary school :	☐	☐
Higher secondary school :	☐	☐
TAFE trade :	☐	☐
Tertiary :	☐	☐

7. What is your usual occupation ?

	Mother/Guardian	**Father/Guardian**
Farmer :	☐	☐
Manual worker :	☐	☐
Professional, administrative :	☐	☐
Private business :	☐	☐
Home duties :	☐	☐
Other :	☐	☐
If other, please, specify :	________________	________________

---

8. In to which category does your total household income fall ?

Household income per month

Under 200,000 VN dong: ☐

From 200,000 to 400,000 VN dong: ☐

From 400,000 to 600,000 VN dong: ☐

From 600,000 to 800,000 VN dong: ☐

From 800,000 to 1,000,000 VN dong: ☐

From 1,000,000 to 2,000,000 VN dong: ☐

Over 2,000,000 VN dong: ☐

---

9. How many people are dependent on this total household income, including yourself ? --------

(Write number)

---

10. Which best describes your current living arrangement:

Own house: ☐

Jointly own house with other family members: ☐

Share house: ☐

Rent house: ☐

---

11. Do you own a TV: Yes : ☐ No: ☐

(If yes, please, go to question 12. If no, go to question 13)

---

12. What kind of TV : Black & white : ☐ Colour : ☐

---

13. What kind of transport does your family own:

(If your family own more than one, please tick more than one box)

Private car : ☐

Motorbike over 20 million VN dong : ☐

Motorbike from 10 million VN dong to 20 million VN dong : ☐

Motorbike under 10 million VN dong : ☐

Bicycle : ☐

Other : ☐

(If other, please, specify ....)

B. THE DAILY USE OF WATER FOR COOKING AND DRINKING

1. What kind of water resource do you use for cooking:

(If you use more than one water resource, please tick more than one box)

Resource of water

Tap water : ☐

River : ☐

Lake : ☐

Rain water : ☐

Spring water : ☐

Well water : ☐

Bore water : ☐

Other : ☐

(Please, specify ------------------)

---

2. What kind of water resource do you use for drinking:

(If you use more than one water resource, please tick more than one box)

Resource of water

Tap water : ☐

River : ☐

Lake : ☐

Rain water : ☐

Spring water : ☐

Well water : ☐

Bore water : ☐

Other : ☐

(Please, specify ------------------)

C. DENTAL HABITS

1. Did your child brush his/her teeth yesterday: Yes : ☐ No: ☐

2. Does your child ever brush his/her teeth: Yes : ☐ No: ☐
(If yes, please go to questions 3 and 4. If no, go to question 10)

3. When did your child start brushing his/her teeth:
1 year old : ☐
2 year old : ☐
3 year old : ☐
4 year old : ☐
5 year old : ☐
Don't know : ☐

4. How frequently does your child brush his/her teeth:
Once a week : ☐
Several times a week : ☐
Once a day : ☐
Twice a day : ☐
Three times or more a day: ☐

5. Does your child use toothpaste: Yes : ☐ No: ☐
(If yes, please, go to questions 6, 7, 8 and 9. If no, go to question 10)

6. When did your child start brushing with:
1 year old : ☐
2 year old : ☐
3 year old : ☐
4 year old : ☐
5 year old : ☐
Don't know : ☐

7. What kind of toothpaste does your child use: Brand : ....

8. Does that toothpaste contain fluoride :

Yes : ☐
No : ☐
Don't know: ☐

9. How much toothpaste does your child usually put on the toothbrush:

Smear (small amount): ☐
Pea size (medium amount): ☐
Full length of toothbrush head (large amount): ☐
Don't know: ☐

10. Does your child use a mouthrinse: Yes : ☐ No: ☐

(If yes, please go to questions 11, 12,13 and 14. If no, go to question 15)

11. What kind of mouthrinse does your child use : Type : ....

12. Does that mouthrinse contain fluoride :

Yes : ☐
No : ☐
Don't know: ☐

13. How often does your child use mouthrinse:

More than once a week : ☐
Once a week : ☐
Once every two weeks : ☐
Less often than once every two weeks : ☐

14. How long has your child used mouthrinse: -------------- Years

15. Does your child regularly use fluoride tablets: Yes : ☐ No: ☐

D. DENTAL CARE

1. Does your child use tooth picks ? Often : ☐ Sometimes: ☐ Never: ☐

---

2. How long did your child last visit dentist for check up or for dental treatment ?

Less than 6 months: ☐
Between 6 and 12 months: ☐
Between 12 and 24 months: ☐
More than 24 months: ☐
Never been: ☐

---

3. If your child has visited a dentist less than 24 months ago, did your child receive dental treatment at his/her last visit ? Yes : ☐ No: ☐

(If yes, please go to questions 4 and 5. If no, go to the Part E)

---

4. What was the reason for your child last visit :
(Please, tick one or more boxes)

Pain: ☐
Tooth decay: ☐
Bleeding gum: ☐
Loose tooth: ☐
Trauma: ☐
For denture: ☐
Check-up: ☐
Other: ☐
(If other, please, specify ---------------------)

---

5. What treatment did your child received ?
(Please, tick one or more boxes)

Examination and prescription: ☐
Cleaning and scaling: ☐
Extraction: ☐
Filling: ☐
Denture: ☐
Other: ☐
(If other, please, specify ---------------------)

E. DIETARY HABITS

1. Do you use fish sauce or cooking salt for cooking:

Fish sauce: ☐
Table salt : ☐
Both of them : ☐
Neither : ☐
Other : ☐
(If other, please, specify ---------------------)

---

2. What kind of sweets does your child eat on a daily basis and the frequency of use per day:

The kind of sweets	No	Yes	***If yes, please, go to →***	**Frequency of use per day** One	Twice	Three	More
Candy :	☐	☐		☐	☐	☐	☐
Ice-creams :	☐	☐		☐	☐	☐	☐
Biscuits :	☐	☐		☐	☐	☐	☐
Other :	☐	☐		☐	☐	☐	☐

(If other, please, specify ....)

---

3. What kind of drinks does your child have on a daily basis and the frequency of use per day:

The kind of beverage	No	Yes	***If yes, please, go to →***	**Frequency of use per day** One	Twice	Three	More
Soft drinks :	☐	☐		☐	☐	☐	☐
Fruit juice :	☐	☐		☐	☐	☐	☐
Bottled water :	☐	☐		☐	☐	☐	☐
Other water :	☐	☐		☐	☐	☐	☐
Tea :	☐	☐		☐	☐	☐	☐
Cow milk :	☐	☐		☐	☐	☐	☐
Other :	☐	☐		☐	☐	☐	☐

(If other, please, specify.. ....)

---

4. Does your child have sugar added to any of the above drinks :

Often : ☐

Sometimes: ☐

Never: ☐

---

5. Does your family use sugar for cooking ?

Often : ☐

Sometimes: ☐

Never: ☐

---

6. How often does your child eat fresh fruit per day:

Never : ☐

Once : ☐

Twice: ☐

Three times: ☐

More: ☐

Thank you for your contribution. Please take a moment to check that you have answered each question and then return this completed questionnaire to your child' teacher.

If you have any comments, please feel free to write them in the space below:

APPENDIX B: EXAMINATION FORM

CHILD EXAMINATION FORM

Examiner Code : . . . .
Recorder Code : . . . .
Child ID : . . . .
Date : . . . .

Name : .... Sex :...... Date of birth ....../....../19....

School: ....District: .... Province: ....

Dentition status

UPPER RIGHT

7					6					5					4					3				2				1			
o	m	b	d	li	o	m	b	d	li	o	m	b	d	li	o	m	b	d	li	m	l	d	li	m	l	d	li	m	l	d	li

UPPER LEFT

7					6					5					4					3				2				1			
li	d	b	m	o	li	d	b	m	o	li	d	b	m	o	li	d	b	m	o	li	d	l	m	li	d	l	m	li	d	l	m

LOWER LEFT

7					6					5					4					3				2				1			
o	m	b	d	li	o	m	b	d	li	o	m	b	d	li	o	m	b	d	li	m	l	d	li	m	l	d	li	m	l	d	li

lower RIGHT

7					6					5					4					3				2				1			
li	d	b	m	o	li	d	b	m	o	li	d	b	m	o	li	d	b	m	o	li	d	l	m	li	d	l	m	li	d	l	m

* o: occlusal; m: mesial; b: buccal; l: labial; d: distal; li: lingual;

Status	Sound	Decayed	Filling with decay	Filling no decay	Missing as a result of caries	Missing, any other reason	Fissure sealant	Trauma	Unerupted tooth	Not recorded
Primary tooth	A	B	C	D	E	-	-	T	-	-
Permanent tooth	0	1	2	3	4	5	6	7	U	X

Dental fluorosis

Dean's index

0 = Normal
1 = Questionable (a few white flecks)
2 = Very mild (white opaque areas <25% of the tooth surface)
3 = Mild (white opaque areas< 50%)
4 = Moderate (Whole surface is affected)
5 = Severe (Whole surface is affected + Hypoplasia + brown stain)
7 = Enamel defect- nonfluorotic
8 = Excluded
9 = Not recorded

12	11	21	22

Periodontal Index

Bleeding index

0: No bleeding
1: Bleeding
Y: Cannot be assessed

16	11	26
46	31	36

Calculus index

0: No calculus
1: Calculus
Y: Cannot be assessed

16	11	26
46	31	36

APPENDIX C: DIAGNOSTIC CRITERIA FOR DENTAL EXAMINATIONS

Diagnostic Criteria for Dental Examinations

I. CORONAL CARIES CRITERIA (dmfs/DMFS) NIDR Children

A. The D,d (decayed - Record as B or 1 ; C or 2) component of the dmfs, DMFS assessment were diagnosed as follows: Frank lesions were detected as gross cavitation. Incipient lesions were subdivided into three categories according to location, each with special diagnostic considerations. The categories were:

- *a. **Pits and fissures on occlusal, buccal and lingual surfaces :*** these areas were diagnosed as carious when the probe detected a break in the enamel with gentle pressure and there were also one or both of the following signs :
  - Softness at the base of the area.
  - The adjacent enamel showed opacity or shadowing suggesting undermining or demineralisation.
- ***b. Smooth areas on buccal (labial) or lingual (palatal) surfaces :*** these areas were carious if they were decalcified or if there was a white spot as evidence of subsurface demineralisation and the area was found to be soft by :
  - Careful penetration with the probe
  - Gentle scraping away of enamel with the probe.

  The surface was scored as sound when there was only visual evidence of demineralisation, but no evidence of softness.
- *c. **Proximal surfaces:*** When there was no adjacent tooth, the criteria were the same as those for smooth areas on facial, buccal or lingual surfaces. For areas which were not available to direct examination, the following criteria applied :
  - A discontinuity of the enamel in which the probe caught was carious if there was softness.
  - In posterior teeth, visual evidence of undermining under a marginal ridge was not acceptable evidence of a proximal lesion unless a surface break could be detected.
  - In the anterior teeth, transillumination was a useful aid in discovering proximal lesion. Transillumination was achieved by placing a mirror lingually and positioning the examining light so that it passed through the teeth labio-lingually and reflected from the mirror. If a characteristic shadow

or loss of translucency was seen on the proximal surface, this was indicative of caries on the surface.

B. The F, f (filled - Record as D or 3) component of the DMFS, dmfs assessment represented a tooth surface that had been filled, with either a permanent or temporary restoration, as a result of dental caries. It was necessary to distinguish a tooth surface filled for any other reasons such as trauma, hypoplasia or malformation, which was recorded as sound.

C. The M,m (missing - Record as E or 4) component of the DMFS, dmfs assessment traditionally represents only those teeth which have been extracted as a result of caries. It was necessary to distinguish between teeth extracted due to caries or for other reasons such as periodontal disease, trauma or orthodontics. This would be reflected in the recording for missing teeth.

*** Special conditions:***

1. Coronal caries starts at or just above the cemento-enamel junction (CEJ). If the coronal and root surfaces were both affected by the same lesion, it would be necessary to determine whether the lesion originated on the root or the crown. If more than half was above the CEJ, then it can be assumed that the lesion originated on the coronal surface. If the site of origin was determined to be the root surface, then a coronal lesion was not scored. When the lesion appeared to involve both surfaces equally, both surfaces were scored as affected. For restorations, the same rules applied.

2. Teeth restored with full coverage. The examiners tried to determine the reason the crown was placed. If the restoration was required because of caries, the tooth was coded as all surfaces filled (5 surfaces for posterior or 4 for anterior teeth). If the restoration was placed for malformation or cosmetic reasons, all surfaces were scored as sound. If placed as a result of trauma, the score as T or 7.

3. Banded or bracketed teeth. All visible surfaces were to be examined as well as possible and scored in the usual manner.

4. Teeth extracted for orthodontic reasons. Certain teeth (most often first premolars) may have been extracted as part of orthodontic treatment. The examiner should have been sure that the teeth were extracted for orthodontic reasons. Rather than trying to determine whether the extracted teeth were first or second premolar teeth, the convention of calling them first premolar teeth was adopted. (Scored as 5)

5. Non-vital teeth. Non-vital teeth were to be scored in the same manner as vital teeth. However, if it appeared that a restoration on a non-vital tooth was placed solely as a result of root canal treatment and not for caries, that restoration was not scored. If no other lesions or restorations were present, the tooth were called sound.

6. Hypoplastic teeth. If the examiner was sure that a restoration on such a tooth was placed for aesthetic reasons and not for caries, that restoration was not scored.

7. Teeth fractured due to trauma were recorded as T or 7.

General consideration:

1. Stain or pigmentation alone was not regarded as indicative of decay.

2. A tooth was considered erupted when any part of its crown projected through the gum.

3. In the case of supernumerary teeth, the examiner must have determined which tooth was the "legitimate" occupant of the space. Only that tooth was scored.

4. Where both a deciduous and permanent tooth occupied the same tooth space, only the permanent tooth was recorded. However, if only a primary tooth was present, the primary tooth was recorded.

5. Third molars were not included in the survey. If a third molar occupied the space of a missing second molar, the diagnosis and coding must have related to the status of the missing second molar not the drifted third molar.

6. When the tooth crown was destroyed by caries and only the roots remained, these were recorded as all surfaces carious.

7. If a tooth contained both a carious lesion and a restoration, both were recorded (C or 2).

8. If an adhesive sealant was present in a pit and fissure and there was no evidence of caries or restoration, that the tooth was recorded as 6. However, a sealant used as a restoration was recorded as a filling (recorded as D or 3).

9. When a filling or a lesion on a posterior tooth or a lesion on an anterior tooth extended beyond the line angle onto another surface, then the other surface was also recorded. However, a proximal filling on an anterior tooth was not considered to involve the adjacent lingual or labial surface unless it extended at least 1/3 of the distance to the opposite proximal surface.

10. For the purpose of the survey, incisal edges of anterior teeth were not considered as separate surface and were not represented on the data collection form. If a lesion or restoration was confined solely to the incisal edge it was scored as involving the nearest adjacent surface.

11. An effort was made to examine each subject in the same manner regardless of the amount of caries or prior treatment. Teeth were air-dried prior to examining each quadrant. The examination procedure was systematised, and examination sequence followed for each person. For dental caries the exam forms were set up to start with the occlusal surface of the second molar on the upper right jaw (Maxilla) through to the lingual surface of the second molar on the upper left. Then, starting with the occlusal surface of the second molar on the lower left jaw (Mandibular) through to the lingual surface of the second molar on the lower right. The examiner examined the surfaces in the following order: occlusal, mesial, buccal, distal, and lingual for the posterior teeth, and mesial, labial, distal, and lingual (palatal) for the anterior teeth.

12. Mobile teeth were to be recorded in the usual manner, but were examined with caution.

II. DENTAL FLUOROSIS

Dean's index:

It was recommended that Dean's index criteria be used. The recording was made on the basis of the four teeth (12, 11, 21 and 22). Each tooth was scored. If the examiner had any doubt between 2 scores, the lower score was to be taken.

The codes and criteria used are as follows:

0 - *Normal.*	The enamel surface is smooth, glossy and usually a pale, creamy-white colour.
1 - *Questionable.*	The enamel shows slight aberrations from the translucency of normal enamel, which may range from a few white flecks to occasional spots.
2 - *Very mild.*	Small, opaque, paper-white areas scattered irregularly over the tooth but involving less than 25% of the labial tooth surface.
3 - *Mild.*	The white opacity of the enamel of the teeth is more extensive than for score 2, but coves less than 50% of the tooth surface.
4 - *Moderate.*	The enamel surfaces of the teeth show marked wear and brown stain is frequently a disfiguring feature.
5 - *Severe.*	The enamel surfaces are badly affected and hypoplasia is so marked that the general form of the tooth may be affected. There are pitted or worn areas and brown stains are wide speared; the teeth often have a corroded appearance.
7 - *Enamel defect non fluorotic.*	Enamel defect or enamel opacities not caused by fluoride such as hypoplasia, amelogenesis imperfecta, dentinogenesis imperfecta, tetracycline stains and well-demarcated enamel opacity.

8 - *Excluded.* The examiner can not assess exactly because the tooth was changed in term of the shape or colour due to a crown, large restoration, band of fix orthodontic treatment.

Teeth not fully erupted are also excluded (>75% tooth presence can be consider as fully erupted).

9 - *Not recorded.* It is difficult for the examiner to assess accurately the current status of the tooth because of the presence of other developmental lesions, trauma or previously physical interference.

Differential diagnosis of dental fluorosis and non-fluoride enamel opacities.

Characteristic	Dental fluorosis	Enamel opacities
Area affected	- In milder forms can be seen on or near tips of cusps or incisal edges. - With increasing severity, area affected spreads over many parts of the tooth surface but fades toward the cervical margin.	- Usually centered on smooth surface; may affect entire crown.
Shape of lesions	- In mild forms, the shape of lesions resembles line shading in a pencil sketch, the lines following incremental lines in enamel and forming irregular caps on cusps. - In more severe cases, the lines merge to form wider bands, cloudy or paper-white areas. The tooth surface may become entirely opaque with local loss (pits) or major loss (eroded appearance) of the outermost enamel.	- Often round or oval.
Demarcation	- Diffuse distribution over the surface of varying intensity. - Fades from affected to normal enamel.	- Clearly differentiated from adjacent normal enamel.
Colour	- In mild form, the colour of the tooth is slightly more opaque than normal enamel. Opaque white lines or clouds; incisal edges and cusp tips may have snow capped appearance.	- Usually pigmented at time of eruption; often creamy-yellow to dark reddish-orange.

	- With increasing severity, small cloudy areas are scatted over the whole surface. Entire surface may appear opaque, chalky white. - In most severe cases, the colour of lesions can change to yellow or brown stain.	
Teeth affected	- Always on homologous teeth. Usually six to eight homologous teeth. - Early erupting teeth (lower incisors, first molar) least affected. Premolars and second molars (and third molars) most severely and frequently affected.	- Any tooth may be affected but mostly incisors, especially, labial surface of lower incisors. - May occur singularly.
Gross hypoplasia	- In mild forms, no hypoplasia and pits. Enamel surface of milder forms has glazed appearance, is smooth to point of explorer. - In severe cases, pitting and gross hypoplasia can change the shape of the tooth and enamel may be chipped off. The exposed enamel is porous.	- Absent to severe. Enamel surface may seem etched and rough to explorer.
Detection	- In mild form, white lines often invisible under strong light. Most easily detected by line of sight tangential to tooth crown. - With increasing severity, detection becomes easier.	Seen most easily under strong light by line of sight perpendicular to tooth crown.

III. Periodontal criteria

1. Gingival assessment

The buccal and mesial sites of the teeth 16, 11, 26, 36, 31 and 46 were assessed. A score of 0 or 1 was assigned for each tooth site.

0 = No bleeding

1 = Bleeding

Y= Cannot be assessed

The teeth were dried with air before beginning each quadrant. To examine the gingiva adjacent to each tooth, the NIDR probe was inserted no more than two mm into the gingival sulcus, starting just distal of the midpoint of the buccal surface and then it was moved gently into the mesial interproximal area. The bleeding points were assessed. If a tooth was missing or could not be assessed, a single "Y" was recorded.

2. Calculus assessment

A single score was called for each designated tooth space (16, 11, 26, 36, 31 and 46) according to the following codes:

0 = Absence of calculus

1 = Presence of calculus

Y = Cannot be assessed

The assessment was made after designated teeth were dried with air. The examiner used the #17 explorer or the NIDR probe. The examiner observed the buccal and lingual aspects of each tooth to determine the presence of calculus both subgingivally and supgingivally. If a tooth was missing or could not be assessed a single "Y" was recorded.

*Subragingival calculus included calculus located on the exposed crown and root of the tooth and extending to 1mm below the free gingival margin (FGM).

APPENDIX D: FLUORIDE CONCENTRATION IN DRINKING WATER SAMPLES OF SURVEY PROVINCES

Fluoride concentration in drinking water
Of Lao Cai province

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

Cam Duong town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Well water	Sample 1	0101001-02	Pom Han	29/9/99	161.2	0.13
		Sample 2	-	-	-	141.8	0.28
		Sample 3	-	-	-	162.6	0.12
	2. Tap water	Sample 4	0101001-02	Pom Han	29/9/99	148.2	0.22
		Sample 5	-	-	-	146.3	0.23
		Sample 6	-	-	-	166.6	0.10
	3. Stream water	Sample 7	0101001-02	Pom Han	29/9/99	184.2	0.02
		Sample 8	-	-	-	181.5	0.03
2	1. Well water	Sample 1	0101003	Soi Chieng	28/9/99	182.8	0.02
		Sample 2	-	-	-	166.5	0.09
		Sample 3	0101004	Soi Chieng	-	137.8	0.34
		Sample 4	-	-	-	161.4	0.13
		Sample 5	0101005	Cam Duong	-	152.9	0.18

Bao Thang district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Well water	Sample 1	0102006-07	Xa·Lu	30/9/99	155.7	0.15
		Sample 2	-	-	-	158.7	0.14
		Sample 3	-	-	-	180.8	0.03
		Sample 4	-	-	-	181.3	0.03
2	2. Well water	Sample 1	0102008-09	Thai Nien No 3	30/9/99	154.8	0.15
		Sample 2	-	-	-	180.7	0.03
		Sample 3	-	-	-	160.9	0.13
		Sample 4	0102010	Bao Thang No 1	-	147.8	0.21
		Sample 5	-	-	-	165.7	0.11

Fluoride concentration in drinking water
Of Ha Giang province

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

Ha Giang Town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Well water	Sample 1	0203011-12	Tran phó	6/10/99	147.9	0.20
		Sample 2	-	-	-	166.7	0.10
		Sample 3	-	-	-	171.6	0.07
	2. Tap water	Sample 4	0203011-15	Chuyen Tinh	5/10/99	186.1	0.01
		Sample 5	-	-	-	166.2	0.09
		Sample 6	-	-	-	188.0	0.01
2	1. Well water	Sample 1	0203014	Quang Trung	5/10/99	177.0	0.44
		Sample 2	-	-	-	177.8	0.40
		Sample 3	-	-	-	176.3	0.46
	2. Stream water	Sample 7	0203013-14	Quang Trung	5/10/99	182.5	0.02
		Sample 8		-	-	180.7	0.03
		Sample 9		-	-	181.6	0.03

2. Bac Quang district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Well water	Sample 1	0204016-17	Tan Thuong	7/10/99	200.6	< 0.01
		Sample 2	-	-	-	207.6	< 0.01
		Sample 3	-	-	-	206.8	< 0.01
2	1. Well water	Sample 1	0204018-19	La Khuong	8/10/99	165.7	0.10
		Sample 2	-	-	-	180.5	0.03
		Sample 3	-	-	-	172.6	0.07
	2. Steam water	Sample 4	0204020	Viet Vinh	8/10/99	198.62	< 0.01
		Sample 6	0204018	La Khuong	-	02.2	< 0.01

Fluoride concentration in drinking water
Of Hanoi City

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

1. Dong Da district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	0305021-22	Phuong mai	6/12/99	134.5	0.35
		Sample 2	-	-	-	134.6	0.35
		Sample 3	-	-	-	133.3	0.38
		Sample 4	0305023	Quang Trung	-	131.6	0.39
		Sample 5	-	-	-	133.0	0.38

2. Hai Ba Trung district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	0306024-25	Luong Yen	1/12/99	141.5	0.28
		Sample 2	-	-	-	142.9	0.27
		Sample 3	-	-	-	142.3	0.27
		Sample 7	0306026	Thang Long	-	139.9	0.28
	2. Bore water (Well water)	Sample 4	0306025	Luong Yen	1/12/99	104.4	1.30
		Sample 5	-	-	-	101.0	1.50
		Sample 6	-	-	-	107.9	1.10

3. Gia Lam district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore water	Sample 1	0307027	Ngoc Thuy	26/11/99	141.7	0.28
		Sample 2	-	-	-	138.0	0.27
		Sample 3	0307028	Secondary school	-	132.7	0.40
		Sample 4	-	-	-	134.7	0.39
		Sample 5	0307029	Cao B, Quat	-	158.6	0.13
		Sample 6	-	-		152.7	0.18

4. Tu Liem district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore water	Sample 1	0308030	Lien Mac	23/11/99	140.8	0.28
		Sample 2	-	-	-	118.5	0.64
		Sample 3	0308031	Lien Mac	-	147.5	0.21
		Sample 4	-	-	-	150.1	0.19
		Sample 7	0308032	Xuan Dinh		175.2	0.05
		Sample 8	-	-		190.4	< 0.01
	2. Rain water	Sample 5	0308030	Lien Mac	23/11/99	149.2	0.20
		Sample 6	-	-	-	148.4	0.20

Fluoride concentration in drinking water
Of Ha Tay province

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

Son Tay town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	0409033-34	Quang Trung	13/10/99	150.4	0.20
		Sample 2	-	-	-	145.3	0.25
		Sample 3	-	-	-	149.2	0.20
	2. Well water	Sample 4	0409037	Xuan Khanh	14/10/99	162.4	0.12
		Sample 5	-	-	-	192.7	0.01
		Sample 6	0409033-34	Quang Trung	15/10/99	136.4	0.34
		Sample 7	-	-	-	125.7	0.50
		Sample 8	-	-	-	125.8	0.50
2	1. Tap water	Sample 1	0409035-36	Le Loi	8/10/99	140.9	0.27
		Sample 2	-	-	-	135.9	0.32
	2. Well water	Sample 3	0409035-36	Le Loi	13/10/99	138.4	0.30
		Sample 4	-	-	-	135.3	0.33

Ung Hoa district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Well water	Sample 1	0410038-39	Hoa Xa	19/10/99	152.2	0.18
		Sample 2	-	-	-	148.9	0.21
		Sample 3	-	-	-	150.0	0.20
		Sample 4	0410042	Ung Hoa B	-	155.2	0.16
		Sample 5	-	-	-	120.1	0.62
	2. Rain water	Sample 4	0410038-39	Hoa Xa	18/10/99	162.7	0.12
		Sample 5	-	-	-	153.7	0.16
2	2. Well water	Sample 1	0410040-41	Minh Duc	18/10/99	163.3	0.10
		Sample 2	-	-	-	173.7	0.06
		Sample 3	-	-	-	151.9	0.18

Fluoride concentration in drinking water
Of Quang Binh province

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

Dong Hoi town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1.Bore water (Well water)	Sample 1	0511043-44	Dong Son	26/10/99	179.1	0.04
		Sample 2	-	-	-	190.9	< 0.01
		Sample 3	-	-	-	186.6	< 0.01
2	1. Bore water	Sample 1	0511045	Loc Ninh	25/10/99	192.3	< 0.01
		Sample 2	-	-	-	194.6	< 0.01
		Sample 3	0511046	Loc Ninh	-	195.5	< 0.01
	2. Tap water	Sample 4	0511047	Dao Duy Tu	25/10/99	194.8	< 0.01
		Sample 5	-	-	-	196.2	< 0.01
		Sample 6	-		-	192.1	< 0.01
	3. Rain water	Sample 7	0511046-47	Loc Ninh Dao Duy Tu	25/10/99	191.5	< 0.01

2. Quang Trach district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Well water	Sample 1	0512048-49	Quang Phu	27/10/99	194.3	< 0.01
		Sample 2	-	-	-	170.6	0.08
		Sample 3	-	-	-	167.0	0.09
2	2. Well water	Sample 1	0512050-51	Quang Thuan	27/10/99	183.1	0.02
		Sample 2	-	-	-	190.5	< 0.01
		Sample 3	-	-	-	184.6	0.02
		Sample 4	0512052	Quang Trach	-	189.4	0.01
		Sample 5	-	-	-	190.5	< 0.01

Fluoride concentration in drinking water
Of Thua Thien - Hue province

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

1. Hue city

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	0613053-54	Phu Thuan	22/12/99	192.4	< 0.01
		Sample 2	-	-	-	187.0	0.01
		Sample 3	-	-	-	188.1	0.01
2	1. Tap water	Sample 1	0613055-56	Thach Long	21/12/99	187.4	0.01
		Sample 2	-	-	-	186.4	0.02
		Sample 3	-	-	-	185.1	0.02
	2. Rain water	Sample 7	0613055	Thach long	21/12/99	185.3	0.02

2. Phu Vang district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	0614058-59	Vinh Xuan	21/12/99	187.7	0.01
		Sample 2	-	-	-	187.3	0.01
		Sample 3	-	-	-	188.9	0.01
		Sample 4	-	-	-	187.8	0.01
		Sample 5	-	-	-	187.1	0.01
2	1. Well water	Sample 1	0614060-61	Phu Tan	21/12/99	154.1	0.17
		Sample 2	-	-	-	153.1	0.18
		Sample 3	-	-	-	151.4	0.19
		Sample 4	-	-	-	152.4	0.18
		Sample 5	-	-	-	153.8	0.18
	2. Lake water	Sample 6	0614060-61	Phu Tan	21/12/99	178.6	0.04
		Sample 7	-	-	-	181.2	0.03
		Sample 8	-	-	-	181.9	0.03
	3. Rain water	Sample 9	0614060-61	Phu Tan	21/12/99	177.6	0.04
	4. Tap water	Sample 10	0614060-61	Phu Tan	21/12/99	182.3	0.03
		Sample 11	-	-	-	182.3	0.03
		Sample 12	-	-	-	182.0	0.03

Fluoride concentration in drinking water
Of Quang Ngai province

Standard Fluoride ion by MV
in 3/1/2000

0.01 : 188.1 mv
0.10 : 163.8 mv
1.00 : 107.3 mv
10.0 : 47.8 mv
100 : -12.3 mv

Measured in January 3, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet, Dr Minh.

Quang Ngai town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore water (Well water)	Sample 1	0715063-64	Le Hong Phong	4/10/99	159.5	0.14
		Sample 2	-	-	-	160.9	0.13
		Sample 3	-		-	162.3	0.12
	2. Tap water	Sample 7	0715063-64	Le Hong Phong	1/11/99	160.4	0.13
2	1. Bore water	Sample 1	0715065-66	Nghia Dung	1/11/99	164.7	0.10
		Sample 2	-	-	-	154.9	0.16
		Sample 3	-	-	-	194.2	< 0.01
	2. Tap water	Sample 4	0715065-66	Nghia Dung	1/11/99	150.8	0.20
		Sample 5	-	-	-	148.9	0.21
		Sample 6	-	-	-	169.0	0.09

Nghia Hanh district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	Bore water (Well water)	Sample 1	0716068-69	Hanh Duc	8/11/99	198.2	< 0.01
		Sample 2	-	-	-	197.7	< 0.01
		Sample 3	-	-	-	198.8	< 0.01
2	2. Well water	Sample 1	0716070-71	Hanh Nhan	8/11/99	203.5	< 0.01
		Sample 2	-	-	-	202.4	< 0.01
		Sample 3	-	-	-	205.2	< 0.01
		Sample 4	0716072	Nghia Hanh	9/11/99	208.5	< 0.01
		Sample 5	-	-	-	204.6	< 0.01

Fluoride concentration in drinking water
Of Phu Yen province

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet.

1. Tuy Hoa town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	0817073	Au Co	10/1/ 2000	141.3	0.30
		Sample 2	-	-	-	140.5	0.30
		Sample 3	-	-	-	138.9	0.33
		Sample 1	0817074	Hïng Vuong	-	145.2	0.25
		Sample 2	-	-	-	144.3	0.25
		Sample 3	-	-	-	142.2	0.30
	2. Bore water (Well water)	Sample 1	0817073	Au Co	10/1/ 2000	196.2	0.01
		Sample 3	-	-	-	207.9	< 0.01
		Sample 5	-	-	-	199.4	< 0.01
		Sample 2	0817074	Hïng Vuong	-	169.1	0.09
		Sample 3	-	-	-	110.7	1.00
		Sample 4	-	-	-	166.1	0.10
2	Bore/well water	Sample 1	0817075	Hoa Quang	11/1/ 2000	105.0	1.30
		Sample 2	-	-	-	106.1	1.20
	2. Tap water	Sample 1	0817077	Tran Quoc Tuan	10/1/ 2000	137.1	0.34

2. Dong Xuan district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	Bore/well water	Sample 1	0818078	Xuan Lanh	12/1/ 2000	150.7	0.20
		Sample 2	-	-	-	144.5	0.25
		Sample 1	0818079	Xuan Lanh	-	138.8	0.33
		Sample 2	-	-	-	151.7	0.20
2	Bore/well water	Sample 1	0818080	Xuan Quang	12/1/ 2000	100.8	1.10
		Sample 2	-	-	-	101.8	1.50
		Sample 3	-	-	-	144.5	0.25
		Sample 1	0818081	Xuan Quang	-	147.9	0.22
		Sample 1	0818082	Le Loi	11/1/ 2000	149.9	0.20

Fluoride concentration in drinking water
Of Gia Lai province

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet.

1. Pleiku town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	Bore/well water	Sample 1	0919083	Le Lai	29/12/99	206.5	< 0.01
		Sample 2	-	-	-	201.9	< 0.01
		Sample 3	-	-	-	168.6	0.10
		Sample 4	-	-	-	165.9	0.11
		Sample 5	-	-	-	163.6	0.12
		Sample 1	0919084	Lý Tù Träng	-	183.6	0.03
		Sample 2	-	-	-	188.3	0.02
		Sample 3	-	-	-	188.2	0.02
		Sample 4	-	-	-	189.2	0.02
		Sample 5	-	-	-	190.0	0.01
2	Bore/well water	Sample 1	0919085	Phan Dang Luu	30/12/99	199.6	0.01
		Sample 2	-	-	-	202.6	< 0.01
		Sample 3	-	-	-	203.4	< 0.01
		Sample 4	-	-	-	205.6	< 0.01
		Sample 5	-	-	-	206.8	< 0.01
		Sample 1	0919086	Nguyen Van Ca	-	207.8	< 0.01
		Sample 2	-	-	-	206.9	< 0.01
		Sample 3	-	-	-	207.1	< 0.01
		Sample 4	-	-	-	206.7	< 0.01
		Sample 5	-	-	-	203.0	< 0.01
		Sample 1	0919087	Bien Ho	29/12/99	186.2	0.03
		Sample 2	-	-	-	186.4	0.03
		Sample 3	-	-	-	184.4	0.03
		Sample 4	-	-	-	183.3	0.03
		Sample 5	-	-	-	183.7	0.03

2 Ayun Pa district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	Bore/well water	Sample 1	0920088	Chu A Thai	30/12/99	100.7	1.50
		Sample 2	-	-	-	99.8	1.50
		Sample 3	-	-	-	99.5	1.50
		Sample 4	-	-	-	98.8	1.60
		Sample 5	-	-	-	97.4	1.70
		Sample 1	0920089	Chu A Thai	-	128.5	0.50
		Sample 2	-	-	-	127.7	0.54
		Sample 3	-	-	-	128.9	0.50
		Sample 4	-	-	-	128.8	0.50
		Sample 5	-	-	-	127.9	0.54
2	1. Bore/well water	Sample 1	0920090	Chu Rang	31/12/99	93.6	2.00
		Sample 2	-	-	-	94.5	2.00
		Sample 3	-	-	-	94.8	1.90
		Sample 4	-	-	-	93.3	2.00
		Sample 5	-	-	-	94.2	2.00
		Sample 1	0920091	A Ma Ron	30/12/99	117.3	0.80
		Sample 2	-	-	-	117.4	0.80
		Sample 3	-	-	-	117.5	0.80
		Sample 4	-	-	-	118.0	0.70
		Sample 5	-	-	-	116.9	0.80
		Sample 1	0920092	A Yun Pa	31/12/99	148.0	0.23
		Sample 2	-	-	-	150.7	0.20
		Sample 3	-	-	-	150.7	0.20
		Sample 4	-	-	-	151.6	0.19
		Sample 5	-	-	-	151.8	0.19

Fluoride concentration in drinking water
Of Kon Tum province

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet.

1. Kon Tum town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore/well water	Sample 1	1021093	Doan Ket	31/12/99	177.6	0.06
		Sample 2	-	-	-	180.0	0.04
		Sample 3	-	-	-	182.5	0.04
		Sample 4	-	-	-	186.2	0.03
		Sample 5	-	-	-	187.6	0.02
		Sample 1	1021094	Thang Loi	-	186.5	0.02
		Sample 2	-	-	-	186.9	0.02
		Sample 3	-	-	-	187.0	0.02
		Sample 4	-	-	-	188.1	0.02
		Sample 5	-	-	-	190.3	0.01
2	1. Bore/well water	Sample 1	1021095	Vinh Quang	3/1/ 2000	156.8	0.15
		Sample 2	-	-	-	155.7	0.15
		Sample 3	-	-	-	155.5	0.16
		Sample 4	-	-	-	154.1	0.17
		Sample 5	-	-	-	155.0	0.16
		Sample 1	1021096	Vinh Quang	-	193.9	0.01
		Sample 2	-	-	-	199.6	0.01
		Sample 3	-	-	-	202.1	< 0.01
		Sample 4	-	-	-	203.8	< 0.01
		Sample 5	-	-	-	205.5	< 0.01
		Sample 1	1021097	Nguyen Hue	-	206.4	< 0.01
		Sample 2	-	-	-	207.5	< 0.01
		Sample 3	-	-	-	207.9	< 0.01
		Sample 4	-	-	-	208.9	< 0.01
		Sample 5	-	-	-	210.0	< 0.01

2. Dak Glei district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore/well water	Sample 1	1022098	TX Dak Glei	5/1/ 2000	150.8	0.20
		Sample 2	-	-	-	148.1	0.22
		Sample 3	-	-	-	146.5	0.24
		Sample 4	-	-	-	145.6	0.25
		Sample 5	-	-	-	146.5	0.24
		Sample 1	1022099	TX Dak Glei	-	137.2	0.35
		Sample 2	-	-	-	136.7	0.35
		Sample 3	-	-	-	138.5	0.33
		Sample 4	-	-	-	137.6	0.35
		Sample 5	-	-	-	137.3	0.35
2	1. Bore/well water	Sample 1	1022100	Dac Long	5/1/ 2000	155.6	0.16
		Sample 2	-	-	-	157.5	0.15
		Sample 3	-	-	-	159.5	0.14
		Sample 4	-	-	-	159.8	0.13
		Sample 5	-	-	-	159.2	0.14
		Sample 1	1022101	Dac Long	-	146.0	0.23
		Sample 2	-	-	-	158.8	0.14
		Sample 3	-	-	-	159.4	0.13
		Sample 4	-	-	-	160.3	0.13
		Sample 5	-	-	-	147.3	0.22

Fluoride concentration in drinking water
Of Ho Chi Minh City

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam.
Investigators : Dr Thuû, Dr Hïng, Dr Viet.

1. I district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	1123103	Khai Minh	12/1/ 2000	120.1	0.70
		Sample 2	-	-	-	143.0	0.25
		Sample 3	1123104	Dong Khoi	-	119.2	0.70
		Sample 4	1123105	Truong Vuong	14/1/ 2000	121.7	0.70

2. IX district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	1124106	Long Thanh My	10/1/ 2000	198.5	0.01
	2. Bore water	Sample 1	1124106	Long Thanh My	10/1/ 2000	199.5	0.01
		Sample 2	1124107	Long Thanh My	-	193.2	0.01
		Sample 3	-	-	-	200.8	< 0.01
		Sample 4	1124108	Nguyen Hue	-	199.2	< 0.01
		Sample 5	-	-	-	171.1	0.08

3. XI district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	1125109	De Tham	13/1/ 2000	134.1	0.40
		Sample 2	1125110	Ng Minh Hoang	-	161.0	0.13
		Sample 3	1125111	Nguyen Hien	-	183.6	0.03

4. Cu Chi district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore water	Sample 1	1126112	Phuoc Thanh	11/1/ 2000	180.7	0.04
		Sample 2	-	-	-	187.6	0.02
		Sample 3	1126113	Phuoc Thanh	-	183.4	0.03
		Sample 4	1126114	An Nhon Tay	-	198.3	0.01

Fluoride concentration in drinking water
Of Baria - Vung Tau province

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam. Investigators : Dr Thuû, Dr Hïng, Dr Viet.

1. Ba Ria town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	1227115	Dien Bien	7/12/99	168.2	0.09
		Sample 2	-	-	-	170.6	0.09
		Sample 3	-	-	-	170.2	0.09
		Sample 1	1227116	Dien Bien	8/12/99	160.2	0.13
		Sample 2	-	-	-	168.3	0.09
		Sample 3	-	-	-	170.4	0.09
		Sample 4	-	-	-	170.9	0.09
		Sample 5	-	-	-	167.8	0.10
	Bore/well water	Sample 1	1227115	Dien Bien	7/12/99	160.2	0.15
		Sample 2	-	-	-	154.7	0.16
		Sample 3	-	-	-	153.0	0.17
2	1. Well water	Sample 1	1227117	Phan Boi Chau	9/12/99	162.2	0.09
		Sample 2	-	-	-	167.7	0.10
		Sample 3	-	-	-	167.7	0.10
		Sample 4	-	-	-	168.9	0.09
		Sample 1	1227118	Phan Boi Chau	8/12/99	168.0	0.09
		Sample 2	-	-	-	170.1	0.09
		Sample 3	-	-	-	169.7	0.09
		Sample 4	-	-	-	169.7	0.09
		Sample 5	-	-	-	170.6	0.09
		Sample 1	1227119	Le Hong Phong	8/12/99	171.4	0.08
		Sample 2	-	-	-	170.8	0.09
		Sample 3	-	-	-	171.9	0.09
		Sample 4	-	-	-	172.3	0.08
		Sample 5	-	-	-	171.3	0.08

2. Chau Duc district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	Bore water (Well water)	Sample 1	1228120	Nguyen Dinh Chieu	8/12/99	181.7	0.04
		Sample 2	-	-	-	182.9	0.04
		Sample 3	-	-	-	183.1	0.03
		Sample 4	-		-	182.3	0.04
2	1. Well water	Sample 1	1228122	Binh Ba	9/12/99	194.5	0.01
		Sample 2	-	-	-	196.9	0.01
		Sample 3	-	-	-	199.4	0.01
		Sample 4	-	-	-	201.0	< 0.01
		Sample 5	-	-	-	201.2	< 0.01
	2. Well water	Sample 1	1228124	Ngo Quyen	8/12/99	155.8	0.16
		Sample 2	-	-	-	151.5	0.20
		Sample 3	-	-	-	151.8	0.20
		Sample 4	-	-	-	150.7	0.20

Fluoride concentration in drinking water
Of Tien Giang province

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam. Investigators : Dr Thuû, Dr Hïng, Dr Viet.

1. My Tho town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	1329125	Kim Dong	17/11/ 99	162.4	0.13
		Sample 2	-	-	-	161.6	0.13
		Sample 3	-	-	-	164.3	0.11
		Sample 4	-	-	-	164.0	0.11
		Sample 5	-	-	-	165.1	0.11
2	1. Tap water	Sample 1	1329129	Tien Giang	17/11/99	135.2	0.37
		Sample 2	-	-	-	135.1	0.37
		Sample 3	-	-	-	133.1	0.41
		Sample 4	-	-	-	134.8	0.40
		Sample 5	-	-	-	135.6	0.36

2. Cho Gao district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Tap water	Sample 1	1330130	Hoa Tinh	17/11/99	153.3	0.21
		Sample 2	-	-	-	157.1	0.15
		Sample 3	-	-	-	156.6	0.16
		Sample 1	1330131	Tinh Ha	-	157.9	0.16
		Sample 2	-	-	-	156.8	0.16
		Sample 3	-	-	-	160.5	0.13
	2. Bore water	Sample 1	1330130	Hoa Tinh	17/11/99	126.4	0.56
		Sample 2	-	-	-	127.1	0.54
		Sample 3	-	-	-	127.2	0.54
	3. Rain water	Sample 1	1330130	Hoa Tinh	17/11/99	188.0	0.02
		Sample 2	-	-	-	194.5	0.01
		Sample 3	-	-	-	197.0	0.01
	4. River water	Sample 1	1330131	Tinh Ha	17/11/99	135.0	0.36
		Sample 2	-	-	-	134.9	0.36
		Sample 3	-	-	-	134.1	0.36
2	1. Tap water	Sample 1	1330132	Long Binh Dien	18/11/99	189.3	0.02
		Sample 2	-	-	-	187.4	0.02
		Sample 3	-	-	-	170.8	0.08
	Bore/well water	Sample 1	1330134	Thu Khoa Huan	18/11/99	161.2	0.13
		Sample 2	-	-	-	159.3	0.14
		Sample 3	-		-	156.9	0.16

Fluoride concentration in drinking water
Of Soc Trang province

Standard Fluoride ion by MV
in 20/1/2000

0.01 : 194.5 mv
0.10 : 167.2 mv
1.00 : 111.2 mv
10.0 : 52.2 mv
100 : -7.0 mv

Measured in January 20, 2000.
In Odonto - Stomatology of Hanoi, Vietnam. Investigators : Dr Thuû, Dr Hïng, Dr Viet.

Soc Trang town

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1 and 2	1. Tap water	Sample 1	1431137	Phuong 10	30/11/99	160.5	0.13
		Sample 2	-	-	-	161.6	0.12
		Sample 3	-	-	-	162.4	0.12
		Sample 1	1431138	Phuong 10 and	-	160.8	0.13
		Sample 2	-	Phuong 7	-	159.3	0.14
		Sample 3	-	-	-	161.2	0.13
	2. Bore / Well water	Sample 1	1431137	Phuong 10	30/11/99	149.4	0.20
		Sample 2	-	-	-	152.1	0.19
		Sample 3	-	-	-	150.9	0.20
	3. Rain water	Sample 1	1431137	Phuong 10	30/11/99	140.2	0.30
		Sample 2	-	-	-	138.9	0.32
		Sample 3	-	-	-	140.3	0.30

2. Dong Xuan district

Cluster	Water source		Area code	Name of school	Collected day	MV	PPM
1	1. Bore water	Sample 1	1432140	Lai Hoa	2/12/99	163.7	0.12
		Sample 2	-	-	-	145.4	0.25
		Sample 3	-	-	-	144.9	0.25
		Sample 1	1432141	Lai Hoa	3/12/99	144.5	0.25
		Sample 2	-	-	-	147.5	0.22
		Sample 3	-	-	-	144.0	0.25
	2. Bore water	Sample 1	1432140	Lai Hoa	2/12/99	161.8	0.13
		Sample 2	-	-	-	142.5	0.27
		Sample 3	-	-	-	162.1	0.12
	3. Rain water	Sample 1	1432140	Lai Hoa	2/12/99	140.2	0.30
		Sample 2	-	-	-	139.4	0.30
		Sample 3	-	-	-	139.5	0.30
		Sample 1	1432141	Lai Hoa	3/12/99	192.2	0.01
		Sample 2	-	-	-	198.3	0.01
		Sample 3	-	-	-	201.2	< 0.01
2	Bore/well water	Sample 1	1432142	Vinh Phuoc	3/12/99	146.1	0.24
		Sample 2	-	-	-	144.5	0.25
		Sample 3	-	-	-	144.1	0.25
		Sample 1	1432143	Vinh Phuoc	-	143.8	0.26
		Sample 2	-	-	-	157.4	0.15
		Sample 3	-	-	-	162.2	0.13
	2. Rain water	Sample 1	1432142	Vinh Phuoc	3/12/99	157.8	0.16
		Sample 2	-	-	-	147.8	0.22
		Sample 3	-	-	-	203.6	< 0.01

APPENDIX E: RESPONSE RATE BY AGE GROUPS AND BY CLUSTERS

THE RESPONSE RATE BY AGE GROUPS AND BY CLUSTERS

AREA		Cluster	Group A	%	Group B	%	Group C	%	Group D	%
LAOCAI	CD_TOWN	1	12		12		14		25	
		2	12		12		12			
	BT_DIS	1	12 (1)	92%	12		17		24	
		2	9 (3)	75%	12		13			
HAGIANG	HG_TOWN	1	13 (1)	93%	12		11 (1)	92%	27 (1)	96%
		2	13		14 (1)	93%	14			
	BQ_DIS	1	12		16		11(1)	92%	28	
		2	13		10 (2)	83%	12			
HANOI CITY	DD	1	12		12		12		13	
	HBT	1	12		8 (4)	67%	18		12	
	GL	1	12		11 (1)	92%	12		12	
	TL	1	12		14		14 (1)	93%	12	
HATAY	ST_TOWN	1	13		12		13 (1)	93%	25	
		2	13		17		17			
	UH_DIS	1	12		12		14		24	
		2	12		12		12			
QUANG BINH	DH_TOWN	1	13		12		12		24	
		2	16		12		15			
	QT_DIS	1	12		12		12		25	
		2	13		12		14			

TT HUE	HUE_CITY	1	12		12		12		25	
		2	12		13		12			
	PV_DIS	1	12		12		12		24	
		2	12		12		12			
QUANG NGAI	QN_TOWN	1	12		12		12		25	
		2	12		12		14			
	NH_DIS	1	12		14		12		24	
		2	12		12		12			
PHU YEN	TH_TOWN	1	12		12		12		24	
		2	13		12		13			
	DX_DIS	1	12		12		14		24	
		2	12		12		12			
GIALAI	PK_TOWN	1	12		12		12		12 (12)	50%
		2	12		12		12			
	AP_DIS	1	12		12		12		24	
		2	12		12		12			
KONTUM	KT_TOWN	1	12		12		12		24	
		2	12		12		12			
	DL_DIS	1	13		14		13		24	
		2	12		12		12			
HCM CITY	I	1	13		12		12		15	
	IX	1	12		12		12		12	
	XI	1	12		12		13		13	
	CC	1	14		15		13		15	
BARIA - VUNG TAU	BR_TOWN	1	13		12		12		18 (6)	75%
		2	14		12		12			
	CD_DIS	1	13		13		13		15 (9)	63%
		2	12		13		13			

TIEN GIANG	MT_TOWN	1	12		13		13		24	
		2	13		13		13			
	CG_DIS	1	13		11 (1)	92%	12		23 (1)	96%
		2	13		12		12			
SOC TRANG	ST_TOWN	1	12		13		24		24	
		2	12		12 (1)	92%				
	DX_DIS	1	13		12		12		24	
		2	12		12		14			

- These numbers in the bracket indicate the number of children who did not attend the dental examination.

APPENDIX F: THE MEAN AND PERCENTAGE OF dmfs, DMFS, FLUOROSIS AND FLUORIDE CONCENTRATION IN DRINKING WATER BY AGE GROUP

The mean and percentage dmfs, dmfs, fluorosis
and fluoride concentration in drinking water
In age group from 6 to 8 years old.

	dmfs			DMFS		F-concentration		Fluorosis		
	N	mean	% caries	Mean	% caries	*N*	F con	N	%	CFI
1	*12*	14.7	100.0	0.17	8.3	*11*	0.18	*2*	0.0	0.00
2	*12*	11.1	75.0	0.50	25.0	*12*	0.15	*1*	0.0	0.00
3	*12*	11.4	75.0	0.58	16.7	*12*	0.09	*5*	0.0	0.00
4	*9*	7.8	77.8	0.44	22.2	*9*	0.10	*4*	0.0	0.13
5	*13*	20.0	84.6	0.15	7.7	*13*	0.06	*1*	0.0	0.00
6	*13*	14.8	69.2	0.54	30.8	*12*	0.30	*5*	0.0	0.00
7	*12*	11.5	75.0	0.42	16.7	*11*	0.01	*4*	0.0	0.00
8	*13*	20.3	92.3	0.46	23.1	*13*	0.07	*6*	0.0	0.08
9	*12*	9.7	75.0	0.25	16.7	*12*	0.30	*6*	0.0	0.33
10	*13*	12.1	84.6	0.00	0.0	*13*	0.31	*5*	0.0	0.30
11	*12*	6.0	66.7	0.00	0.0	*12*	0.18	*2*	0.0	0.00
12	*12*	4.3	75.0	0.17	16.7	*12*	0.12	*2*	0.0	0.25
13	*12*	10.8	100.0	0.25	16.7	*12*	0.02	*5*	20.0	0.20
14	*16*	17.9	81.2	0.13	6.2	*16*	0.01	*3*	0.0	0.17
15	*12*	18.6	91.7	0.25	25.0	*12*	0.06	*3*	0.0	0.00
16	*13*	17.8	92.3	0.77	38.5	*13*	0.02	*9*	0.0	0.00
17	*12*	16.7	91.7	1.67	33.3	*12*	0.01	*5*	0.0	0.00
18	*11*	13.4	72.7	0.55	18.2	*11*	0.02	*4*	0.0	0.00
19	*12*	6.0	75.0	0.92	25.0	*9*	0.01	*5*	0.0	0.00
20	*11*	20.5	72.7	1.72	45.5	*11*	0.06	*6*	0.0	0.00
21	*11*	17.5	100.0	1.09	63.6	*11*	0.13	*6*	33.3	0.33
22	*11*	14.3	100.0	2.18	72.7	*11*	0.09	*7*	0.0	0.00
23	*12*	21.3	91.7	2.42	75.0	*12*	0.01	*6*	0.0	0.00
24	*12*	10.5	91.7	1.75	58.3	*12*	0.01	*8*	0.0	0.00
25	*14*	18.4	100.0	0.71	28.6	*14*	0.25	*10*	0.0	0.00
26	*14*	11.4	92.9	0.36	21.4	*14*	1.25	*8*	25.5	0.31
27	*18*	13.3	88.9	0.50	22.2	*18*	0.25	*10*	20.0	0.45
28	*18*	9.7	88.9	0.94	33.3	*18*	0.77	*15*	20.0	0.57
29	*12*	2.8	83.3	2.08	50.0	*12*	0.05	*7*	28.6	0.36

30	*12*	6.9	83.3	1.08	41.7	*12*	0.01	*6*	66.7	0.67
31	*13*	5.6	69.2	0.23	23.1	*13*	1.04	*8*	12.5	0.13
32	*8*	6.8	87.5	0.13	12.5	*8*	1.38	*3*	33.3	0.33
33	*12*	6.8	91.7	0.58	41.7	*12*	0.03	*5*	0.0	0.00
34	*9*	14.0	77.8	0.56	33.3	*8*	0.08	*2*	0.0	0.50
35	*15*	13.5	80.0	0.20	6.7	*14*	0.29	*10*	0.0	0.00
36	*16*	1.8	43.7	0.06	6.2	*2*	0.16	*7*	0.0	0.00
37	*13*	15.1	100.0	0.23	23.1	*11*	0.12	*6*	33.3	0.75
38	*13*	9.3	84.6	0.31	23.1	*11*	0.09	*8*	0.0	0.00
39	*13*	20.5	100.0	0.38	23.1	*12*	0.04	*5*	0.0	0.20
40	*11*	13.5	90.9	1.18	36.4	*8*	0.01	*1*	0.0	0.00
41	*10*	17.1	100.0	0.30	20.0	*4*	0.12	*8*	12.5	0.38
42	*13*	14.8	100.0	0.00	0.0	*9*	0.38	*9*	22.2	0.22
43	*13*	19.5	100.0	0.46	30.8	*13*	0.08	*6*	0.0	0.17
44	*12*	18.8	100.0	0.75	41.7	*2*	0.04	*9*	0.0	0.22
45	*12*	8.0	66.7	0.50	25.0	*11*	0.25	*4*	0.0	0.00
46	*12*	11.5	91.7	1.00	41.7	*12*	0.23	*8*	0.0	0.00
47	*13*	11.4	92.3	0.15	15.4	*12*	0.19	*8*	0.0	0.00
48	*11*	17.2	100.0	1.27	36.4	*11*	0.17	*8*	0.0	0.00
49	*12*	4.9	58.3	0.00	0.0	*12*	0.36	*9*	11.1	0.11
50	*12*	5.2	66.7	0.00	0.0	*12*	0.66	*6*	0.0	0.00
51	*12*	10.1	75.0	0.75	33.3	*12*	0.34	*7*	14.3	0.29
52	*12*	12.5	100.0	1.75	50.0	*12*	0.29	*6*	0.0	0.25
53	*13*	6.5	84.6	0.23	15.4	*12*	0.55	*6*	33.3	0.33
54	*16*	13.6	75.0	0.36	12.5	*15*	0.01	*5*	0.0	0.10
55	*14*	13.1	78.6	0.50	21.4	*9*	0.27	*8*	0.0	0.06
56	*17*	24.1	88.2	0.94	52.9	*13*	0.03	*12*	0.0	0.00

The mean and percentage dmfs, dmfs, fluorosis
and fluoride concentration in drinking water
In age group from 9 to 11 years old.

	dmfs			DMFS		F-concentration		Fluorosis		
	N	mean	% caries	Mean	% caries	*N*	F con	N	%	CFI
1	*12*	2.4	66.7	1.42	50.0	*11*	0.18	*12*	0.0	0.12
2	*12*	8.8	75.0	1.08	58.3	*12*	0.15	*11*	0.0	0.18
3	*12*	4.0	91.7	0.83	33.3	*12*	0.09	*12*	0.0	0.04
4	*12*	4.0	83.3	1.58	58.3	*12*	0.10	*11*	0.0	0.04
5	*12*	6.2	75.0	0.50	33.3	*12*	0.09	*11*	9.1	0.23
6	*14*	3.9	57.1	1.93	50.0	*12*	0.36	*12*	0.0	0.08
7	*15*	5.6	60.0	0.67	33.3	*14*	0.01	*14*	0.0	0.04
8	*10*	6.7	70.0	1.00	50.0	*10*	0.07	*10*	10.0	0.30
9	*13*	5.7	76.9	0.69	30.8	*12*	0.34	*12*	0.0	0.04
10	*17*	4.9	41.2	0.88	41.2	*16*	0.30	*17*	0.0	0.05
11	*12*	5.0	58.3	0.42	33.3	*12*	0.17	*11*	0.0	0.14
12	*12*	1.8	41.7	1.92	75.0	*12*	0.11	*12*	16.6	0.38
13	*13*	4.0	61.5	1.69	46.2	*13*	0.02	*11*	9.1	0.09
14	*12*	6.4	58.3	3.08	75.0	*12*	0.01	*12*	0.0	0.00
15	*6*	1.7	33.3	1.50	66.7	*6*	0.06	*6*	0.0	0.00
16	*12*	8.8	66.7	1.92	66.7	*12*	0.02	*12*	0.0	0.08
17	*12*	5.2	83.3	1.83	58.3	*10*	0.01	*12*	0.0	0.04
18	*14*	1.1	21.4	2.71	64.3	*14*	0.02	*14*	0.0	0.00
19	*12*	5.2	54.5	1.18	36.4	*9*	0.01	*11*	0.0	0.00
20	*13*	5.2	69.2	3.00	76.9	*13*	0.06	*12*	0.0	0.00
21	*11*	5.5	63.6	4.45	90.9	*11*	0.13	*11*	0.0	0.00
22	*14*	4.2	64.3	3.36	85.7	*13*	0.09	*14*	0.0	0.07
23	*14*	6.5	64.3	3.57	85.7	*14*	0.01	*14*	0.0	0.00
24	*12*	5.8	66.7	2.42	66.7	*12*	0.01	*12*	0.0	0.00
25	*13*	3.9	53.8	1.46	53.8	*13*	0.27	*13*	0.0	0.00
26	*17*	0.1	5.9	1.41	41.2	*17*	1.25	*17*	17.7	0.68
27	*6*	3.5	66.7	0.67	33.3	*5*	0.25	*6*	33.3	0.42
28	*10*	2.8	30.0	5.10	70.0	*10*	0.77	*10*	30.0	0.70
29	*12*	0.8	41.7	1.00	41.7	*11*	0.05	*12*	25.0	0.25

30	*10*	2.0	20.0	0.90	30.0	*10*	0.01	*10*	20.0	0.20
31	*11*	2.2	63.6	0.27	27.3	*10*	1.04	*11*	27.3	0.55
32	*15*	4.0	33.3	1.80	33.3	*13*	1.38	*15*	66.7	0.93
33	*12*	1.1	41.7	0.58	50.0	*12*	0.03	*12*	8.3	0.08
34	*14*	4.9	50.0	0.50	28.6	*11*	0.08	*14*	7.1	0.07
35	*18*	4.1	44.4	1.11	38.9	*14*	0.29	*18*	5.6	0.22
36	*14*	1.7	14.3	0.36	21.4	*2*	0.16	*14*	0.0	0.00
37	*11*	3.4	54.5	1.36	45.5	*9*	0.12	*11*	9.1	0.14
38	*13*	7.8	76.9	1.46	76.9	*13*	0.09	*13*	0.0	0.03
39	*13*	1.6	61.5	1.31	61.5	*12*	0.04	*13*	30.8	0.31
40	*14*	8.8	71.4	2.43	64.3	*13*	0.01	*12*	8.3	0.13
41	*13*	4.2	61.5	1.46	46.2	*4*	0.12	*12*	0.0	0.00
42	*11*	6.2	54.5	1.36	45.5	*3*	0.38	*11*	0.0	0.09
43	*4*	5.5	25.0	0.75	50.0	*4*	0.01	*4*	25.0	0.50
44	*11*	3.9	36.4	2.18	81.8	*1*	0.14	*11*	9.1	0.18
45	*13*	2.2	61.5	1.92	61.5	*13*	0.23	*13*	0.0	0.00
46	*13*	2.2	46.2	3.92	76.9	*13*	0.25	*13*	0.0	0.00
47	*12*	2.8	41.7	1.83	58.3	*12*	0.20	*10*	0.0	0.00
48	*13*	8.4	69.2	2.69	53.8	*13*	0.18	*12*	0.0	0.00
49	*15*	5.6	73.3	0.27	20.0	*14*	0.36	*14*	14.3	0.32
50	*8*	6.1	50.0	0.75	50.0	*8*	0.53	*8*	12.5	0.31
51	*11*	3.5	72.7	0.64	36.4	*10*	0.34	*11*	9.1	0.14
52	*16*	3.6	62.5	2.44	68.7	*15*	0.27	*15*	6.7	0.23
53	*13*	2.5	30.8	1.38	23.1	*12*	0.55	*13*	7.7	0.27
54	*11*	2.7	36.4	2.09	45.5	*10*	0.01	*11*	0.0	0.00
55	*11*	3.3	36.4	1.18	45.5	*9*	0.27	*11*	18.2	0.32
56	*16*	6.7	41.7	3.31	68.7	*14*	0.03	*16*	0.0	0.03

The mean and percentage dmfs, dmfs, fluorosis
and fluoride concentration in drinking water
In age group from 12 to 14 years old.

	DMFS			F-concentration		Fluorosis		
	N	Mean	% caries	N	F con	N	%	CFI
1	14	3.93	85.7	14	0.17	14	0.0	0.03
2	12	2.25	50.0	12	0.15	12	0.0	0.08
3	17	4.65	76.5	12	0.09	17	0.0	0.08
4	13	3.62	61.5	13	0.10	13	7.7	0.07
5	11	2.91	63.6	11	0.07	11	0.0	0.00
6	14	3.14	78.6	11	0.32	14	7.1	0.29
7	12	1.67	50.0	11	0.01	12	8.3	0.08
8	12	3.17	75.0	12	0.07	12	0.0	0.00
9	13	3.23	69.2	13	0.31	13	15.4	0.38
10	17	1.24	35.3	17	0.31	17	0.0	0.02
11	13	1.62	30.8	13	0.16	12	8.3	0.25
12	12	1.42	50.0	11	0.14	12	8.3	0.13
13	12	2.08	58.3	12	0.02	12	8.3	0.08
14	11	2.27	63.6	11	0.01	11	0.0	0.00
15	15	3.93	66.7	15	0.06	15	0.0	0.00
16	14	2.64	50.0	14	0.02	14	7.1	0.07
17	12	4.33	83.3	8	0.01	11	0.0	0.00
18	11	3.55	72.7	11	0.02	11	0.0	0.00
19	13	3,03	61.5	13	0.02	13	7.7	0.15
20	12	6.08	83.3	12	0.05	12	8.3	0.17
21	14	4.36	64.3	13	0.13	14	0.0	0.03
22	11	10.18	100.0	11	0.09	10	0.0	0.00
23	12	10.75	100.0	12	0.01	12	0.0	0.00
24	12	2.83	75.0	12	0.01	12	0.0	0.00
25	9	3.33	88.9	9	0.23	9	0.0	0.00
26	7	1.43	57.1	7	1.25	7	0.0	0.07
27	14	5.00	57.1	9	0.25	14	42.8	1.14
28	8	4.63	87.5	8	0.77	8	37.5	1.19
29	12	7.58	100.0	11	0.47	12	16.7	0.17

30	*12*	2.17	83.3	*12*	0.05	*12*	0.0	0.21
31	*14*	2.57	50.0	*14*	0.01	*14*	21.4	0.21
32	*11*	1.64	45.5	*9*	1.04	*11*	18.2	0.45
33	*7*	1.43	57.1	*7*	1.38	*7*	71.5	1.29
34	*12*	2.17	66.7	*12*	0.03	*12*	0.0	0.17
35	*13*	0.85	30.8	*13*	0.08	*13*	15.4	0.15
36	*7*	2.14	57.1	*7*	0.29	*6*	16.7	0.17
37	*6*	0.00	0.0	*1*	0.16	*6*	0.0	0.00
38	*13*	3.46	76.9	*13*	0.12	*13*	7.7	0.07
39	*10*	3.50	70.0	*10*	0.09	*10*	0.0	0.05
40	*10*	2.30	70.0	*10*	0.01	*10*	0.0	0.05
41	*12*	3.08	50.0	*12*	0.07	*12*	41.7	0.42
42	*14*	4.21	78.6	*6*	0.12	*14*	14.3	0.14
43	*15*	3.73	93.3	*5*	0.38	*15*	26.7	0.33
44	*18*	2.72	55.6	*17*	0.03	*18*	5.6	0.22
45	*14*	5.64	71.4	*2*	0.14	*14*	14.3	0.25
46	*23*	3.00	78.3	*22*	0.23	*23*	0.0	0.00
47	*11*	2.18	72.7	*11*	0.19	*11*	0.0	0.00
48	*14*	3.79	78.6	*14*	0.17	*14*	0.0	0.00
49	*9*	1.22	55.6	*9*	0.36	*9*	11.1	0.17
50	*16*	2.94	75.0	*16*	0.43	*16*	12.5	0.25
51	*12*	3.83	58.3	*12*	0.34	*12*	0.0	0.00
52	*11*	1.18	45.5	*9*	0.29	*11*	0.0	0.18
53	*11*	0.36	9.1	*11*	0.55	*11*	0.0	0.09
54	*9*	3.44	100.0	*9*	0.01	*9*	0.0	0.00
55	*12*	4.92	83.3	*9*	0.27	*12*	0.0	0.04
56	*9*	3.78	88.9	*9*	0.03	*9*	11.1	0.11

The mean and percentage dmfs, dmfs, fluorosis
and fluoride concentration in drinking water
In age group from 15 to 17+ years old.

	DMFS			F-concentration		Fluorosis		
	N	Mean	% caries	*N*	F con	*N*	%	CFI
1	*23*	3.70	91.3	*22*	0.16	*23*	4.3	0.15
2	*24*	3.29	50.0	*23*	0.11	*24*	12.5	0.19
3	*26*	4.77	73.1	*24*	0.13	*26*	19.2	0.25
4	*28*	2.86	75.0	*28*	0.03	*28*	0.0	0.02
5	*25*	2.96	60.0	*24*	0.30	*25*	4.0	0.06
6	*24*	0.86	25.0	*24*	0.17	*24*	20.9	0.35
7	*24*	3.04	62.5	*24*	0.01	*24*	0.0	0.02
8	*25*	2.60	56.0	*25*	0.03	*25*	0.0	0.00
9	*25*	5.04	72.0	*19*	0.01	*25*	0.0	0.00
10	*24*	6.33	79.2	*24*	0.07	*24*	0.0	0.00
11	*25*	11.48	96.0	*25*	0.13	*25*	0.0	0.02
12	*24*	9.58	91.7	*24*	0.01	*23*	0.0	0.00
13	*24*	4.75	75.0	*23*	0.47	*24*	8.2	0.23
14	*12*	10.92	100.0	*12*	0.47	*12*	33.3	0.63
15	*12*	4.50	91.7	*12*	0.03	*11*	27.3	0.45
16	*24*	4.88	70.8	*20*	1.00	*24*	58.3	0.58
17	*24*	6.50	66.7	*24*	0.04	*24*	41.7	0.71
18	*23*	4.04	60.9	*22*	0.22	*21*	57.1	1.19
19	*18*	5.94	83.3	*15*	0.10	*18*	11.2	0.14
20	*15*	3.53	80.0	*15*	0.07	*15*	6.7	0.06
21	*24*	4.79	75.0	*12*	0.25	*24*	4.2	0.25
22	*22*	4.36	90.9	*21*	0.20	*22*	18.2	0.34
23	*24*	8.46	87.5	*24*	0.22	*24*	4.2	0.04
24	*24*	3.87	83.3	*24*	0.19	*24*	4.2	0.08
25	*13*	4.23	61.5	*13*	0.37	*13*	0.0	0.12
26	*12*	2.75	41.7	*12*	0.37	*12*	0.0	0.13
27	*12*	1.83	58.3	*10*	0.28	*11*	0.0	0.00
28	*11*	1.73	63.6	*9*	0.22	*10*	0.0	0.15
29	*15*	8.07	93.3	*12*	0.59	*15*	0.0	0.00

30	*7*	4.57	57.1	*6*	0.01	*7*	0.0	0.00
31	*13*	7.23	100.0	*12*	0.19	*13*	0.0	0.03
32	*15*	6.20	100.0	*14*	0.03	*15*	0.0	0.06

REFERENCES

Akizawa, Y., Sakurai, Y., Hara, N., Fujita, Y., Nagai, M., Nakamura., Y., Sakata. K. and Yanagawa, H. 1990, An epidemiological study of the influence of sweets intake and tooth brushing on dental caries among children in Japan, *Asia-Pacific Journal of Public Health*, Vol. 4, No. 4, pp. 242 – 250.

Aleksejuniene, J., Arneberg, P. and Eriksen, H. M. 1996, Caries prevalence and oral hygiene in Lithuanian children and adolescents, *Acta Odontologica Scandinavica*. Vol. 54, No. 1, pp. 75 – 80.

Al-Khateeb, T. L., Darwish, S. K., Bastawi, A. E. and O'Mullane, D. M. 1990, Dental caries in children residing in communities in Saudi Arabia with differing levels of natural fluoride in the drinking water. *Community Dental Health*, Vol. 7, No. 2, pp. 165 – 171.

Andlaw, R. J. 1978, Oral hygiene and dental caries a review, *International Dental Journal*. Vol. 28, No. 1, pp. 1 – 6.

Angelillo, I. F., Romano, F., Fortunato, L. and Montanaro, D. 1990, Prevalence of dental caries and enamel defects in children living in areas with different water fluoride concentrations, *Community Dental Health*, Vol. 7, pp. 229-236.

Angelillo, I. F., Torre, I., Nobile, C. G. and Villari, P. 1999, Caries and fluorosis prevalence in communities with different concentrations of fluoride in the water. *Caries Research*. Vol. 33, No. 2, pp. 114 – 122.

Arnadottir, I. B., Rozier, R. G., Semundsson, S. R., Sigurjons, H. and Holbrool, W. P. 1998, Approximal caries and sugar consumption in Icelandic teenagers, *Community Dental Oral Epidemiology*. Vol. 26, pp. 115 – 121.

Ashley, F. P and Sainsbury, R. H. 1981, The effect of a school-based plaque control programme on caries and gigivitis, *British Dental Journal*, Vol. 150, pp. 41 – 45.

Australian Bureau of Statistics. 1980, *Consultation Manua,* Unpublished.

Barmes, D. E and Tala, H. 1987, *Health manpower out of balance: conflicts and prospects for oral health*, In health manpower out of balance: conflicts and prospects for oral health, ed. Z. Bankowski and A. Mejia, pp. 158 – 167, Geneva, CIOMS.

Barmes, D. E. 1999, A global view of oral disease: today and tomorrow, *Community Dental Oral Epidemiology*. Vol. 27, pp. 2 – 7.

Barrette, P. A., Lynch, G., Wu, A. S. M., Offord, D. R and Last, J. M. 1981, Dental utilization and dental health status of children from a rent-to-income housing complex, *Canadian Journal of Public Health*, Vol. 72, pp. 105 – 110.

Beck, J. D, Kohout, F. and Hunt, R. J. 1988, Identification of high caries risk adults: attitudes, social factors and diseases, *International Dental Journal,* Vol. 38, pp. 231 – 238.

Berenie, J., Ripa, L. W. and Leske, G. 1973, The relationship of frequency of tooth brushing, oral hygiene, gingival health and caries experience in school children. *Journal of Public Health Dentistry*, Vol. 33, No. 3, pp. 160 – 171.

Blinkhorn, A. S., Holloway, P. J. and Davies, T. G. 1983, Combined effects of a fluoride dentifrice and mouthrinse on the incidence of dental caries. *Community Dental Oral Epidemiology*. Vol. 11, No. 1, pp. 7 – 11.

Brothwell, D. J. and Limeback, H. 1999, Fluorosis risk in grade 2 students residing in a rural area with widely varying natural fluoride. *Community Dental Oral Epidemiology*, Vol. 27, No. 4, pp. 130 – 136.

Brown, R. H. 1989, Fluorides and the prevention of dental caries. Part II: The case for water fluoridation. *New Zealand Dental Journal*, Vol. 85, pp. 8 – 10.

Brunelle, J. A. and Carlos, J. P. 1990, Recent trends in dental caries in U.S. children and the effect of water fluoridation. *Journal of Dental Research,* Vol. 69 (Special Issue), pp. 723 – 727.

Burt, B. A. 1984, Patterns of community-based prevention programs. *International Dental Journal,* Vol. 34, pp. 41 – 48.

Burt, B. A., Eklund, S. A., Morgan, K. J., Larkin, F. E., Guire, K. E., Brown, L.O. and Weintraub, J. A. 1988, The effects of sugars intake and the frequency of ingestion on dental caries increment in a three year longitudinal study. *Journal of Dental Research.* Vol. 67, No. 11, pp. 1422 – 1429.

Burt, B. A. and Eklund, S. A. 1992, *Dentistry, Dental Practice and The Community.* W.B. Saunders Company. Mexico.

Cleaton-Jones, P., Chosack, A., Hargreaves, J. A and Fatti, L. P. 1994, Dental caries and social factors in 12 year old South African children. *Community Dental Oral Epidemiology.* Vol. 22, No. 1, pp. 25 – 29.

Correns, C. W. 1956, The geochemistry of the halogens. *In Physics and Chemistry of the Earth.* Vol. 1, pp.181 – 233. *Pergamon, London*

Correns, C. W. 1969, *Introduction to Mineralogy.* Heidelberg. New York.

Cortes, D. F., Mullane, D. M. and Bastos, J. R. 1996, Drinking water fluoride levels, dental fluorosis and caries experience in Brazil. *Journal of Public Health Dentistry.* Vol. 56, No. 4, pp. 226 – 228.

Davies, G. N. 1991, Primary oral health care for developing countries. *World Health Forum.* Vol. 12, pp. 168 – 174.

Dean, H. T. and Evolve, E. 1935, Studies on the minimal threshold of the dental sign of chronic endemic fluorosis. *Public Health Report.* Vol. 49, pp. 1719 – 1729.

Dean, H. T., Dixon, R. M and Cohen, C. 1935, Mottled enamel in Texas. *Public Health Report*. Vol. 50, pp. 424 – 442.

Dean, H. T. and Evolve, E. 1936, Some epidemiological aspects of chronic endemic dental fluorosis. *Public Health Report*. Vol. 26, pp. 567 – 575.

Dean, H. T and Evolve, E. 1937, Further studies on the minimal threshold of chronic endemic fluorosis. *Public Health Report.* Vol. 52, pp. 1249 – 1264.

Dean, H. T. 1938, Endemic fluorosis and its relation to dental caries. *Public Health Report*, Vol. 53, pp. 1443 – 1452.

Dean, H. T., Jay, P., Arnold, F. A. Jr., McClure, F. J., Evolve, E. 1939, Domestic water and dental caries, including certain epidemiological aspects of oral *L. Acidophilus*. *Public Health Report*. Vol. 54, pp. 862-888.

Dean, H. T. 1942, The investigation of physiological effects by the epidemiological method. *American Association for the Advancement of Science*. Vol. 19, pp. 23-31.

Dean, H. T., Jay. P., Arnold, F. A. Jr and Evolve, E. 1941, Domestic water and dental caries. II. A study of 2,832 white children, aged 12-14 years of eight suburban Chicago communities, including *Lactobacullus Acidophilus* studies of 1,761 children. *Public Health Report*. Vol. 56, pp. 761 - 792.

Dean, H.T., Arnold, F.A. Jr., Evolve, E. 1942, Domestic water and dental caries. V. Additional studies of the relation of fluoride domestic waters to dental caries experience in 4,425 white children aged 12-14 years of 13 cities in states. *Public Health Report*. Vol. 57, pp. 1155-1179.

de-Muniz, B. R. 1985, Epidemiologic oral health survey of Argentine children. *Community Dental Oral Epidemiology*. Vol. 13, No. 6, pp. 328 – 333.

DenBesten, P. K. and Thariani, H. 1992, Biological mechanisms of fluorosis and level and timin of systemic exposure to fluoride with respect to fluorosis. *Journal of Dental Research*, Vol. 71, No. 5, pp. 1238 – 1243.

Disney, J. A., Graves, R. C., Stamm, J. M., Bohannan, H. M. and Abernathy, J. R. 1989, Comparative effects of a 4-year fluoride mouthrinse program on high and low caries forming grade 1 children. *Community Dental Oral Epidemiology*. Vol. 17, No. 3, pp. 139– 143.

Dunning, J.M. 1977, *Principles of Dental Public Health*. 2nd ed. Ch 16. Water fluoridation. Harvard University Press. USA, pp. 367–403.

Eklund, S. A. and Striffler, D. F. 1980, Anticaries effect of various concentrations of fluoride in drinking water : evaluation of empirical evidence. *Public Health report*. Vol. 95, pp. 486-490.

El-Nadeef, M. A. I., Adegbembo, A. O. and Honkala, E. 1998, The association of urbanisation with the prevalence of dental caries among schoolchildren in Nigeria new capital territory. *International Dental Journal*. Vol. 48, pp. 44 – 49.

Enwonwu, C.O. 1974, Socio-economic factors in dental caries prevalence and frequency in Nigerians. An epidemiological study. *Caries Researches*. Vol. 8, No. 2, pp. 155 – 171.

Ericsson, Y. 1974, Report on the safety of drinking water fluoridation. *Caries Research*, Vol. 8, supplement, pp. 16 – 27.

Ettinger, R. L. 1999, Epidemiology of dental caries. *Dental Clinics of North America*. Vol. 43, No. 4, pp. 679 – 693.

Evans, R. W., Lo, E. C. M. and Lind, O. P. 1987, Changes in dental health in Hong Kong after 25 years of water fluoridation. *Community Dental Health*, Vol. 4, pp. 383 – 394.

Evans, R. W. 1989, Changes in dental fluorosis following an adjustment to the fluoride concentration of Hong Kong's water supplies. *Advances in Dental Researches*. Vol. 3, No. 2, pp. 154 – 160.

Evans, R. W. and Darwell, B. W. 1995, Refining the estimate of the critical period for susceptibility to enamel fluorosis in human maxillary central incisors. *Journal of Public Health Dentistry*. Vol. 55, No. 4, pp. 238 – 249.

FDI. 1984, The prevention of dental caries and periodontal disease. Technical report No. 20. *International Dental Research*. Vol. 34, pp. 141 – 158.

Fejerskov, O., Manji, F., Baelum, V. and Moller, I. J. 1988, *Dental fluorosis*. Munksgaard, Denmark.

Fejerskov, O., Manji, F. and Baelum, V. 1990, The nature and mechanisms of fluorosis in man. *Journal Dental Research*. Vol. 69 (Special Issue), pp. 692 – 700.

Fejerskov, O., Ekstrand, J. and Burt, B. A. 1996. *Fluoride in Dentistry*. Munksgaard. Copenhagen.

Forrest, J. R. 1956, Caries incidence and enamel defects in areas with different levels of fluoride in the drinking water. *British Dental Journal*. Vol. 100, pp. 195-200.

Fosdick, L. S. 1950, The reduction of the incidence of dental caries. I. Immediate tooth brushing with the neutral dentifrice. *The Journal of the American Dental Association*, Vol. 40, No. 2, pp. 133 – 143.

Frencken, J. E., Rugarabamu, P. and Mulder, J. 1989, The effect of sugar cane chewing on the development of dental caries. *Journal of Dental Research*. Vol. 68, No. 6, pp. 1102 – 1104.

Fuge, R. and Anderews, M. J. 1988, Fluorine in the UK environment. *Environment Geochemistry Health*. Vol. 10, pp. 96 – 104.

Galagan, D. J. and Lamson, G. G. 1953, Climate and endemic dental fluorosis. *Public Health Reports*. Vol. 68, pp. 497-508.

Galagan, D. J. 1953, Climate and Controlled Fluoridation. *The Journal of the American Dental Association*, Vol. 47, pp. 159-170.

Galagan, D. J., Vermillion, J. R., Nevitt, G. A., Stadt, Z. M. and Dart, R. E. 1957, Climate and fluid intake. *Public Health Reports*. Vol. 72, No. 6, pp. 484-490.

Galagan, D.J and Vermillion, J. R. 1957, Determining optimum fluoride concentrations. *Public Health Reports*. Vol. 72, No. 6, pp. 491 - 493.

Garcia, A. I. 1989. Caries incidence and cost of prevention programs. *Journal of Public Health Dentistry*. Vol. 49, No. 5, pp. 259 – 271.

General Statistical Office. 1997, *Statistical Yearbook 1996*. Statistical Publishing House, HaNoi, Vietnam.

Gratrix, D. and Holloway, P. J. 1994, Factors of deprivation associated with dental caries in young children. *Community Dental Health*. Vol. 11, pp. 66 – 70.

Harries, N. O. and Christen, A. G. 1987, *Primary Preventive Dentistry*, Los Altos, California, USA.

Hawew, R. M., Ellwood, R. P., Hawley, G. M., Worthington, H.V. and Blinkhorn, A. S. 1996, Dental caries in children from two Libyan cities with different levels of fluoride in their drinking water. *Community Dental Health*. Vol. 13, No. 3, pp. 175 – 177.

Heller, K.E., Eklund, S. A. and Brut, B. A. 1997, Dental caries and dental fluorosis at varying water fluoride concentration. *Journal of Public Health Dentistry*. Vol. 57, pp. 136-143.

Hesselgren, K. and Thylstrup, A. 1982, Development in dental caries among children in 1961 – 1979 in a Danish community with school dental service. *Community Dental Oral Epidemiology*. Vol. 10, pp. 276– 281.

Horowitz, H. S. and Heifetz, S. B. 1979, Methods for assessing the cost-effectiveness of caries preventive agents and procedures. *International Dental Journal*, Vol. 29, No. 2, pp. 106 – 117.

Horowitz, H. S. 1986, Indexes for measuring dental fluorosis. *Journal of Public Health Dentistry*, Vol. 46, No. 41, pp. 179 – 183.

Horowitz, H. S. 1990, The future of water fluoridation and other systemic fluorides. *Journal of Dental Research*, Vol. 69, Spec. No. 760–4; discussion 820 – 823.

Ibrahim, Y. E., Bjorvatn, K. and Birkeland, J. M. 1997, Caries and dental fluorosis in a 0.25 and a 2.5 ppm fluoride area in the Sudan. *International Journal of Paediatric Dentistry*. Vol. 7, No. 3, pp. 161 – 166.

Irigoyen, M. E. and Szpunar, S. M. 1994, Dental caries status of 12-year-old students in the state of Mexico. *Community Dental Oral Epidemiology*. Vol. 22, pp. 311– 314.

Ishii, I. and Suckling, G. 1991, The severity of dental fluorosis in children exposed to water with a high fluoride content for various periods of time. *Journal of Dental Research*. Vol. 70, No. 6, pp. 952 – 956.

Ismail, A. I. and Messer, J. G. 1996, The risk of fluorosis in students exposed to a higher than optimal concentration of fluoride in well water. *Journal of Public Health Dentistry*. Vol. 56, No. 1, pp. 22 – 27.

Jones, I. G. 1984, Social class analysis–an embarrassment to epidemiology. *Community Medicine*. Vol. 6, No. 1, pp. 37-46.

Kadir, R. A. and Yassin, A. T. 1990, Experience of dental caries among Aboriginal children in Selangor, Malaysia. *Journal Nihon University, sch. Dentistry*. Vol. 32, pp. 275 – 280.

Kappana, A. N., Gadre, G. T., Bhavnagary, H. M. and Joshi, J. M. 1962, *Current Science*. Vol. 31, pp. 273-284.

Kerebel, L. M., Le Cabellec, M-T., Daculsi, G. and Kerebel, B. 1985, Report on caries reduction in French schoolchildren 3 years after the introduction of a preventive program. *Community Dental Oral Epidemiology*. Vol. 13, pp. 201– 204.

Kunzel, W. 1974, The cost and economic consequences of water fluoridation. *Caries Research*. Vol. 28 Supplement, pp. 28 – 35.

Kunzel, W. 1993, Systemic use of fluoride – other methods: salt, sugar, milk, etc. *Caries Research*. Vol. 27, Supplement. 1, pp. 16 – 22.

Kunzel, W. and Fischer, T. 1997, Rise and fall of caries experience in German towns with different F concentrations in drinking water. *Caries Research*. Vol. 31, No. 3, pp. 166 – 173.

Landis, J. R. and Koch, G. G. 1977, The measurement of observer agreement for categorical data. *Biometrics*, Vol. 33, pp. 159 – 174.

Leeder, S. and Wigglesworth, E. (eds) 1988, *Research on Health in Human Population* (Technical Report No 3). Melbourne, Australia: The Menzies Foundation.

Leverett, D. H. 1982, Fluorides and the changing prevalence of dental caries. *Science*. Vol. 217, pp. 26 – 30.

Levy, P. and Lemeshow, T. 1980, *Sampling for Health Professionals*. Wadsworth Inc. USA.

Levy, S. M., Maurice, T. J. and Jakobsen, J. R. 1992, A pilot study of preschoolers' use of regular-flavored dentifrices and those flavored for children. *Pediatric Dentistry*, Vol. 14, No. 6, pp. 388 – 391.

Levy, S. M. 1994, Review of fluoride exposures and ingestion. *Community Dental Oral Epidemiology*. Vol. 22, pp. 173 – 180.

Lo, G. L. and Bagramian, R. A. 1997, Declining prevalence of dental caries in school children in Singapore. *Oral Diseases*, Vol. 3, pp. 121 – 125.

Loh, T. 1996, Thirty-eight years of water fluoridation-the Singapore scenario. *Community Dental Oral Epidemiology*. Vol. 13, Supplement 2, pp. 47 – 50.

Mann, J., Sgan-Cohen, H. D., Dakuar, A. and Gedalia, I. 1985, Tea drinking, caries prevalence, and fluorosis among Northern Israeli Arab youth. *Clinical Preventive Dentistry*. Vol. 7, No. 6, pp. 23 – 26.

Marthaler, T. M., Toth, M. K and Vines, J. J. 1978, Caries-preventive salt fluoridation. *Caries Research*. Vol. 12, Supplement 1, pp. 15 – 21.

Mascarenhas, A. K. and Burt, B. A. 1998, Fluorosis risk from early exposure to fluoride toothpaste. *Community Dental Oral Epidemiology*. Vol. 26, No. 4, pp. 241 – 248.

Moller, I. J. 1987, Oral health in Europe. In *The Prevention of Non-communicable Diseases: Experiences and Prospects*, ed. E. Leparski, pp. 79 – 102. Copenhagen. WHO Regional Office for Europe.

Morgan, M. V., Wright, F. A., Matram, Z. N., Sundoro, E. and Chesters, R. K. 1992, The oral health status and health behaviour of 12 and 15 years old adolescents in Jakarta, Indonesia. *Community Dental Health*, Vol. 9, No. 2, pp. 171 – 179.

Moser, C. A. and Kalton, K. 1973, *Survey Methods in Social Investigation*. Heinemann Educational Book. London.

Murray, J. J. and Rugg-Gunn, A. J. 1982, *Fluorides in Caries Prevention.* John Wright & Sons Ltd. 823-825 Bath Road, Bristol BS45Nu, England.

Murray, J. J. 1989, *The Prevention of Dental Disease.* Oxford University Press. New York.

Nainar, S. M. H. 1998, Longitudinal analysis of dental services provided to urban low-income (Medicaid) preschool children seeking initial dental care. *AAPD Journal of Dentistry for Children,* Vol. 65, pp. 339 – 343.

Nanda, R. S., Zipkin, I., Doyle, J. and Horowitz, H. S. 1974, Factors affecting the prevalence of dental fluorosis in Lucknow, India. *Archives of Oral Biology.* Vol. 19, pp. 781 – 792.

National Health and Medical Research Council (NHMRC). 1991, *The Effectiveness of Water Fluoridation.* Australian Government Publishing Service. Canberra.

Newbrun, E. 1977, The safety of water fluoridation. *Journal of the American Dental Association.* Vol. 94, pp. 301 – 304.

Newbrun, E. *Fluoride and Dental Caries*, 1986. Springfield, Illinois, USA.

Newbrun, E. 1989a, *Cariology.* Quintessence Publishing Co, Inc. Chicago, Illinois.

Newbrun, E. 1989b, Effectiveness of water fluoridation. *Journal of Public Health Dentistry.* Vol. 49, No. 5, pp. 279 – 289.

Nguyen, V.Q., Doan, V. T., Nguyen, V. H., Vu, V. T. and Ngo, B. B. 1989, Vietnamese Meteorological and Hydrographic Data. Hanoi: Vietnamese Meteorological Bureau Unpublished Report 42A.01.01.

Office of the Actuary. 1987, Division of National Cost Estimates, Health Care Financing Administration. National health expenditures 1986-2000. *Health Care Financing Review.* Vol. 8, pp. 1- 36.

Nikiforuk, G. 1985, *Understanding Dental Caries*, National Library of Medicine, Cataloging in Publication. Karger. New York.

Olsson, B. 1978, Dental caries and fluorosis in Arussi province, Ethiopia. *Community Dental Oral Epidemiology*. Vol. 6, pp. 338– 343.

Pack, A. R. C. 1998, Dental services and needs in developing countries. *International Dental Journal.* Vol. 48, Supplement 1, pp. 239 – 247.

Richards, L. F., Westmoreland, W. W., Tashiro, M., McKay. C. H. and Morrison, J. T. 1967, Determining optimum fluoride levels for community water supplies in relation to temperature. *Journal of American Dental Association*, Vol. 74, pp. 389 – 397.

Riley, J. C., Lennon, M. A. and Ellwood, R. P. 1999, The effect of water fluoridation and social inequalities on dental caries in 5-year-old children. *International Journal of Epidemiology*. Vol. 28. No. 2, pp. 300 – 305.

Ringelberg, M. L., Allen, S. J and Brown, L. J. 1992, Cost of fluoridation: 44 Florida communities. *Journal of Public Health Dentistry*. Vol. 52, No. 2, pp. 75 – 80.

Ripa, L. W. 1993, A half-century of community water fluoridation in the United States: review and commentary. *Journal of Public Health Dentistry*. Vol. 53, No.1, pp. 17 – 44.

Rowe, N. H., Garn, S. M., Clark, D. C. and Kenneth, E. G. 1976. The effect of age, sex, race and economic status on dental caries experience of the permanent dentition. *Pediatrics*. Vol.57, No. 4, pp. 457 – 461.

Rozier, R. G. and Dudney, G. G. 1981, Dental fluorosis in children exposed to multiple sources of fluoride: implications for school fluoridation programs. *Public Health Reports*. Vol. 96, pp. 542 – 546.

Russell, A. L. 1961, The differential diagnosis of fluoride and non-fluoride enamel opacities. *Journal Public Health Dentistry*. Vol. 21, pp. 143-146.

Sathananthan, K., Vos, T. and Bango, G. 1996, Dental caries, fluoride levels and oral hygiene practices of school children in Matebeleland South, Zimbabwe. *Community Dental Oral Epidemiology*. Vol. 24, No. 1, pp. 21 – 24.

Sgan-Cohen, H. D., Rafalovitz, G., Ron, H. and Mann, J. 1997, Changing caries prevalence in primary and permanent teeth of children in a Jerusalem neighbourhood. *International Journal of Paediatric Dentistry*. Vol. 7, pp. 167 – 170.

Sheiham, A. 1987b, The limitations of dentistry (mimeograph). Department of Community Dental Health and Dental Practice. University College, London, UK.

Sheiham, A. and Joffe, M. 1991. Public dental health strategies for identifying and controlling dental caries in high and low risk populations. *In Risk Markers for Oral Diseases. Vol. 1, Dental Caries.* ed. N. W. Johnson, pp. 445 – 481. Cambridge University Press.

Slade, G. D. Davies, M. J. Spencer, A. J. and Stewart, J. F. 1995, Associations between exposure to fluoridated drinking water and dental caries experience among children in two Australian states. *Journal of Public Health Dentistry*. Vol. 55, No. 4, pp. 218 – 228.

Slade, G. D., Davies, M. J., Spencer, A. J. and Stewart, J. F. 1996, Caries experience among children in fluoridated Townsville and unfluoridated Brisbane. *Australian and New Zealand Journal of Public Health*. Vol. 20, No. 6, pp. 623 – 629.

Slade, G. D., Spencer, A. J., Davies, M. J. and Stewart, J. F. 1996, Influence of exposure to fluoridated water on socio-economic inequalities in children's caries experience. *Community Dental Oral Epidemiology*. Vol. 24, No. 2, pp. 89 – 100.

Sonpaisan, Y. and Davies, G. N. 1989, Dental caries experience in the Chiangmai/ Lamphun province of Thailand. *Community Dental Oral Epidemiology*. Vol.17, No. 3, pp. 131 – 135.

Spencer, A. J., Slade, G. D. and Davies, M. 1996, Water fluoridation in Australia. *Community Dental Oral Epidemiology*. Vol. 13, Supplement 2, pp. 27 – 37.

Stotowski, M. C., Hunt, R. J. and Levy, S. M. 1995, Risk factors for dental fluorosis in pediatric dental patients. *Journal of Public Health Dentistry*. Vol. 55, No. 3, pp. 154 – 159.

Sutton, R. and Sheiham, A. 1974, The factual basis of dental health education. A review. *Health Education Journal.* Vol. 33, No. 2, pp. 49 – 55.

Thylstrup, J., Bille, C. and Brunn, C. 1982, Caries prevalence in Danish children living in areas with low and optimal levels of natural water fluoride. *Caries Researches*. Vol. 16, pp. 413 – 420.

Timmis, J. C. 1971, Caries experience of 5 years old children living in fluoride and non-fluoride areas of Essex. *British Dentistry Journal*, Vol. 130, pp. 278-283.

Toth, K. 1972, Caries prevention in deciduous dentition using table salt fluoridation. *Journal of Dental Research.* Vol. 52, No. 3, pp. 533 – 534.

Toth, K. 1976, A study of 8 years' domestic salt fluoridation for prevention of caries. *Community Dental Oral Epidemiology*. Vol. 4, No. 3, pp. 106 – 110.

Townsend, P., Phillimore, P. and Beattie, A. 1988, *Health and Deprivation: Inequality and the North*. Croom Helm, New York.

Tran, V. T. 1991, *The First National Oral Health Survey in Vietnam*. Institute of Odonto-Stomatology of Hanoi.

Tucker, G. J., Andlaw, R. J. and Burchell, C. K. 1976, The relationship between oral hygiene and dental caries incidence in 11-year-old children. *British Dental Journal*. Vol. 141, pp. 75 – 79.

US Public Health Service. Public Health Service drinking standards 1962. PHS Publication No. 956. Washington, DC: Government Printing Office, 1962. Cited by Burt BA, Eklund SA. Dentistry, dental practice, and the community. 5th ed. Philadelphia: WB Saunders, 1999; pp. 298

Vargas, C. M., Crall, J. J. and Schneider, D. A. 1998, Sociodemographic distribution of pediatric dental caries: NHANES III, 1988 – 1994. *Journal of the American Dental Association*. Vol. 129, pp. 1229 – 1238.

Vinogradov, A. P. 1967, *Chemistry of the Earth's Crus,* Israel Program for Scientists Translations, Jerusalem Science.

Wang, N. J. and Riordan, P. J. 1999, Fluoride supplements and caries in a non-fluoridated child population. *Community Dental Oral Epidemiology*, Vol. 27, No. 2, pp. 117– 123.

Wang, Z. J., Shen, Y. and Schwarz, E. 1994, Dental caries prevalence of 6 – 14 years old children in Guangdong, China. *Community Dental Oral Epidemiology*. Vol. 22, pp. 340 – 341.

Warnakulasuriya, K. A., Balasuriya, S., Perera, P. A. and Peiris, L. C. 1992, Determining optimal levels of fluoride in drinking water for hot, dry climates-a case study in Sri Lanka. *Community Dental Oral Epidemiology*. Vol. 20, No. 6, pp. 364 – 367.

Whittle, J. G and Downer, M. C. 1979, Dental Health and Treatment Needs of Birmingham and Salford School Children. *British Dental Journal*. Vol. 147, pp. 67 – 71.

Winter, G. B. 1988, Prediction of high caries risk – diet, hygiene and medication. *International Dental Journal*. Vol. 38, pp. 227 – 230.

Winter, G. B. 1990, Epidemiology of dental caries. *Archives of Oral Biology*. Vol. 35, Supplement, pp. 1S – 7S.

World Health Organisation. 1970, *Fluorides and Human Health*. Geneva.

World Health Organization. 1984a, *Prevention Methods and Programmes for Oral Disease*. Technical Report Series 713. WHO. Geneva.

World Health Organization. 1984b, *Health promotion: A discussion Document on the Concept and Principles*. WHO. Copenhagen.

World Health Organisation. 1997, *Oral Health Surveys (Basic methods) 4 th ed. WHO.* Geneva.

World Health Organisation. 1994, *Fluoride and Oral Health (Report of a WHO Expert Committee on Oral Health Status and Fluoride Use)*. WHO. Geneva.

Wright, G. Z., Banting, D. W. and Feasby, W. H. 1977, Effect of interdental flossing on the incidence of proximal caries in children. *Journal of Dental Research*. Vol. 56, No. 6, pp. 574 – 578.

Yamaguchi, N., Saito, T., Oho, T., Sumi, Y., Yamashita, Y. and Koga, T. 1997, Influence of the discontinuation of a school-based, supervised fluoride mouthrinsing programme on the prevalence of dental caries. *Community Dental Health*. Vol. 14, No. 4, pp. 258 – 261.