FLUORIDE EXPOSURE, DENTAL FLUOROSIS AND CARIES AMONG SOUTH AUSTRALIAN CHILDREN

by

Loc Giang Do

Submitted for the degree of

Doctor of Philosophy

Dental School

Supervised by Professor A John Spencer

The University of Adelaide

2004

Table of Contents

List of Figures

List of Tables

Notes

References
Reference to published work was made in the text by listing the author(s) and date of publication in parentheses. References were listed in the Bibliography in alphabetical order of authors and date order where there were multiple references for an author. To uniquely identify each reference in the text, up to three authors were included. Where there were four or more authors, the first author was named, followed by "et al." in the text. All the authors were listed in the Bibliography.

List of Abbreviations

ARCPOH	Australian Research Centre for Population Oral Health
CDC	The Centre for Disease Control
CFS	The Child Fluoride Study
COHS	The Child Oral Health Study
COHQoL	Child oral health-related quality of life
CPQ	Child Perception questionnaire
DAI	Dental Aesthetic Index
DEJ	Dentino-enamel junction
DMFS	Decayed, missing and filled permanent tooth surface
dmfs	Decayed, missing and filled deciduous tooth surface
F	Fluoride
FRI	The Fluorosis Risk Index
MRC	The Medical Research Council
NHMRC	The National Health and Medical Research Council
OHRQoL	Oral health-related quality of life
PPQ	Parental Perception questionnaire
SA	South Australia
SADS	South Australian Dental Service
SD	Standard deviation
SDS	School Dental Service
TF	The Thylstrup and Fejerskov Index of fluorosis
TSIF	The Tooth Surface Index of Fluorosis

Abstract

The use of fluoride involves a balance between the protective effect against caries and the risk of having fluorosis. Fluorosis in Australian children was highly prevalent in the early 1990s. Policy initiatives were introduced to control fluoride exposure so as to reduce the prevalence of fluorosis.

Objective:

The study aimed of describing the prevalence, severity and risk factors for fluorosis, and to describe the trend of fluorosis among South Australian children. The study also aimed of exploring the effect of the change in fluoride exposure on dental fluorosis and caries.

Methods

This research project was nested in a larger population-based study, the Child Oral Health Study (COHS) in Australia 2002–2005. The parent study's sample was chosen using a multistage, stratified random selection with probability of selection proportional to population size. Fluoride exposure history was retrospectively collected by a parental questionnaire. This nested study sample (n=1401) was selected from the pool of South Australian (SA) COHS participants. Children were selected by year of birth to form three birth cohorts: those born in 1989/90; 1991/92; and 1993/94. Children were approached in two further stages: a dental health perception questionnaire, and a clinical examination for fluorosis. Some 898 children took part in the first stage. Among those, one trained dentist examined 677 children for fluorosis under clinic conditions using two indices (the Fluorosis Risk Index (Pendrys, 1990) and the TF Index (Thylstrup and Fejerskov, 1978)). The Dental Aesthetic Index score (DAI) was also recorded. Caries experience extracted from dental records of all previous visits to school dental clinics was used to enable calculation of dmfs/DMFS scores at different anchor ages.

Data were re-weighted age and sex to represent the South Australian child population. Per cent lifetime exposure to fluoride in water and patterns of discretionary fluoride use were calculated. Fluorosis data were used to calculate the prevalence and severity of fluorosis. Caries dmfs/DMFS scores were calculated at different anchor ages to enable comparison between birth cohorts.

Results

A higher proportion of children in the later birth cohorts used low concentration fluoride toothpaste, and a smaller amount of toothpaste was used when they commenced toothbrushing. There was a significant decline in the prevalence of fluorosis across the three successive birth cohorts. Risk factors for fluorosis, defined by the two indices, were use of standard fluoride toothpaste, an eating and/or licking toothpaste habit, and exposure to fluoridated water. Means (SD) of the deciduous caries dmfs scores at age six and eight were 1.45 (3.11) and 2.46 (3.93) respectively. Evaluation of the “trade-off” between fluorosis and caries with fluoride exposure indicated that the use of low concentration fluoride toothpaste and preventing an eating/licking of toothpaste habit could reduce the prevalence of fluorosis without a significant increase in caries experience.

Conclusion

There was a marked decline in the prevalence of fluorosis across the three successive birth cohorts. The decline was linked with the reduction in exposure to fluoride. Exposure to fluoridated water and several components of toothpaste use were risk factors for fluorosis. Establishing an appropriate use of fluoride toothpaste could be successful in reducing fluorosis without a significant increase in caries experience.

Declaration

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

I give my consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed: ______________________________ ____ / ____ / ____

Loc Giang Do

Acknowledgements

I wish to express my sincere gratitude to Professor A. John Spencer of The University of Adelaide for his thorough supervision of this project and for his endless guidance and encouragement throughout the research process and writing-up the thesis.

I wish to thank the help and guidance from Dr Anna Puzio, Dr Kaye F Roberts-Thomson and Professor Gary D Slade of The University of Adelaide, whose contributions were important to successful completion of my research. The generous help of Professor Steven Levy of the University of Iowa in providing training materials and sharing experience is highly appreciated.

I would like to specially thank Mr Jason M Armfield, Ms Carmen Koster, and many others in the Child Oral Health Study's team, whose work has played major roles in setting up of this project.

I would like to acknowledge The University of Adelaide in providing my scholarship during 2001-2004, and the South Australian Dental Service in organising the fieldwork in 2003/04. Assistance from the staff of the eight SADS clinics that were sites of the study is specially appreciated.

I would like to express gratitude to Ms Dana Teusner for help with database, Ms Anne Ellershaw for weighting the data, Dr Suzanna Mihailidis and Ms Liana Luzzi for their encouragement and their help in editing the thesis, Mrs Judy Stewart for help with the questionnaires, Mrs Silvana Marveggio and Mrs Lorna Lucas for help with administrative matters, and all the friendly staff of Australian Research Centre for Population Oral Health at the University Adelaide for their highly qualified assistance during the study.

I want to express my dearest love to my family, who always support and encourage me in my study and in my life. Their love and help are essential for my life and career.

1. Introduction

1.1 Background

The use of fluorides for oral health has always involved a balance between the protective benefit against dental caries and the risk of developing fluorosis. The association between fluoride and dental health was established as a result of determining the causes of dental fluorosis (enamel mottling). However, it was the benefit of the exposure to fluoride from between 0.7 to 1.2 ppm in public water supplies for the prevention of dental caries that soon became the dominant public health policy. Dean (1935) recognised that there was a level of exposure to fluoride that was associated with near maximal reduction in caries experience with minimal risk of fluorosis. Establishing that level of exposure has always been a primary goal of population oral health research.

In the population, dental fluorosis serves as the "canary in the coal mine", alerting both members of the public and public health authorities to potential over-exposure to sources of fluoride. With the onset of fluoridation in the 1960s and 1970s the improvement in dental health that followed fluoridation blunted attention or interest in the low prevalence of fluorosis. However, as the prevalence of fluorosis increased during the 1980s, research began to focus on fluorosis again.

In Australia, Riordan and Banks (1991) and Riordan (1993a), using the Thylstrup and Fejerskov (TF) Index and case definition of TF score ≥ 1, reported on the prevalence of fluorosis in Western Australian children. The prevalence was 40.2% in fluoridated and 33.0% in non-fluoridated areas among 12-year-olds and 48% among 7-year-olds in a fluoridated area. Puzio, Spencer and Brennan (1993) investigating fluorosis in South Australian children in 1993 reported that the prevalence of fluorosis, using the Dean Index, was 19.0% and 34.3% in non-fluoridated and fluoridated areas respectively. These figures were well above historical standards, i.e. 12.2% in Kewanee, Illinois (0.9 ppm F) as reported by Dean (1942).

Riordan, investigating risk factors for fluorosis among 7-year-olds (Riordan, 1993a) and 12-year-olds (Riordan and Banks, 1991), reported that residence in a fluoridated area (especially for a period of more than 2.5 years), use of fluoride supplements, weaning from breast feeding before the ninth month, and liking and swallowing toothpaste were all risk factors. Puzio, Spencer and Brennan (1993) also reported that exposure to water fluoridation, use of infant formula and fluoride tablets were risk factors for fluorosis among 10–17-year-old South Australians. This research documented an increase in the number and use of a range of discretionary fluoride sources (i.e. infant formula, fluoridated toothpaste and fluoride supplements). The findings suggested that the postulated threshold fluoride intake for the development of fluorosis (0.05 to 0.07mg/kg body weight/day) (Burt, 1992) was being exceeded in a proportion of children, irrespective of the fluoridation status of the water supply.

Some researchers returned to the benefit/risk relationship and argued that the risks were trivial compared to the benefits in reduced caries experience. Phrases like “not discernible except by trained dentists” or “minimal aesthetic impact” were often used to describe fluorosis. However, a small proportion of affected children and their parents both recognised and reacted to the tooth colour changes because of fluorosis. For many children or their parents the risks of fluorosis were identified, but often there was little appreciation of the benefits for the child and the community of decreased caries experience. Also, there is often an assumed capacity to maintain this low caries experience without the use of fluoride and risk of fluorosis. Riordan (1993d) also reported on the perceptions of fluorosis by laypersons and professionals. As the severity of fluorosis increased from TF 0 to 3, there was a general decline in agreement expressed to the statement “The appearance of these two teeth is pleasing and looks nice.” Hoskin and Spencer (1993) in South Australia also reported that fluorosis was a significant factor in the satisfaction with colour and the appearance of teeth for South Australian children aged 10–17 years old. Fluorosis was a significant factor in parents’ dissatisfaction with the colour of their child’s teeth, even in the presence of factors for malocclusion. The findings from these and other studies have initiated a process of review that is reconsidering the topic of risks and benefits from fluoride use.

In Australia a policy response to these issues was developed through the NHMRC Working Group report on the Effectiveness of Water Fluoridation (NHMRC, 1991), an NHMRC Expert Panel on the Use of Discretionary Fluorides (NHMRC, 1993a) and the Consensus Conference on the Appropriate Use of Fluorides sponsored by the Western Australian Department of Health and University of Western Australia (NHMRC, 1993b).

These separate review processes both targeted and suggested reductions in exposure to the known risk factors for dental fluorosis (fluoride in infant formula, the ingestion of fluoridated toothpaste, regimens for fluoride supplementation) in children 0-6 years old. By 1993 fluoride concentration in infant formula powder manufactured in Australia (Nestle, Sydney) or imported from New Zealand was reduced. Colgate Palmolive introduced a brand of low concentration fluoride toothpaste in 1991, following a recommendation from the Dental Statistics and Research Unit at the University of Adelaide (Spencer, 1989). By 1993 all three major toothpaste manufacturers had introduced low fluoride concentration children’s toothpaste and greater attention was provided for consumer advice on its use. The advice was specific at using a pea-sized amount of toothpaste, using low concentration fluoride toothpaste, delaying toothbrushing with toothpaste until after 24 months of age, and encouraging rinsing and expectorating after brushing. The NHMRC Expert Panel guidelines on fluoride supplements were used by school dental services and the Australian Dental Association.

If these measures have been widely implemented and are effective, children born post 1993 should show reduced prevalence and severity of fluorosis. Available evidence suggested a reduction in the prevalence of fluorosis as result of reduction in exposure to fluoride in water (Evans and Stamm, 1991; Burt, Keels and Heller, 2000; 2003). However, the effect of the reduction in exposure to discretionary fluoride has yet to be established. Therefore, it was necessary to document the change in dental fluorosis and caries experience in the study population following the introduction of the measures.

The most recent contribution by Riordan (2002), aiming at evaluating the effect of the policy initiatives, reported a reduction in the prevalence of fluorosis in Western Australian children 10 years of age compared with the findings of their previous studies (Riordan and Banks, 1991). However, comparability of the two unweighted samples in 1990 and 2000 might have been distorted to some extent. Also, the evaluation of caries experience was only a simple comparison of caries scores observed in the years 1990 and 2000. This comparison might have been distorted by factors other than the policy measures alone. However, this study has set a background for a more detailed evaluation of this community trial of the initiatives to control fluoride exposure among children.

1.2 Rationale

The use of fluoride in dental caries prevention has been one of the most remarkable successes in the history of public health programs. Controlling fluoride exposure in childhood has been, is and will continue to be important in preserving the effectiveness and reducing the risk of the measure. The introduction of the policy initiatives in Australia in the early 1990s aimed to decrease the risk of fluorosis associated with the fluoride prevention program by recommending an appropriate fluoride supplements schedule, reduction of the fluoride level in infant formula, introduction of low concentration fluoride toothpaste, and advice for appropriate use of toothpaste. These major population measures were based on sound knowledge of the fluoride action available at that time. It was timely to evaluate the effectiveness of the measures in balancing the caries protective effect and risk of enamel fluorosis. It was also highly appropriate to assess the policy measures in the light of current scientific understanding of the effect of fluoride on oral health.

1.3 Research framework

The study aimed to evaluate outcomes of the policy initiatives introduced in Australia in the early 1990s with the objective of reducing the risk associated with fluoride use while preserving its effectiveness. The policy initiatives would have affected Australian children born at and after its introduction, since fluorosis is a product of fluoride exposure in early childhood. The outcomes would be best assessed by comparing children who were likely to be affected by the policy measures (test group) and children who were not, i.e. having their tooth formation period before the introduction of the policies (control). The target population to pursue the study's objectives was, therefore, Australian children who were born immediately before, during and after the introduction of the measures which occurred in 1993. The findings of the study, however, would be generalised to Australian children who were born after that period.

The main objective of the study was to evaluate two sides of the balance of fluoride action: dental caries and fluorosis. Therefore, the requirement was to gather information on possible fluoride sources that could potentially have been affected by the policies. The data collection process and analysis was conceptually based on available understanding of the fluoride action. Hence, one of the main focuses of the study was the exposure measurement and its analysis so as to understand the effect of fluoride on dental caries and fluorosis.

1.4 Study hypothesis

The primary research hypothesis of this study was that the prevalence and severity of fluorosis reduced among children who were born after the implementation of measures to reduce the fluoride exposure in children 0 to 6 years old. The secondary hypothesis was that the reduction in fluoride exposure has not resulted in a significant increase in the prevalence and severity of caries among children born after the implementation of the policies.

1.5 Specific objectives

The specific objectives of the study were:

Aim 1: to describe the patterns and time trend of fluoride exposure in South Australian children

Aim 2: to describe the prevalence and severity of dental fluorosis among 8–13-year-old South Australian children in 2003/2004

Aim 3: to evaluate the inter-cohort change in the prevalence and severity of fluorosis and to identify factors that were responsible for the change

Aim 4: to identify and quantify risk factors for dental fluorosis among South Australian children

Aim 5: to quantify the perception of oral health and dental appearance among children and their parents in relation to fluorosis and other contributing factors

Aim 6: to evaluate dental caries prevalence and severity among South Australian children

Aim 7: to explore the appropriateness of the measures by evaluating a "trade-off" in associations between changes in fluoride exposures and dental caries and fluorosis.

2. Fluoride and oral health

2.1 Fluoride exposure – overview

One of the most successful programs ever carried out in the epidemiology of chronic diseases of the mankind was the series of studies that led to the discovery of the beneficial effect of fluoride in caries prevention. An extensive dental and medical literature has comprehensively covered every aspect of the action of fluoride in the prevention of dental caries. This thesis attempts only to briefly summarise several aspects of fluoride use that relates to the research framework of this study with a focus on the Australian literature.

2.1.1 Availability, absorption, excretion and metabolism of fluoride

Fluoride is a trace element available in soil and water. As it is one of the most reactive elements it is not found in its elemental form; however, the fluoride ion occurs almost universally in soils and water in differing concentrations. Fluoride availability in soil and water means that all plants and animals contain fluoride to varying extents.

Ingested fluoride is absorbed mainly from the upper gastrointestinal tract. About 80 to 90 per cent of fluoride in food is absorbed, as is 85 to 97 per cent of fluoride in water (Cremer and Buttner, 1970). The amount absorbed can vary, depending on the presence or absence of cations such as calcium, magnesium and aluminium. These cations can bind the fluoride ion and form insoluble substances (Whitford, 1983). The rate of absorption may also positively relate to the acidity of the gastric environment (Whitford and Pashley, 1984). Trace amounts of fluoride in blood leave the blood within minutes, concentrating in the bone and kidneys. Most ingested fluoride is excreted by healthy individuals in the urine, with about half of the absorbed fluoride being excreted within 24 hours (Whitford, 1983).

Fluoride in the human body is deposited mainly in calcified tissues such as bone and teeth. Approximately 99 per cent of fluoride in the body is associated with these calcified tissues, with the concentration in different locations varying (Weatherell et al., 1977). Dentine and bone have a similar fluoride concentration, while the concentration in enamel can be lower (Whitford, 1983). Enamel fluoride level is highest at the surface and reduces progressively toward the dentine-enamel junction (DEJ). This level increases from the DEJ toward the pulpal surface (Weatherell, Hallsworth and Robinson, 1972). Enamel fluoride mainly reflects the level of fluoride exposure during the tooth formation stage, whereas dentine and bone fluoride levels are generally the result of the dynamic metabolism of fluoride (Weatherell, Hallsworth and Robinson, 1972). The level of fluoride measured in tooth enamel may differ between sources of exposures available (Aasenden and Peebles, 1974).

2.1.2 Potential sources of fluoride exposure

Fluoride can be found in various quantities from barely detectable to hundreds of parts per million (ppm). Since the discovery of its anti-caries effect, fluoride has become broadly available for human access in a more controlled concentration. Fluoride sources are drinking water, fluoridated salt, milk, dietary fluoride supplements, and dental care products such as fluoride toothpaste and mouthrinse.

Water fluoridation schemes are currently available to hundreds of millions people worldwide. The effectiveness of this scheme was supported in numerous reviews (Newbrun, 1989b; Ripa, 1993; Rozier, 1995; Spencer, Slade and Davies, 1996; NHMRC, 1999; CDC, 2001; MRC, 2002; Burt, 2002). Canberra was the first Australian city to be fluoridated in 1964. Fluoridation was started in South Australia in Adelaide in 1971. Currently, all major Australian capital cities except Brisbane are fluoridated (Spencer, Slade and Davies, 1996). Also, a large number of regional centres have been fluoridated at varying fluoride concentrations. Other fluoridation schemes through salt or milk are available in many other areas in the world. However, these schemes are not available in Australia since the majority of the Australian population is covered by the water fluoridation scheme.

Fluoride toothpaste has been available for a little over three decades and currently consists of up to 95% of the toothpaste market in western countries (Horowitz, 1999). The standard toothpaste contains fluoride at 1000–1500 ppm in different forms. Low fluoride toothpastes have been introduced recently and contain from 250 to 600 ppm of fluoride. High concentration fluoride toothpastes may be available on prescription to high-risk patients. Individuals may vary significantly in exposure to fluoride from toothpaste depending on their toothbrushing practice. Those variations may be largely dependent on the age when toothbrushing with toothpaste commences, the frequency of toothbrushing, the amount of toothpaste used per brush, the type of toothpaste used, the method of clearing toothpaste from the mouth, and eating and/or licking toothpaste habits.

Fluoride supplementation was introduced with the aim of providing fluoride to high-risk patients or people living in non-fluoridated areas. Fluoride tablets, drops and lozenges are available. Evidence on the effectiveness and risk of fluoride supplements varies greatly. However, there is one common finding that the level of accessible fluoride from these supplements depends substantially on the methods of use and compliance issues (Ismail, 1994; Burt, 1999). Different recommendations for the use of fluoride supplements have been made over time (Newbrun, 1992). In Australia, a new supplementation scheme was proposed and adopted in the early 1990s to further limit the use of these means of fluoride (NHMRC, 1993b).

Several food and nutrient sources have had fluoride present at varying levels. Infant formula may have different levels of fluoride depending on the sources of water used during the manufacturing process. Evidence in the late 1980s and early 1990s reported large variations in fluoride levels measured in infant formula. Infant formula in Australia is available in powder-concentrated form only, unlike the United States where "ready-to-feed" formula and liquid-concentrated formula are also available. A study in Australia reported that several types of infant formula powder had high levels of fluoride (Silva and Reynolds, 1996). Those infant formula powders, when reconstituted with fluoridated water, might exceed the threshold level of fluoride intake.

2.1.3 Fluoride intake

Fluoride exposure during the first years of life is important not only to prevent caries, but also in the development of fluorosis. Some research has shown that exposure during the enamel formation period, especially the maturation of enamel, is critical for the fluorosis aetiology and pathogenesis (Evans and Darvell, 1995; Aoba and Fejerskov, 2002). Other research stated the importance of cumulative exposure rather than a specific period of time (Bardsen and Bjorvatn, 1998). However, there is general agreement that excessive ingestion of fluoride in the first years of life may pose a certain risk for developing fluorosis. Therefore, as far as risk of fluorosis is concerned, the total amount of systemic fluoride intake and the level of fluoride intake, where risks and benefits are balanced, are of interest.

In his pioneer studies, Dean suggested a concentration of 1 ppm fluoride in drinking water as an optimal level where there was minimal risk for fluorosis and a high anti-caries effect (Dean, 1935). Similarly, McClure estimated that children living in fluoridated areas would have a fluoride intake from water and food of around 0.1 mg per kilogram body weight, which was considered an effective and safe level (McClure, 1943). This view was supported by a number of studies several decades ago (Ophaug, Singer and Harland, 1980b; 1980a; 1985). However, as water ceased to be the only source of fluoride, the level of fluoride in water does not provide enough information to estimate actual intake of fluoride. Ingestion of fluoride toothpaste, use of fluoride supplements, and consumption of certain foods and beverages form a significant proportion of systemic fluoride intake. Later, the level of 0.1 mg/kg body weight was considered as the uppermost safe level and some authors suggested an intake of 0.05 to 0.07 mg per kg body weight as another "optimal" level (Ophaug, Singer and Harland, 1985). However, other authors considered these later recognised optimal levels to be the threshold level, an excess of which could cause fluorosis (Fejerskov et al., 1987). Burt (1992) reviewed available evidence and concluded that fluoride intake of 0.05—0.07 mg F/kg body weight from all sources of fluoride was the upper limit of the useful level.

Numerous studies have reported measuring fluoride intake among children, using dietary surveys (Ophaug, Singer and Harland, 1985; Burt, 1992) and duplicate diet techniques (Chowdhury, Brown and Shepherd, 1990; Guha-Chowdhury, Drummond and Smillie, 1996; Zohouri and Rugg-Gunn, 2000; Paiva, Lima and Cury, 2003). An Iowa fluoride study following children from birth has reported detailed fluoride intake among children in regards to different sources of fluoride. Reports of fluoride intake during two periods from birth to 36 months and from 36 to 72 months have been published (Levy et al., 1997; Levy, Warren and Broffitt, 2003).

Levy and Guha-Chowdhury (1999) conducting a literature review on fluoride intake in children indicated the large variation of fluoride sources available to children in the early childhood years. These authors stressed the importance of measuring fluoride from various sources including water and beverages, children's foods, fluoride supplements, and fluoride toothpaste, which were ignored in a number of studies. Their review concluded that individuals might have very variable levels of fluoride intake. Some 10 to 20 per cent of children might receive an excess fluoride intake from a single source. It was speculated that about a third of children would have excessive fluoride intake when all sources of fluoride are combined.

The Iowa Fluoride Study provided the most comprehensive evidence of fluoride intake among children at different ages (Levy et al., 2001; Levy, Warren and Broffitt, 2003). This was a longitudinal investigation of fluoride intake from birth of a reasonably large sample of children. The study collected detailed data on water and beverage use, dietary patterns, and use of fluoride supplements and toothpaste. From that information total fluoride intake was estimated for different age periods. The study identified that there was large variation between children in levels of fluoride intake. The mean fluoride intake per kg body weight was slightly higher in the first year of life. The mean and median fluctuated around 0.05 mg per kg body weight from birth to 72 months of age. However, the 75th percentile was up to 0.10 mg per kg body weight up to the 9th month of age, and the 90th percentile could be over 0.15 mg per kg body weight. Fluoride intake from water increased from a low level in the first 9 months of life to around 20% of total intake. The intake from toothpaste was negligible in the first 9 months, but reached a peak of over 30% of total intake in the third and fourth years.

Guha-Chowdhury and co-workers (1990; 1996) investigated the fluoride intake among 12-month-old and 3–4-year-old children in New Zealand, a close and highly comparable country to Australia. These studies found that fluoride intake among children was fairly low both in fluoridated and non-fluoridated areas. Some children, however, had exceeded the intake level of 0.10 mg per kg body weight. Children from non-fluoridated areas had a lower mean intake of fluoride. The main sources of fluoride intake were once again dietary fluoride, supplements and toothpaste.

A review for the National Health and Medical Research Council (NHMRC) (NHMRC, 1999) used dietary data from the Australian Market Basket Survey 1994 to estimate fluoride intake by Australian children living in fluoridated and non-fluoridated areas. The estimates varied widely depending on residential fluoridation status and diet. There was a marked difference in the estimates between breast-fed infants and infant formula users in both fluoridated and non-fluoridated areas. The difference was larger in the former area when formula was reconstituted with fluoridated water. Fluoride toothpaste contributed a significant proportion of fluoride intake after the age of 9 months. A certain proportion of children under one year old might have ingested the amount of fluoride that was well above the 0.05–0.07 mg/kg body weight/day level. Although these estimates were only very approximate, they supported the view that fluoride intake in Australian children followed the similar trend observed in other countries.

To summarise, the available evidence suggests substantial variation in levels of fluoride intake by children of different ages. There is evidence that a considerable proportion of children may have fluoride intakes exceeding the threshold level and can be at risk for fluorosis. The range of fluoride sources accessible to children has made it difficult to better estimate total fluoride intake. Studies on the measurement of fluoride intake, except for a few recent studies, were limited by their sample size. Those studies are difficult to conduct and hence have found limited use in large-scale population-based research of fluoride.

2.1.4 Fluoride exposure measurement

As discussed above, fluoride intake measurement is a more precise measure of risk for fluorosis, but the difficulty associated with this measurement restricts its use. Therefore, measurement of the fluoride exposure pattern is often used in epidemiological research related to both dental caries and fluorosis. This measurement can be used in large-scale population-based studies. This characteristic of the measurement is important in generalising research findings to the population of interest. In general, fluoride exposure measurements would be best to mimic fluoride intake measurement – a continuous measurement of fluoride quantity. Exposure measurements of fluoride from several main sources of fluoride are discussed below.

Exposure to fluoride in water in studies of dental fluorosis is often measured as a nominal variable. Most studies have used a dichotomised residential characteristic, namely living in a fluoridated or a non-fluoridated area (Adair et al., 1999; Osuji et al., 1988; Bagramian, Narendran and Ward, 1989; Ellwood and O'Mullane, 1994a; Wiktorsson, Martinsson and Zimmerman, 1994; Heller, Eklund and Burt, 1997; Angelillo et al., 1999; Brothwell and Limeback, 1999; Beltran-Aguilar, Griffin and Lockwood, 2002). Recent studies by Pendrys and co-workers (1989; 1994; 1996) separately assessed children living in fluoridated or non-fluoridated areas. These strategies might not allow for evaluation of a dose response effect of exposure to water fluoridation in the risk assessment of fluorosis.

Several studies classified subjects as fluoridated or non-fluoridated area residents according to the proportion of their lifetime children spent in either area (Riordan, 1991; 1993a). These studies divided children into living less than one year, from one to less than two and half years, and two and half years or more in fluoridated area. This classification attempted to order children by level of exposure to water fluoridation. However, it did not take into account the fact that some children might not use public water. Also, residential history in areas with a sub-optimal fluoride level in water, i.e. from 0.3 to less than 0.7 ppm, was not accounted for. A more refined approach that was designed to estimate the per cent of lifetime exposure to fluoride in water is used in study of the relationship between fluoride and caries (Slade et al., 1995a; Singh, Spencer and Armfield, 2003). This approach accounted for residential history, a three-level fluoride concentration in the water supply, and the proportion of public water usage to calculate a continuous measurement of exposure to fluoridated water. This measure has yet to be used in the study of dental fluorosis. A more detailed discussion of this measure is in the section 5.2.2.1.

Measurements of patterns of fluoride toothpaste use were often differentiated as ordinal variables in studies of dental fluorosis. The age when toothbrushing is commenced, the amount of toothpaste used per brushing episode, and the frequency of brushing per day are often collected. These variables can be used to estimate the amount of fluoride from toothpaste that may be ingested by children. Other oral hygiene behaviours such as after-brushing routine and an eating and/or licking toothpaste habit are also often measured in studies of risk for fluorosis.

History of fluoride supplementation and the use of fluoride mouth rinsing were often collected indicating whether a child used or did not use these schemes. The age when children start and stop these fluoride schemes and the dosage of supplementation were also collected. Generally, exposure measurement data related to fluoride supplementation and the use of fluoride mouth rinsing were less well defined.

2.2 Dental fluorosis among children – review of current evidence

2.2.1 Aetiology and clinical appearance of dental fluorosis

Dental fluorosis is a developmental defect in tooth enamel that is caused by excessive exposure to fluoride during the enamel formation period (Fejerskov, Manji and Baelum, 1990). Fluoride is considered a necessary factor in the aetiology of fluorosis. However, the presence of fluoride may have an effect only during the tooth development stage. Several authors considered a specific "window" period during enamel development as critical for fluorosis to occur (Evans and Darvell, 1995; Aoba and Fejerskov, 2002). Other authors suggested that the duration of fluoride exposure during the amelogenesis, rather than specific risk periods, would have more impact on the aetiology of dental fluorosis (Den Besten, 1999; Bardsen, 1999). However, there was general agreement that exposure during the post-secretory or early maturation period of enamel development may pose a higher risk for fluorosis.

Fluorosed enamel is histologically characterised by hypocalcification and subsurface porosity (Fejerskov, Johnson and Silverstone, 1974; Sundstrom, Jongebloed and Arends, 1978; Thylstrup and Fejerskov, 1979). Clinically, fluorosis varies from barely visible white striations on the tooth surface to staining and pitting of enamel (Fejerskov, Manji and Baelum, 1990). In the mild form, the structural arrangement of the crystals in the outer layer of enamel is microscopically normal, but is more porous, i.e. the inter-crystalline space is larger than normal. The degree and extent of porosity characterise the clinical appearance of fluorotic enamel, and it depends on the concentration of fluoride in the tissue fluids during the tooth development (Fejerskov, Manji and Baelum, 1990).

The mild form of fluorosis appears as white lines along the perikymata, which may merge to form irregular areas. With increasing severity the affected area is larger, and can cover the whole surface of the tooth. Severe fluorosis may be characterised with brownish staining, and even minute pitting on the enamel surface. These features are mostly post-eruptive changes (Fejerskov, Manji and Baelum, 1990).

Mild fluorotic lesions often affect the whole tooth surface and may be more visible on or near the tip of cusps/incisal edges. The fluorotic lesion is a diffuse discoloration without clear demarcation with normal enamel. Fluorotic teeth erupt with an opaque white colour, or even chalky appearance. Another typical characteristic is that fluorosis always affects homologous pairs of teeth. These characteristics are used to differentiate mild forms of fluorosis from non-fluorotic lesions.

The mechanism underlying the development of enamel fluorosis has not been fully understood. There is general agreement that fluorotic enamel is formed during the period of enamel development. Fluoride is thought to affect the enamel formation process causing enamel porosity (Fejerskov et al., 1994). There is a clear linear relationship between fluoride exposure and severity of fluorosis. Despite extensive literature concerning the mechanism which leads to dental fluorosis, there are still unanswered questions. The most accepted concept is that the fluoride ion affects the early maturation phase by causing retention of intact and degraded proteins (Robinson et al., 1997; Aoba and Fejerskov, 2002; Robinson et al., 2004). Proteins, mainly amelogenins, are not completely removed from the enamel organ. The retention of proteins may explain the incomplete crystal growth that is observed in fluorotic enamel. Enamel developed under that condition may be characterised by greater inter-crystalline space and hence is more porous.

2.2.2 Historical trend of dental fluorosis

Dean (1942) stated that some 12.2% of children living in areas with the optimal level of fluoride (1 ppm) had mild or very mild fluorosis. This percentage was around 1% in children from areas with negligible levels of fluoride in water. These data were collected when water was the only source of fluoride. They have served as the standard for the balance between the protective effect against caries and the risk of having fluorosis in population water fluoridation.

There have been dramatic changes in the second half of the last century when fluoride was introduced in other forms. Water ceased to be the only source of fluoride. Studies around the world repeatedly reported a significant increase in the prevalence and severity of fluorosis among children.

A series of studies in the late 1980s and early 1990s examining the prevalence of fluorosis reported an increase in the prevalence of fluorosis in both fluoridated and non-fluoridated areas in North America (Driscoll et al., 1983; Segreto et al., 1984; Driscoll et al., 1986; Leverett, 1986; Szpunar and Burt, 1987; 1988; Ismail et al., 1990; Ismail, Messer and Hornett, 1998). Although these studies employed different scoring methods, it was widely accepted that the prevalence and severity of fluorosis was on a sharp increase from the 1970s. The studies also provided evidence of a greater increase in fluorosis in non-fluoridated areas (Leverett, 1986; Pendrys and Stamm, 1990; Bawden et al., 1992). The prevalence of fluorosis ranged from

4.4% to 55.0% in non-fluoridated areas and from 11.4% to 80.9% in fluoridated areas, with the majority of changes observed in the milder forms of the conditions (Clark, 1994).

Rozier (1999) reviewing studies of dental fluorosis in North American children pointed out an increase in the prevalence of fluorosis. The increasing trend was sharper in non-fluoridated areas whereas the trend was less clear in fluoridated areas. The majority of fluorosis cases were mild, with around 1.3% of the US child population with moderate-to-severe fluorosis. The author suggested that individual behaviours were the main contributing factors to the increase in the prevalence of fluorosis.

The prevalence of fluorosis reported in European countries had a similar trend (Wenzel and Thylstrup, 1982; Hellwig and Klimek, 1985; Clarkson and O'Mullane, 1992; Woltgens et al., 1989). More recent studies also reported a high prevalence of fluorosis (Heller, Eklund and Burt, 1997; Carvalho, Declerck and Vinckier, 1998). The York Review (CRD, 2000) reported a prevalence of fluorosis of 48% in fluoridated areas and 15% in non-fluoridated areas after a comprehensive review of 88 studies. The prevalence of the condition that was classified as unaesthetic was 12.5% and 6.3% in fluoridated and non-fluoridated areas respectively.

In general, the prevalence of dental fluorosis was on a sharp increase in the last three decades of the 20th century. The increase was suggested to be a result of an introduction of numerous forms of fluoride available for children's use. This trend drew greater attention from the public and the profession in the late 1980s and early 1990s.

2.2.3 The prevalence and severity of dental fluorosis among Australian children

The study of the prevalence and severity of dental fluorosis in a population is an important step towards identifying its public health importance. These two indicators can be used not only for purely descriptive purposes but can also serve to determine factors that are responsible for the condition. A number of attempts have been made in Australia to assess the prevalence and severity of dental fluorosis.

There were no published studies of dental fluorosis in Australian children prior to 1990. Barnard (1990; unpublished) followed 259 12-year-old children in Tamworth (New South Wale, Australia) in the period between 1967 and 1988, to find no consistent time trend of fluorosis in the 21-year observation period. The author reported a prevalence of fluorosis of 4.1% using Dean's index in those children in 1988.

Riordan and co-workers contributed a series of high-quality studies that provided background information of dental fluorosis in Australia in the early 1990s (Riordan and Banks, 1991; Riordan, 1993a). These studies investigated fluorosis among 659 12-year-old children in fluoridated Perth and non-fluoridated Bunbury, and among 350 7-year-old children in fluoridated Perth, Western Australia using the TF Index. The sample was selected from public schools where dental service centres were available. Fluoride exposure history was collected by a parental questionnaire. The prevalence of fluorosis was 40.2% in fluoridated and 33.0% in non-fluoridated areas among 12-year-olds and 48% among 7-year-olds in fluoridated areas.

Puzio, Spencer and Brennan (1993) reported a study investigating dental fluorosis in South Australian children that was nested in the Child Fluoride Study (CFS) in South Australia conducted in 1991/92 (Slade et al., 1995a; Slade et al., 1996a; Slade et al., 1996b). The sample for the fluorosis study (n=471) was CFS participants predominantly aged 10–15 years old residing in South Australia. They were selected from the larger cohort of 9,690 children in the CFS. Study subjects had already reported their socioeconomic status, fluoride exposure history and use of dental services in the CFS data collection process. The fluorosis study subjects and their parents were asked to complete a questionnaire about the perception of their dental appearance and to attend a clinical examination which recorded occlusal traits and dental fluorosis using the TF Index and Tooth Surface Index of Fluorosis (TSIF) (Horowitz et al., 1984). The prevalence of dental fluorosis in the study sample is presented in Table 2.1.

Table 2.1: Distribution of TF and TSIF scores among a sample of South Australian children, 1992

% of subjects with different scores

	Score 0	Score 1	Score 2+
TF Index	56.2	40.5	3.3
TSIF	49.5	39.0	11.5

* From (Puzio, Spencer and Brennan, 1993)

The above-cited studies reported a high prevalence of fluorosis compared to earlier documented levels of prevalence. The data indicated a trend of increasing prevalence of dental fluorosis in Australian children up to the early 1990s. This trend was similar to that observed in North American and European countries. The prevalence of fluorosis in Australian children was higher than the median of the range of figures reported from other areas.

2.2.4 Risk factors for dental fluorosis

There is well-established agreement that dental fluorosis can occur only during the enamel development period. Therefore, any source of systemic fluoride available during the amelogenesis phase may pose a level of risk for the condition. Up to now, fluoride from water and beverages, fluoride supplements, dietary fluoride, fluoride toothpaste, and the number of topical fluoride applications are known sources of fluoride that can be available systemically during the enamel formation period (Ophaug and Singer, 1988). The evidence of these sources as risk for fluorosis will be considered below.

2.2.4.1 Fluoridated water

Fluoridated water had been the first controlled source of fluoride in the fight against dental caries. While the caries-protective effect of water fluoridation has been well documented (Newbrun, 1989b; Ripa, 1993; Rozier, 1995; Spencer, Slade and Davies, 1996; NHMRC, 1999; CDC, 2001; Burt, 2002; MRC, 2002), fluoride from water has also been a known risk for fluorosis.

When Dean conducted his path-finding studies, there was a difference found in the prevalence of dental fluorosis between areas with varying levels of fluoride. Residence in an area where fluoride in the water supply was around 1 ppm carried significantly higher risk for fluorosis compared with residence in an area with a negligible level of fluoride in water. The prevalence of mild to very mild fluorosis was about 18-fold higher in the former area compared to the latter. However, risk of having fluorosis in an optimally fluoridated area is now only twice as high compared to a non-fluoridated area. This phenomenon can be explained by the universal availability of fluoride from numerous sources such as fluoride supplements, fluoride toothpaste, and dental products. Also, the so-called "diffusion" effect can occur, in that residents in a non-fluoridated area can be exposed to fluoride in foods and beverages that are produced in a fluoridated area and transported for consumption into that non-fluoridated area.

A number of published studies investigated water fluoridation as a risk factor for fluorosis (Szpunar and Burt, 1988; Ismail et al., 1990; Riordan and Banks, 1991; Riordan, 1993a; Skotowski, Hunt and Levy, 1995; Heller, Eklund and Burt, 1997). The odds ratios of having fluorosis by living in an area with a fluoride level in water of 0.8 to 1.2 ppm ranged from 2 to 8.5, after being adjusted for other exposures. Studies in Australia reported that residence in fluoridated area would have four times higher risk of having fluorosis (Riordan and Banks, 1991; Riordan, 1993a). This result was consistent with the finding of Szpunar and Burt in an area with a similar fluoride level in the water supply (Szpunar and Burt, 1988).

Griffin and co-workers (2002) investigated the risk of having aesthetically objectionable fluorosis that could be attributable to water fluoridation using the Dean Index and the anterior index (a modification of the Dean Index applied for use on anterior teeth only). Using the anterior index, fluoridation was a risk factor for very mild (attributable risk = 15%)

and mild fluorosis (attributable risk = 3%). The risk of fluorosis (very mild or greater) attributable to fluoridation using the Dean Index was 24%. The mean values of the risk of perceived aesthetic problems attributable to very mild and mild fluorosis were 9% and 33%, respectively. The authors concluded that approximately 2% of US schoolchildren might experience a perceived aesthetic problem related to dental fluorosis which could be attributed to water fluoridation.

2.2.4.2 Fluoride toothpaste

One of the most popular sources of fluoride is fluoride toothpaste. Introduced in the 1970s, fluoride toothpastes consist of more than 90% of the toothpaste market in western countries (Horowitz, 1992). Available in different forms and concentrations, fluoride toothpaste significantly contributes to the prevention of dental caries (Marinho et al., 2003). However, its use can be a risk factor for fluorosis as well. Children can ingest an amount of fluoride from toothpaste that may well exceed the optimal daily intake (Rock and Sabieha, 1997; Bentley, Ellwood and Davies, 1999; Cochran et al., 2004).

Evidence regarding fluoride toothpaste as a risk factor for fluorosis varies depending on study design and specific aims. A number of studies could not confirm the association between use of fluoride toothpaste and the prevalence of fluorosis (Holm and Andersson, 1982; Driscoll et al., 1983; Butler, Segreto and Collins, 1985; Kumar et al., 1989; Pendrys and Katz, 1989). These studies, however, did not specifically aim to evaluate fluoride exposure from toothpaste. One study (Osuji et al., 1988) using case control methodologies identified toothbrushing with toothpaste before 25 months of age as a risk factor for fluorosis.

More recent studies were specifically designed to address the use of toothpaste as a risk factor for fluorosis. Those studies reported a link between toothpaste and the prevalence and severity of fluorosis (Rock and Sabieha, 1997; Ellwood and O'Mullane, 1994b; Mascarenhas and Burt, 1998; Pendrys, 2000; Pereira et al., 2000). Some studies found that early use of toothpaste was a risk factor for fluorosis (Maupome et al., 2003; Pendrys, Katz and Morse, 1996; Pereira et al., 2000). Another study reported higher frequency of brushing with toothpaste as a risk indicator for fluorosis (Pendrys, Katz and Morse, 1994).

Studies that calculated adjusted attributable risk also found factors linked to toothpaste use as risk factors for fluorosis. A study among Western Australian children living in a fluoridated area reported that 47% of fluorosis cases were attributed to swallowing toothpaste in infancy (Riordan, 1993a). Another study (Pendrys, Katz and Morse, 1994) reported that 72% of fluorosis cases could be explained by commencement of toothbrushing in the first two years of life. Using more than a pea-sized amount of toothpaste more than once per day in a fluoridated population attributed to 46% of fluorosis cases, whereas brushing more than once per day in the first two years of life by children in non-fluoridated areas explained a third of fluorosis cases (Pendrys, 2000).

There are recommendations to reduce fluoride intake from fluoridated toothpaste by using a lower concentration of fluoride toothpaste and implementing stricter guidelines for its use (Horowitz, 1992). Low concentration fluoride toothpaste is available for use in a number of countries including European nations and Australia. Its use was reportedly linked with a lower prevalence of fluorosis among children in a clinical trial (Holt et al., 1994).

2.2.4.3 Fluoride supplements

Fluoride supplements have been used to prevent dental caries in children for more than half a century. They are available in the form of tablets, drops or lozenges. These supplements are recommended for children living in fluoride-deficient places. Dosage schemes are available to guide their use based on the age of the child and on the fluoride level of drinking water (Driscoll and Horowitz, 1979; Dowell and Joyston-Bechal, 1981; Riordan, 1993b; 1997; 2001b). However, evidence is available that fluoride supplements are prescribed to children without taking into account the level of fluoride in drinking water (Pendrys and Morse, 1990; Szpunar and Burt, 1990; Lalumandier and Rozier, 1995). Supplement use has been linked with low compliance with recommended dosage schedules (Riordan, 1996).

Numerous studies identified fluoride supplement use as a risk factor for fluorosis both in fluoridated (Pendrys, Katz and Morse, 1994; Pendrys and Katz, 1998; Kumar and Swango, 1999) and fluoride-deficient areas (Pendrys and Katz, 1989; Lalumandier and Rozier, 1995; Pendrys, Katz and Morse, 1996; Wang, Gropen and Ogaard, 1997; Jackson et al., 1999; Kumar and Swango, 1999; Brothwell and Limeback, 1999). Odds ratios of having fluorosis by use of supplement in fluoridated areas vary from 10.8 (95% CI: 1.9-61.6) to 23.7 (95% CI: 3.4-164.3) (Pendrys, Katz and Morse, 1994; Pendrys and Katz, 1998). The likelihood of having fluorosis linked to fluoride supplement use in a non-fluoridated area was reported at 6.5 (Lalumandier and Rozier, 1995).

Ismail and Bandekar (1999) reviewed ten cross-sectional/case control and four follow-up studies of the relationship between supplement use and fluorosis in non-fluoridated areas. The meta-analysis using the Mantel-Haenszel method reported odds ratios of the association between any use of fluoride supplement and fluorosis of 2.3 (95% CI: 1.5-3.4) and 6.6 (95% CI: 2.9-15.2) observed in the cross-sectional/case control and follow-up studies, respectively. Therefore, the risk of fluoride supplement use for having fluorosis is well confirmed. Recommendations were made to reduce the available dosage schedule (Newbrun, 1999) as well as eliminate fluoride supplement use in children (Burt, 1999). These recommendations were incorporated into guidelines published by major dental research bodies (NHMRC, 1993a; CDC, 2001; AAPCN, 1995).

2.2.4.4 Fluoride from foods

Children can be exposed to differing levels of fluoride available from their diet during the tooth formation period. Various foods have been found to contain varying amounts of fluoride (Levy, Kiritsy and Warren, 1995; Heilman et al., 1997; Fomon and Ekstrand, 1999; Levy, Warren and Broffitt, 2003). Several infant foods were also found to have high levels of fluoride, such as mechanically processed chicken (Fein and Cerklewski, 2001). Food sources have been found to be risk factors for fluorosis in a number of African populations (Yoder et al., 1998; Awadia et al., 2000). However, those sources of fluoride are not available in western countries like Australia.

In the last decade, infant formula was often found to have high levels of fluoride and could potentially be responsible for a certain proportion of fluorosis in children (Mascarenhas, 2000; Pendrys, 2000). In Australia before the 1990s, the fluoride content of milk-based formula ranged from 0.23 to 3.71 and for soy-based formula from 1.08 to 2.86 micrograms of fluoride in a gram of powder (Silva and Reynolds, 1996). Infant formula was considered a risk factor for fluorosis in a number of studies (Pendrys and Katz, 1989; Clark et al., 1994; Pendrys, Katz and Morse, 1994; Pendrys and Katz, 1998). Mild-to-moderate enamel fluorosis on early forming (Fluorosis Risk Index (FRI) classification I) enamel surfaces was strongly associated with both milk-based (odds ratio (OR) = 3.34, 95% confidence interval (CI) 1.38–8.07) and soy-based (OR = 7.16, 95% CI 1.35–37.89) infant formula use (Pendrys, Katz and Morse, 1994). It has been recommended that powder concentrate infant formula be reconstituted with water low in fluoride (Fomon, Ekstrand and Ziegler, 2000).

2.3 Dental caries among Australian children

2.3.1 Prevalence and severity of dental caries among Australian children

There has been a continuous program in Australia, the Australian School Dental Scheme Evaluation Program and the Child Dental Health Survey, designed to monitor dental caries in children throughout the country since 1977 (Carr, 1982; 1983; 1988; Armfield et al., 2003; 2004). Comprehensive data on dental caries among Australian children have been collected annually and evaluated.

In general, the trend of dental caries in Australian children was similar to that of other western countries (Marthaler, 2004). The prevalence and severity of dental caries in Australian children decreased dramatically in the second half of the 20th century (Spencer et al., 1994). The DMFT score of 12-year-old Australians was as high as 12 teeth in the 1950s, with a very high proportion of untreated decay. Almost all children of this age were affected by caries (Barnard, 1956). The prevalence and severity of caries in children have decreased since the introduction of water fluoridation and the use of fluoride toothpaste in Australia. This trend continued through to the early 1990s, when the mean permanent DMFT score of 12-year-old children was 1.2 teeth. There were very few permanent teeth missing due to caries in this age group. The trend of deciduous caries in 6-year-old children followed a similar trend. The mean deciduous dmft of 6-year-old children was around 2.0 in the early 1990s (Davies, Spencer and Slade, 1997).

The caries experience in Australian children continued to decline in the first half of the 1990s (Armfield, Roberts-Thomson and Spencer, 2003). However, the decreasing trend was significantly slower, and reached a plateau in 1996 with a dmft score of 1.45 among 6-year-old children and 1.69 among 8-year-old children. Some slight increases in mean deciduous dmft scores were observed in the second half of the last decade in children aged from 5 to 9 years. In the year 2000, the mean dmft of Australian children aged six and eight years was 1.65 (SD 2.73) and 1.82 (SD 2.61), respectively (Armfield et al., 2004). The per cent of caries-free children of those two ages were 56.6% and 51.1%, respectively. Around 65% of 12-year-old children did not have caries on their permanent teeth and the mean permanent DMFT score was 0.84 (SD 1.60).

2.3.2 Caries and fluoride exposure

Fluoride use is one of the most frequently cited reasons for the decline in dental caries among children (NHMRC, 1991; 1999; CDC, 2001; MRC, 2002). Fluoride has been the cornerstone of modern dental caries management. The child populations in many countries have exposure to numerous sources of fluoride, which continue to control dental caries.

Numerous studies have been published stating the effectiveness of fluoride use in the population worldwide. Water fluoridation has been, is and continues to be one of the main measures to control dental caries in children (Ripa, 1993; Spencer, Slade and Davies, 1996). Hundreds of millions people worldwide have access to a constant low dose of fluoride every day. There is little doubt about the effectiveness of water fluoridation in preventing caries in children. Evidence from the 1950s onward suggested a 40% to 60% decrease in caries experience between children living in fluoridated and non-fluoridated areas before 1979, and around 20% to 40% in the following decade (Newbrun, 1989a). This difference is now much narrower owing to the universal availability of fluoride from numerous sources. However, the effectiveness of water fluoridation in the prevention of dental caries continues to be supported (NHMRC, 1999; CRD, 2000). The York Review (CRD, 2000) confirmed the effectiveness of water fluoridation in reducing caries. The reduction in caries experience attributed to water fluoridation was greater in areas with higher baseline levels of caries experience. The meta-analysis estimated a 15% increase in the proportion of caries-free children and a decrease of 2.2 in the mean number of decayed, missing or filled teeth (dmft/DMFT) that were related to water fluoridation.

The benefit of water fluoridation in prevention of caries of Australian children was evidenced in the Child Fluoride Study 1991/92 (Slade et al., 1995a; 1996b). A difference of 2.0 surfaces with deciduous caries experience between fluoridated Townsville and non-fluoridated Brisbane had both statistical and practical significance. The effects of water fluoridation were weaker for caries experience in permanent dentition. However, the association still existed after controlling for socioeconomic factors.

Fluoride toothpaste has also had a significant impact on dental caries experience in children since its introduction three decades ago. A systematic review of randomised clinical trials on fluoride toothpaste confirmed its effectiveness (Marinho et al., 2003). The prevented fraction of permanent decayed, missing, and filled surfaces attributed to fluoride toothpaste was 24% (95% CI: 21%–28%). The effectiveness of toothpaste was significantly related with frequency of brushing, concentration of fluoride in toothpaste, and baseline caries experience. Studies of the effectiveness of low concentration fluoride toothpaste were scarce and reported conflicting results (Winter, Holt and Williams, 1989; Stephen, 1993; Bloch-Zupan, 2001).

Fluoride supplements have been used in caries prevention for several decades. Evidence of their efficacy in preventing caries, however, is conflicting, leading to several authors suggesting a re-evaluation of fluoride supplements use in children (Szpunar and Burt, 1992) (Ismail, 1994; Riordan, 1996; Burt, 1999; Riordan, 1999). Others have supported the retention of a controlled use of fluoride supplements (Moss, 1999). In general, fluoride supplement use is limited owing to its poor compliance with dosage regimens by both users and dental professionals. A number of public health bodies have made recommendations for a more limited use of fluoride supplement in children (NHMRC, 1993b; NHMRC, 1999; CDC, 2001).

2.4 Effect of a change in fluoride exposure on the pattern of dental fluorosis and caries

A number of studies have investigated the change in prevalence and severity of dental fluorosis as result of a change in fluoride exposure. The change in fluoride exposure in water might be intentional, such as when the fluoride level in water was lowered in Hong Kong (Evans, 1989), or owing to a technical breakdown (Burt, Keels and Heller, 2000; 2003). Differences between fluoridated and non-fluoridated areas can be considered to be variations in exposure. Variation in fluoride exposure related to toothpaste has been evaluated in a clinical trial of fluoride toothpaste (Holt et al., 1994).

Evans and Stamm (1989) evaluated the effect of a downward adjustment of fluoride level in drinking water from 1 ppm to 0.7 ppm on fluorosis experience of children. This study used Dean's Index to record the fluorosis status of children born in six birth cohorts. Very mild fluorosis on one maxillary incisor was used as a threshold for the case definition for fluorosis to enable comparison between different birth cohorts. Some 1062 children aged from 7 to 12 were included in the study. The prevalence of fluorosis (very mild or greater) decreased from 64% to 47%. The Community Fluorosis Index score also decreased from 1.01 to 0.75 across birth cohorts. The authors concluded that fluorosis experience among Hong Kong children was reduced following the adjustment of fluoride in the water supply. However, any effect of the downward adjustment of the fluoride level in water on caries experience has not been evaluated in this study.

Burt, Keels and Heller (2000; 2003) reported a series of comprehensive studies which aimed to investigate the effect of an 11-month break in water fluoridation on caries and fluorosis. Data on five (Burt, Keels and Heller, 2000) and seven (Burt, Keels and Heller, 2003) successive birth cohorts were collected and analysed. Children who were born before, at, and after the break in water fluoridation were selected and examined for fluorosis and caries using the TF Index. The successive birth cohorts were compared to evaluate the trend of fluorosis and caries that might be related to the break in fluoride exposure.

The authors reported no significant effect of the break in fluoride exposure on caries experience of the first and second premolars in children born before, at or after the break in water fluoridation. There was a cohort effect in the prevalence of dental fluorosis reported in the first publication of the series (Burt, Keels and Heller, 2000). Children who were four or five years old at the time of the break had a significantly higher prevalence of fluorosis, defined as having a TF score of 1, compared to children who turned two or three at that time. Children who were three years old at the break had the lowest prevalence of fluorosis, which was defined as having a TF score of 2 on the upper incisors. Based on results of the first phase of the series, the authors suggested that dental fluorosis was highly sensitive to even minor changes in fluoride exposure from water, whereas caries was less affected. However, results of the second phase did not confirm the fluorosis reduction effect of the break in water fluoridation when two younger cohorts were included in the study (Burt, Keels and Heller, 2003). The later cohorts had a prevalence of fluorosis similar to those who had their fluoride exposure interrupted in the early development stage. This rather unexpected result indicated possible wider changes in fluoride exposure among children during recent times. Overall, the studies succeeded in pursuing their aims. The methodology used in the studies set a benchmark for evaluating the effect of a change in fluoride exposure on fluorosis and caries.

A comprehensive study was carried out to compare fluorosis and caries between children from a fluoridated and a non-fluoridated area (Stephen et al., 2002). Children were examined for dental fluorosis and caries. Fluoride exposure history was also collected. The examination was conducted in a neutral site. Therefore, examiners conducting the clinical examinations were not aware of the child's residential status or fluoride exposure history. Children who lived in the fluoridated area had superior dental health in terms of dental caries status compared with their counterparts in the non-fluoridated area. The prevalence of fluorosis was significantly higher among children living in the fluoridated area. However, the aesthetically discernable level of fluorosis was low and similar among children with exposure to different levels of fluoride in water.

A clinical trial of the effect of different concentration fluoride toothpastes on enamel opacities and dental caries was carried out among 1523 5-year-old children (Holt et al., 1994). The 3-year study tested the effect of 550-ppm fluoride toothpaste versus 1100-ppm fluoride toothpaste as control. Children had photographs of their teeth scored for fluorosis using the TF Index (Fejerskov, Manji and Baelum, 1988). Children who used 550-ppm fluoride toothpaste had a significantly lower prevalence of fluorosis, defined as having a TF score of 2 or more on the maxillary incisors. When all examined teeth were considered, the test group had a significantly lower prevalence of fluorosis, defined as having a TF score of 1 or higher and as having a TF score of 2 or more. Those same children had a slightly higher prevalence of dental caries. This trend was not statistically significant, however. The study indicated that using lower concentration fluoride toothpaste could reduce the prevalence of fluorosis without a significant increase of caries.

2.5 Dental appearance – perception and psychological impact

Numerous studies have demonstrated that poor dental appearance could negatively affect psychological wellbeing (Shaw, 1981; Shaw and Humphreys, 1982; Shaw et al., 1985). Children with a normal dental appearance could be judged by laypersons to be better looking, more desirable as friends, more intelligent, and less likely to behave aggressively (Feng, Newton and Robinson, 2001; Newton, Prabhu and Robinson, 2003). The psychological impact of the colour of anterior teeth was reported to be as important as other occlusal traits such as crowding and overbite (Spencer, Slade and Davies, 1996). A number of cross-sectional studies reported that people with stained teeth were often considered as having poor general and oral health, lower intelligence, poorer personal hygiene and a lack of social skills (Hawley, Ellwood and Davies, 1996; Astrom, Awadia and Bjorvatn, 1999; Astrom and Mashoto, 2002).

There has been some controversial evidence suggesting that children with poorer dental appearance in general may develop psycho-behavioural problems. Children with poor dental appearance may be disruptive at school or academically underachieve (Richman and Eliason, 1982). There is some evidence suggesting a link between severe forms of fluorosis and behavioural problems (Rodd and Davidson, 1997). Another study did not find a significant association between fluorosis and children's behaviour using the Child Behaviour Checklist (Morgan et al., 1998).

There has long been an assertion that mild dental fluorosis was not discernible to the affected persons and their surroundings. However, recent evidence has suggested otherwise. Children who had more severe fluorosis expressed increasing concerns about their tooth colour (Clark et al., 1993). Riordan reported that laypersons could distinguish between different fluorosis levels (Riordan, 1993c). The same study reported that in response to a statement "teeth look pleasing", there was an increasing level of disagreement with increasing fluorosis severity. Parents were at least as sensitive as clinicians about dental appearance (Riordan, 1993d). A study in the UK reported that higher fluorosis severity was increasingly noticeable to parents of affected children (Sigurjons et al., 2004), but also found that the presence of fluorosis was not always linked with dissatisfaction with the appearance of teeth.

A South Australian study of fluorosis among children reported on the perception of dental appearance by children and their parents (Hoskin and Spencer, 1993). The study design has been described elsewhere in this chapter (Section 2.2.3). Children and their parents who had fluorosis often noticed tooth discoloration. Fluorosis, defined by TSIF score, was the contributing factor in the perception of tooth colour by both children and their parents (Table 2.2). Parents and children reported a significant impact of fluorosis on colour of teeth. The psychological impact of fluorosis was also significant, especially among children, even in the presence of malocclusion.

Table 2.2: Oral health predictors of four aspects of appearance and psychosocial impact among South Australian children, 1993

Predictor variables	Colour of teeth	Teeth appearance	Face appearance	Psychological scale

Parent's scores				
TSIF	0.33	-	-	0.1
Overjet	-	0.22	-	0.12
Crowding	-	0.41	-	0.24
Child's scores				
TSIF	0.29	0.11	-	0.17
Overjet	-	0.22	-	0.10
Crowding	-	0.35	-	0.18

* Numbers in the table are significant ($p < 0.05$) standardised regression coefficients from least squares regression models in which dependent variables were subscale scores for appearance (three subscales) and psychosocial impact (one subscale). From (Hoskin and Spencer, 1993)

While there is ample literature investigating the impact of fluorosis on an individual's perception of their dental appearance, there has been a lack of attention in exploring the potential impact of dental fluorosis on one's perception of oral health and the impact on quality of life. Elsewhere, more severe fluorosis (TF score of 4 or higher) was found to have a psychological impact on affected children (van Palenstein Helderman and Mkasabuni, 1993). Other studies reported no impact of mild fluorosis on psychological dimensions (Peres et al., 2003; Robinson et al., 2003). Tooth discoloration caused by fluorotic lesions with an effect on dental appearance may have an impact on the quality of life of affected individuals and their surroundings. On the other hand, as far as a balance between the risks and benefits of fluoride use is concerned, having some fluorosis may be tantamount to having lower caries experience. Dental caries per se has an impact on the perception of oral health and its related quality of life (Reisine, 1988). The question arising is, therefore, to what extent may there be a trade-off between dental fluorosis and caries in terms of the perception of oral health and oral health-related quality of life.

2.6 Initiatives to control fluoride exposure in Australia

In Australia a policy response to these issues was developed through the NHMRC Working Group report on the Effectiveness of Water Fluoridation (NHMRC, 1991), an NHMRC Expert Panel on the Use of Discretionary Fluorides (NHMRC, 1993b) and the Consensus Conference on the Appropriate Use of Fluorides sponsored by the Western Australian Department of Health and University of Western Australia (NHMRC, 1993a).

These separate processes targeted reductions in exposure to known risk factors for dental fluorosis (fluoride in infant formula, the ingestion of fluoridated toothpaste, regimens for fluoride supplementation) in children aged 0–6 years old. By 1993 fluoride concentration in infant formula powder manufactured in Australia (Nestle, Sydney) or imported from New Zealand was reduced. Colgate Australia introduced a brand of low concentration fluoride toothpaste (My First Colgate toothpaste (400 ppm of fluoride)) specifically for children's use in 1991 (Robinson, 2004). By 1993 all three major toothpaste manufacturers had introduced low fluoride concentration children's toothpaste with a greater emphasis placed on consumer advice regarding its use. Other toothpastes introduced for children's use included Macleans Milk Teeth (530 ppm of fluoride) and Oral B children's toothpaste (500 ppm of fluoride). The NHMRC Expert Panel guidelines on fluoride supplements were used by school dental services and the Australian Dental Association (NHMRC, 1993b).

2.7 Early evaluation of the policy initiatives

Riordan (2002) conducted a study of dental fluorosis in 10-year-old children in Western Australia in 2000, aiming at evaluating the effectiveness of the policy initiatives introduced some seven years earlier. Children from Perth and Bunbury, the two sites of the previous fluorosis studies (Riordan and Banks, 1991; Riordan, 1993a), were examined for fluorosis using the TF Index. Caries experience was also recorded at the examination. A questionnaire collected information on fluoride exposure history.

The study found that about a quarter of the children reported using low fluoride toothpaste, with some 40 (7.0%) children reporting to use fluoride supplements. The use of fluoride supplements was almost exclusively in the non-fluoridated town of Bunbury.

The author defined fluorosis as having a TF score of 1 or higher on the upper right central incisor. The overall percentage of the children with fluorosis based on this case definition was 18.0%, with 22.2% and 10.8% in fluoridated Perth and non-fluoridated Bunbury, respectively. Over 80% of cases had a TF score of 1 and 18% had a TF score of 2. Residence in a fluoridated area was the only significant risk factor for fluorosis in this study sample.

The author claimed a reduction in the prevalence of fluorosis in Western Australian children compared to the finding of the 1990 study of 12-year-old children by the same author, with a reported percentage of children with fluorosis of 40.3% and 33.0% in fluoridated Perth and non-fluoridated Bunbury, respectively (Riordan and Banks, 1991). Also, the author compared caries experience of the study sample in 2000 (reported mean DMFT: 0.3) with that of the 10-year-old Western Australian children in 1990 (mean DMFT: 0.84). Hence, two main conclusions were drawn: the policy initiatives were effective in reducing the prevalence of dental fluorosis, and these changes did not cause an increase in dental caries experience.

While findings of that study were promising, there were still limitations associated with the study. First, the study sample was born in 1990, and hence was less likely to be affected by changes in fluoride exposure initiated in 1993 if the development period of upper central incisors was of interest in terms of fluorosis status. Outcome of the measures might be attenuated if evaluated using this age group. Second, the two study samples (1990 and 2000) were unweighted and therefore might not be representative of the population. The percentage of children with fluorosis in those samples might not be directly comparable. Lastly, a direct comparison of caries experience between 10-year-old children in 1990 and 10-year-old children in 2000 might be unsuitable. There were possibilities that the trend in caries between the two time points was affected by a number of factors other than the policy initiatives alone. That decade was characterised by a period of decrease followed by several years of increase in the prevalence and severity of caries experience of Australian children (Armfield, Roberts-Thomson and Spencer, 2003). Data of caries experience of 10-year-old Western Australian children (DMFT: 0.8) (Armfield, Roberts-Thomson and Spencer, 2003) was markedly higher than that reported by Riordan in that study (DMFT: 0.3). Combining all of the above, findings of that study served as early information of a change in the prevalence of fluorosis in Australian children. Further investigation was required to evaluate the effectiveness of the policy initiatives aimed at controlling fluoride exposure in Australian children. A methodology used to evaluate the time trend of fluorosis by Burt and co-workers (2000; 2003) was deemed more appropriate to evaluate the effectiveness of the policy initiatives.

3. Research Methodology

This chapter outlines the method of sampling, the mode of data collection employed, the data collection instruments and data items, aspects of sample size and power, and the analytical approach.

3.1 Study design

The study was nested within the Child Oral Health Study (COHS) which was conducted in South Australia in 2002–03. This nested study was designed with both cross-sectional and retrospective components. Four types of data were collected: a retrospective fluoride history and current dietary and socioeconomic status drawn from the COHS questionnaire; retrospective caries experience data collected from School Dental Service clinical records; data on child and parent perception of current dental appearance and oral health; and clinical data on fluorosis. The data collection process for each of the four types of data is described in detail in this chapter.

3.1.1 The Child Oral Health Study

The Child Oral Health Study is a large-scale population-based study in Australia designed to investigate children's oral health and related factors. The objectives of the study were to document the prevalence and severity of dental caries among 5–17-year-old children and analyse their association with different exposures to fluoride. The study was designed as a multisite epidemiologic study involving South Australia, Victoria, Tasmania, and Queensland. The population consisted of children enrolled in the South Australia School Dental Service (SA SDS). Children were sampled in a multistage stratified random sampling process. Four strata in South Australia were defined: metropolitan fluoridated, metropolitan non-fluoridated, non-metropolitan non-fluoridated, and non-metropolitan fluoridated. The sampling frame in South Australia were children aged 5 to 17 years. Sampling ratios were calculated based on the number of children enrolled in SA SDS clinics in the previous twelve months in each stratum.

Equal numbers of children were targeted for each stratum, independent of their population size. Children enrolled at SA SDS clinics were selected based on their date of birth. The clinic staff were instructed to describe the study to the children and their parents and invite them to participate. Upon agreeing to participate in the study, parents of eligible children were given a package containing an information sheet, a consent form, a reply-paid self-addressed envelope and a questionnaire. Completed questionnaires and consent forms were returned directly to the Australian Research Centre for Population Oral Health (ARCPOH). Non-respondents were followed up three times to achieve the desired response rate. The response rate achieved during the course of the study in South Australia was over 67%.

The clinic staff were given detailed instructions on how to examine children for cavitated and non-cavitated lesions and how to record the examination results into the electronic data management information system EXACT. The data were managed centrally by the South Australian Dental Service's Information Technology department and transferred to ARCPOH on a regular basis for analysis.

Full procedures of the selection of subjects, the enrolment package delivery, and the clinical examination and recording manuals were detailed in a COHS Manual for Staff of School Dental Service, which can be viewed in Appendix 2.

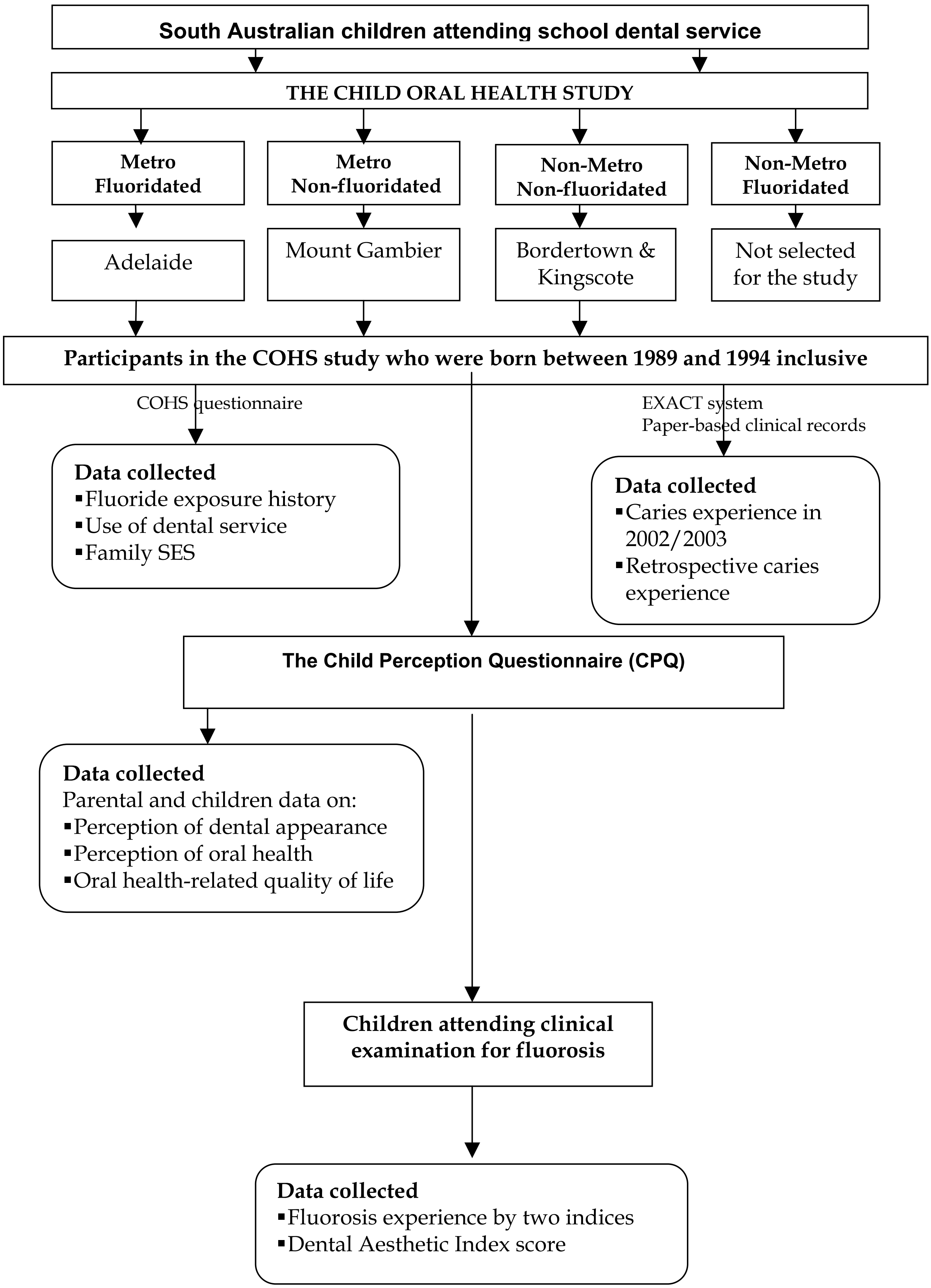
3.1.2 Sampling strategy for this nested study

3.1.2.1 Study design

The COHS participants in South Australia served as the sampling frame for this nested study. The aim was to select children born before, at, and after the introduction of the new policy initiatives that aimed at controlling fluoride exposure in 1993. Therefore, the decision was made to target children born between 01 January 1989 and 31 December 1994 inclusive. The assumption for this selection was that the 89/90 birth cohorts were less likely to be affected by the policy initiatives. Children who were in the following 91/92 birth cohort were born before the initiatives but they might be affected by the measures to some extent. Therefore, these children could serve as a transitional group. Children of the latest 93/94 birth cohort were born and grew up during and after the introduction of those initiatives. It was assumed that this birth cohort would be affected by the changes in fluoride exposure as a result of the policy initiatives. Children who were born after 31 December 1994 were not included because they might have only a few or no permanent teeth erupted.

In the sampling scheme for the COHS, Adelaide and Mount Gambier entirely represented two sampling strata: metropolitan fluoridated (Adelaide) and metropolitan non-fluoridated (Mt Gambier). These two areas were therefore automatically selected for this nested study. The third stratum, non-metropolitan non-fluoridated, consisted of several small towns. Bordertown and Kingscote were subsequently selected from this stratum. A decision was made not to include the non-metropolitan fluoridated stratum in this nested study because those areas had been fluoridated only recently. Consequently, water fluoridation might have varying effects on fluorosis experience of the three birth cohorts born in those particular areas depending on when fluoridation was introduced. Inclusion of those areas was out of the scope of this study. A schematic presentation of the study design, sample selection, and data collection is shown in Figure 3.1.

Figure 3.1: Study sample selection and data collection scheme



3.1.2.2 Sample size

The sample size was calculated to achieve several study objectives. It addressed the two study hypotheses, namely to test for a significant difference in the prevalence of fluorosis between age cohorts and whether caries experience was not significantly different between birth cohorts. The first hypothesis was tested with clinical examinations for fluorosis. The second hypothesis was tested with retrospective caries experience at an anchor age, which was collected from clinical records of the COHS participants. Children were divided by date of birth into three age groups: born 1989/1990; born 1991/1992; and born 1993/1994. A program PS Power and Sample Size Calculations, Version 2.1.30, 2003 by Dupont and Plummer was used to calculate required sample size. This program was available online at http://www.mc.vanderbilt.edu/prevmed/ps/index.htm.

Sample size requirements for each of the hypotheses were as follows.

Hypothesis 1: The required sample sizes were calculated based on the expected rate ratio. The sample size that was required to detect a difference in the prevalence of fluorosis among children of each age group with 80% power and a significance level of 0.05 (two-side) was calculated on an expected population prevalence of 40%. A difference of 30% in the prevalence of fluorosis was deemed as clinically meaningful to test the difference between exposure groups (Burt, Keels and Heller, 2000). The estimated total required sample size was 630 children.

The estimated response to the dental perception questionnaire was 65%, while the estimated response of questionnaire respondents to clinical examination was 75% (based on averaged response rates reported from other similar studies conducted by ARCPOH (Puzio, 2000)). Therefore, the initial sample of COHS participants required to achieve the above number of clinical examinations was 1294 children.

Hypothesis 2: The sample size required to detect a 25% difference in population mean decayed, missing and filled deciduous surfaces (dmfs) with 80% power and significance level of 0.05 (population mean dmfs at 8 years of age in South Australia was 2.50, SD: 4.02 (Armfield, Roberts-Thomson and Spencer, 2003)) was calculated. The sample size required for one group was 448 subjects. The total calculated required sample for three groups was 1344 children.

Overall, the total sample size required was at least 1344 children. Incomplete caries data and questionnaire data was expected in 5% of children. Therefore, the final total sample size required was 1400 children. In order to achieve this sample size, a decision was made to approach all eligible children who participated in the COHS in the selected areas. Based on the turnout rate of children attending school dental clinics in those areas, an estimated time frame for the recruitment period was approximately nine months.

3.1.3 Ethical clearance

Ethical approvals were given from the University of Adelaide Human Research Ethics Committee. The ethical clearance for the collection and use of dental caries and fluoride exposure data was given for the Child Oral Health Study. A separate ethical clearance was given for conducting the dental perception questionnaire survey and the clinical examination for fluorosis. A formal approval from the Executive Board of the South Australian Dental Service was received before the commencement of the study.

3.2 Data collection instruments and methods of execution

The data collection process of this project employed a number of data types and different data collection instruments. It consisted of retrospective data collection and collection of concurrent data. Each data collection instrument and the executing methods will be discussed in detail in Section 3.2.1 through to Section 3.2.6.

3.2.1 Child Oral Health Study questionnaire

In 2002, the staff from ARCPOH designed a questionnaire to be used in the COHS. Specific questions were included to address a number of research objectives.

Fluoride exposure in childhood was the main objective of the questionnaire. The questionnaire contained a series of questions relating to children's toothbrushing habits, use of toothpaste, fluoride supplements and use of products that might contain fluoride. Residential history was specifically collected to enable calculation of lifetime exposure to fluoride. Parents were asked to list all locations where their child resided for more than six months. Details of types of water used at each location were also sought. Other questions sought information about infant formula use and other dietary factors.

Information was also collected on the use of the dental service, general health and family socioeconomic status. The self-rated oral health of parents and parental attitude towards their children's oral health were also collected.

A draft of the questionnaire was pilot-tested among groups of parents of children attending School Dental Service clinics. A number of changes were subsequently made based on results of the pilot test and group discussions. This draft of the questionnaire was reviewed and commented on by a number of oral epidemiological experts. The questionnaire was then finalised. The whole questionnaire can be viewed in Appendix 1.

3.2.2 Dental caries measurement

Data describing dental caries experience were collected by the dental therapists or dentists who examined children at SA SDS clinics at the time of the periodic examination. These procedures had been in use for many years during the Child Dental Health Survey of Australia and the Child Fluoride Study 1991/92 (Carr, 1988; Slade et al., 1995a; 1996a; 1996b; Armfield et al., 2003; 2004). Written instructions were provided to clinical staff concerning the assessment of caries experience. The instructions were based on the World Health Organisation's criteria (WHO, 1987; 1998) and the National Institute of Dental Research (NIDR, 1987). Individual tooth surfaces were classified as decayed, filled because of caries or missing because of caries. An additional code designated surfaces that contained fissure sealants and that were otherwise sound and not restored. Five surfaces were coded for each molar and premolar tooth and four surfaces were coded for each incisor and canine tooth. For the deciduous dentition, additional guidelines were used to distinguish between teeth missing due to caries and teeth that might have been exfoliated (Palmer, Anderson and Downer, 1984). The clinical staff were trained in assessment and recording of dental caries following the instructions. However, there were no additional procedures for calibrating examiners.

3.2.3 The measurement of dental fluorosis

3.2.3.1 Approaches in the measurement of fluorosis

Enamel fluorosis is a developmental defect of the tooth appearance. It is one of numerous discolorations observed on the tooth's enamel surface. Instruments available to record such developmental changes of enamel can be divided into descriptive and fluorosis-specific indices. The descriptive indices do not specifically diagnose fluorosis but rather describe the appearance of discoloration on the tooth surface. They include the Developmental Defects of Enamel (DDE) Index (FDI, 1982), Murray-Shaw Index (Murray and Shaw, 1979) and Al-Alousi Index (Al-Alousi et al., 1975). Among these indices, the DDE Index is the most commonly used. These indices, however, do not allow for estimation of the prevalence of dental fluorosis. Therefore, they are not relevant instruments for this study, which investigated fluoride-related development changes.

The fluorosis-specific indices initially diagnose dental fluorosis and then record it according to a range of severity levels. These indices are the Dean Index (Dean, 1942), the Thylstrup and Fejerskov (TF) Index (Fejerskov, Manji and Baelum, 1988), the Tooth Surface Index of Fluorosis (TSIF) (Horowitz et al., 1984), the Fluorosis Risk Index (FRI) (Pendrys, 1990) and the Chronological Index of Fluorosis (Evans, 1993). These indices are more relevant to this study and will be discussed in more detail in Section 3.2.3.3.

3.2.3.2 Differential diagnosis of fluorosis

Clinical diagnosis of mild form of enamel fluorosis is often problematic owing to similarities in its appearance with other non-fluorotic enamel conditions (Russell, 1961). In order to document the presence/absence of fluorosis in a person and/or an individual tooth, a differential diagnosis of the condition is required. The differential diagnosis is based on specific characteristics of fluorotic lesions such as bilateral symmetry, colour or shape of lesion. The criteria developed by Russell (1961) and presented in Table 3.1 are the most widely accepted.

Table 3.1: Differential diagnostic criteria for dental fluorosis (Russell, 1961)

Characteristics	Dental fluorosis	Enamel opacities
Area affected	The entire tooth surfaces (all surfaces) often enhanced on or near tips of cusp/incisal edge.	Usually centred in smooth surface of limited extent
Lesion shape	Resemble line shading in pencil sketch, which follow incremental lines in enamel (perikymata). Lines merging and cloudy appearance. At cusp/incisal edges formation of irregular white caps ("snow cap").	Round or oval
Demarcation	Diffuse distribution over the surface of varying intensity.	Clearly differentiated from adjacent normal enamel.
Colour	Opaque white lines or clouds; even chalky appearance. "Snow cap" at cusp/incisal edge. Some lesions may become brownish discoloured at mesio-incisal part of central upper incisors after eruption.	White opaque or creamy-yellow to dark reddish-orange at time of eruption.
Teeth affected	Always on homologous teeth. Early erupting teeth (incisors/1st molars) least affected. Premolars and second molars (and third molars) most severely affected.	Most common on labial surfaces of single or occasionally homologous teeth. Any teeth may be affected but mostly incisors.

3.2.3.3 Fluorosis indices available

3.2.3.3.1 The Dean Index (Dean, 1934)

Dean had made a fundamental contribution to the assessment of dental fluorosis. While conducting his investigation of dental mottling, Dean recognised the value of a classification system for the clinical manifestation of the condition in answering several research questions. The questions to be addressed by Dean's efforts were aetiology and pathogenesis of dental fluorosis, and its pattern in a population. Therefore, Dean developed a six-category index with the aim of describing the clinical manifestation of fluorosis and reflecting as closely as possible the biological effects of fluoride on tooth enamel. The description of the categories is shown in the Table 3.2.

Table 3.2: The Dean Index (modified by the author in 1942) (Dean, 1942)

Category	Description
Normal	The enamel surface is smooth, glossy and usually a pale creamy-white colour
Questionable	The enamel shows slight aberrations from the translucency of normal enamel, which may range from a few white flecks to occasional spots. This classification is used where the classification "normal" is not justified.
Very mild	Small opaque paper-white areas scattered irregularly over the tooth but involving less than 25% of the labial tooth surface.
Mild	The white opacity of the enamel of the teeth is more extensive than in category 2, but covers less than 50% of the tooth surface
Moderate	The enamel surface of the teeth show marked wear and brown stain is frequently a disfiguring feature
Severe	The enamel surface is 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 widespread; the teeth often have corroded appearance

This index has been a historically remarkable instrument in measuring fluorosis. It has been the most widely used index of fluorosis, especially in population descriptive studies. However, there are several limitations of the index that may affect its validity in relating fluorosis to sources of fluoride exposure and in risk assessment studies in light of the current knowledge of fluoride action. The index does not clearly identify histological characteristics of fluorotic enamel. It may incorrectly accept extrinsic discoloration as an indication of the severity of fluorosis. Also, the category "Questionable" is vaguely characterised. Therefore, diagnosis of fluorosis by the index may vary depending on the case definition chosen by investigators. On the other hand, as more severe fluorotic enamel is not classified in detail, its use may be limited where populations have more severe conditions.

3.2.3.3.2 The Thystrup & Fejerskov (TF) Index (Fejerskov, Manji and Baelum, 1988)

The Thystrup & Fejerskov (TF) Index assesses buccal surfaces of teeth using a ten-point scale (Table 3.3). This index was designed in the late 1970s with the aim of classifying the clinical features of fluorosis reflecting the histological changes in enamel in association with differing degrees of fluorosis severity. The index was based on histological and electron microscopic characteristics of fluorotic enamel. Several clinical manifestations such as discoloration and surface pitting were considered as post-eruptive and were subsequently taken into account in the design of the index.

One of the advantages of this index is that it distinctively identifies fluorosis, especially milder forms of fluorosis, from other non-fluorotic discolorations. The requirement for drying teeth before examination increases the capability of the index to identify teeth with fluorosis. The assessment can be made for any present teeth, which may facilitate the description of the intra-oral distribution of fluorosis. Comparability of data collected from different studies with a different number of examined teeth is also feasible provided the same tooth (or group of teeth) is to be compared. These features have made the TF Index one of the methods of choice in studying the prevalence and severity of dental fluorosis.

Table 3.3: Criteria for the Thylstrup and Fejerskov (TF) Index

Category	Description
TF score 0	The normal translucency of the glossy creamy white enamel remains after wiping and drying of the surface
TF score 1	Thin white opaque lines are seen running across the tooth surface. Such lines are found on all part of the surface. The lines correspond to the position of the perikymata. In some cases, a slight "snow-capping" of cusps/incisal edge may also be seen.
TF score 2	The opaque white lines are more pronounced and frequently merge to form small cloudy areas scattered over the whole surface. "Snow-capping" of the incisal edges and cusp tip is common.
TF score 3	Merging of the white lines occurs, and cloudy areas of opacity occur over many parts of the surface. In between the cloudy areas white lines can also be seen.
TF score 4	The entire surface exhibits a marked opacity, or appears chalky white. Parts of the surface exposed to attrition or wear may appear to be less affected.
TF score 5	The entire surface is opaque, and there are round pits (focal loss of the outermost enamel) that are less than 2 mm in diameter.
TF score 6	The small pits may frequently be seen merging in the opaque enamel to form bands that are less than 2 mm in vertical height. In this class are included also surfaces where the cuspal rim of facial enamel has been chipped off, and the vertical dimension of the resulting damage is less than 2 mm.
TF score 7	There is a loss of the outermost enamel in irregular areas, and less than half of the surface is so involved. The remaining intact enamel is opaque.
TF score 8	The loss of the outermost enamel involves more than half of the enamel. The remaining intact enamel is opaque.
TF score 9	The loss of major part of the outer enamel results in a change of the anatomical shape of the surface/tooth. A cervical rim of opaque enamel is often noted.

3.2.3.3.3 The Fluorosis Risk Index (FRI) (Pendrys, 1990)

The FRI features a scoring system of different zones of a tooth surface. It divides tooth surfaces into four surface zones: occlusal/incisal edge; incisal one third; middle one third; and cervical one third (Pendrys, 1990). The index then divides the surface zones into two distinctive classifications based on their time of mineralisation: classification I zones are 10 surface zones that are mineralised in the first year of life; classification II zones are 48 zones that are mineralised during the third year through to the sixth year of life. Surface zones that are mostly mineralised during the second year after birth are not included in the classification system for the index. This makes the two classifications more distinctive from each other. The rationale for this classification was that different fluoride exposures may have different effects on fluorosis experience on surface zones that are mineralised at different times during an individual's life. The surface zones of the two classifications are presented in Table 3.4.The diagnostic criteria for fluorosis used in this index are shown in Table 3.5.

Table 3.4: Surface zone classifications by the FRI

Upper teeth

Tooth number	7	6	5	4	3	2	1
Occl/incisal edge	C2	C1	C2	C2			C1
Incisal 1/3	C2		C2	C2			
Middle 1/3	C2		C2	C2	C2		
Cervical 1/3						C2	C2

Lower teeth

Tooth number	7	6	5	4	3	2	1
Occl/incisal edge	C2	C1	C2	C2		C1	C1
Incisal 1/3	C2		C2	C2			
Middle 1/3	C2		C2	C2	C2		
Cervical 1/3						C2	C2

C1: classification I surface zone
C2: classification II surface zone
Blank: not classified surface zones

Table 3.5: Criteria for the Fluorosis Risk Index (FRI)

Category	Description
Negative finding	
Score 0	A surface zone will receive a score of 0 when there is absolutely no indication of fluorosis being present. There must be a complete absence of any white spots or striations, and tooth surface coloration must appear normal.
Questionable finding	
Score 1	Any surface zone that is questionable as to whether there is fluorosis present (i.e. white spots, striations, or fluorotic defects cover 50% or less of the surface zone) should be score as 1.
Score 7	Any surface zone that has an opacity that appears to be a non-fluoride opacity should be score as 7.
Positive finding	
Score 2	A smooth surface zone will be diagnosed as being positive for enamel fluorosis if greater than 50% of the zone displays parchment-white striations typical of enamel fluorosis. Incisal edges and occlusal tables will be scored as positive for enamel fluorosis if greater than 50% of that surface is marked by the snow-capping typical of enamel fluorosis.
Score 3	A surface zone will be diagnosed as positive for severe fluorosis if greater than 50% of the zone displays pitting, staining and deformity, indicative of severe fluorosis.
Surface zone excluded	
Score 9	A surface zone is categorised as excluded (i.e. not adequately visible for a diagnosis to be made) when any of the following conditions exist: Incomplete eruption Rule 1: If a tooth is in proximal contact but the occlusal surface is not parallel with existing occlusion, the occlusal two-thirds of the tooth is scored, but the cervical one-third is recorded as excluded. Rule 2: If a tooth is erupted, but not yet in contact, the incisal/occlusal edge is scored, but all other surfaces are recorded as excluded. Orthodontic appliances and bands Rule 1: If there is an orthodontic band present on a tooth only the occlusal table or incisal edge should be scored. Rule 2: If greater than 50% of the surface zones are banded, the surface should be recorded as excluded. Surface crowned or restored Rule: Surface zones that are replaced by either a crown or restoration covering greater than 50% of the surface zone should be recorded as excluded. Gross plaque and debris Rule: Any subject with gross deposits of plaque or debris on greater than 50% of the surface zones should be excluded from examination.

3.2.3.3.4 The Tooth Surface Index of Fluorosis (TSIF) (Horowitz et al., 1984)

The Tooth Surface Index of Fluorosis (TSIF) was designed to record fluoride-related conditions on different tooth surfaces (Table 3.6). It consists of a seven-point scale based on the area affected and the presence of discoloration and pitting. This index has been found to be relevant in assessing the aesthetic impact of fluorosis (Clark et al., 1993; Clark, 1995). The biological effect of fluoride on tooth enamel, however, is less emphasised in this index. It may, therefore, be less sensitive to changes in fluorosis severity because of different levels of fluoride exposure.

Table 3.6: The Tooth Surface Index of Fluorosis (TSIF)

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

3.2.3.4 Assessment of fluorosis in this study

Two fluorosis indices were selected to pursue the specific objectives of this study. The Thylstrup & Fejerskov (TF) Index was selected as the main index to pursue the study's objectives. This index is a sensitive and reliable scoring system to evaluate the prevalence and severity of fluorosis, which is suitable to investigate the time trend of fluorosis. Also, different case definitions based on scores of the index can be used to enable comparison between successive birth cohorts and comparison with other studies. The Fluorosis Risk Index (FRI) was selected owing to its ability to relate age-specific fluoride exposures to the experience of fluorosis. It can be a valid measurement to evaluate risk factors for the condition. The above advantages of these two indices supported their appropriateness for the study's objectives. Furthermore, the two indices differ markedly in examination requirements. This was particularly important in preventing a "carry over" effect when one examiner conducted two different fluorosis indices. The FRI is a "wet" index, whereas air-drying is essential for the TF Index. Also, the two indices examine different tooth surface zones with distinguishing diagnostic criteria. The TF Index examines the whole buccal surface while the FRI divides buccal surface into four distinctive zones. The different requirements for the use of these two indices are presented in Table 3.7.

Table 3.7: Procedures required in preparing teeth for each of the fluorosis indices

Requirement	FRI index	TF index
Teeth examined	All present permanent teeth	All present permanent teeth This study assesses teeth from 14 to 24
Tooth surface examined	Classification I surfaces Classification II surfaces	Labial surface of examined teeth
Cleaning	Quick wipe with gauze	Required
Drying	Not necessary	Necessary

3.2.4 Dental Aesthetic Index

The Dental Aesthetic Index (DAI) was designed with the aim of specifically measuring dental aesthetics using objective physical measurements (Cons, Jenny and Kohout, 1986). Its development was based on measuring the relative social acceptability of dental appearance based on the public's perception of dental aesthetics. The DAI score was collected in this study as a potential confounding factor in evaluation of the impact of dental fluorosis and caries on perception of dental appearance and oral health-related quality of life.

The DAI takes 10 physical measurements of occlusal traits by intra-oral examination. These component scores are then put into a formula with their appropriate weights which have been calculated in the index development process as regression coefficients. The result of the formula is a person's Dental Aesthetic Index score. The regression equation used to calculate a DAI score is illustrated as followed.

DAI score = 6 × (Missing Visible teeth) + 1 × (Crowding) + 1 × (Spacing) + 3 × (Diastema) + 1 × (Largest Upper Anterior Irregularity) + 1 × (Largest Lower Anterior Irregularity) + 2 × (Anterior Maxillary Overjet) + 4 × (Anterior Mandibular Overjet) + 4 × (Vertical Anterior Openbite) + 3 × (Antero-posterior Molar Relation) + 13.

DAI scores can range from 13 to 52, with lower scores indicating the more aesthetic occlusal traits and higher scores the presence of less aesthetic traits. A score of 35 was selected as an arbitrary cut-off point for aesthetics (Cons, Jenny and Kohout, 1986). DAI scores above this cut-off point are considered to indicate less socially acceptable dental appearance.

The DAI may not be a "stable" index in the clinical assessment of orthodontic treatment needs or in longitudinal assessment of dental aesthetics (Tarvit and Freer, 1998). However, it is simple to conduct and it can be validly related to public perception of dental appearance (Cons et al., 1989; Jenny and Cons, 1996).

3.2.5 Perception of dental health

3.2.5.1 Dental appearance perception

A number of items were used to ask the participants' opinions about the children's dental appearance. The items used were adopted from the Dental Aesthetic Index questionnaire (Cons, Jenny and Kohout, 1986). These same items were used in the previously conducted study of dental appearance among South Australian children (Hoskin, 1997). Items covered included the perception of tooth colour, shape and alignment of teeth. A global question asked children and parents about satisfaction with the appearance of their teeth.

3.2.5.2 Child Perception questionnaire and Parental Perception questionnaire

Over the past several decades measuring health-related quality of life has been emphasised as being just as important as measuring the clinical aspects of health. There have been numerous measures to assess oral health-related quality of life among adults and the elderly (Atchison and Dolan, 1990; Slade and Spencer, 1994; McGrath and Bedi, 2001). However, few measures have been developed to measure oral health-related quality of life among children. The Child Oral Health Quality of Life Questionnaire (COHQoL) is one of the newly developed measures and has been found to have good reliability and validity (Jokovic et al., 2002; 2003).

The COHQoL consists of a Parental Perception Questionnaire (PPQ) applicable to parents of children aged from 6 to 14 years, and a separate Child Perception Questionnaire (CPQ) for children aged 6 to 7 (CPQ_{6-7}), 8 to 10 (CPQ_{8-10}), and 11 to 14 (CPQ_{11-14}) years. The PPQ measures parental perception of the child's oral health-related quality of life (OHRQoL), while the CPQ measures children's own perception of their OHRQoL. All questionnaires conform to contemporary concepts of child health. Four main domains are encompassed: oral symptoms, functional limitations, emotional wellbeing, and social wellbeing. Each domain contains a number of items related to that aspect of oral health and quality of life. Because the study sample was from 8 to 13 years old, the PPQ, CPQ_{8-10} and CPQ_{11-14} were used.

The items ask about the frequency of events experienced by children in the immediately past reference period (three months for the PPQ and the CPQ_{11-14} and four weeks for the CPQ_{8-10}) in relation to their oral/orofacial conditions. Responses to the questionnaires were made on a 5-point Likert-type scale. The five response options used in the questionnaires were "Never", "Once or twice", "Sometimes", "Often", and "Very often". The PPQ has an additional "Don't know" option.

The questionnaires contain two "global" items asking respondents to rate the child's oral health and the impact of the child's oral and orofacial condition on overall wellbeing. In the PPQ and CPQ_{11-14}, five-point scales range from "Excellent" to "Poor" for the former item, and "Not at all" to "Very much" for the latter. The CPQ_{8-10} has a four-point scale for the first global item and five-point scale for the second.

3.2.6 Data collection procedures

3.2.6.1 Child Oral Health Study data collection

Starting from June 2002, training programs on COHS data collection were provided to staff from clinics that were selected for the study. The program covered tasks of sample selection, handling the study description and subjects' invitation, delivering the questionnaire, and clinical examination of children. A training manual was also provided.

When a child attended a clinic, the clinic staff checked if the child satisfied the selection criteria. A brief description of the study was provided to the child who satisfied the selection criteria. If an agreement to participate was received, the information package that included an information sheet, the COHS questionnaire, a consent form, and a reply-paid envelope was given to the child's parent. A unique identifier was recorded into the child's electronic file. The child was then examined and the information was recorded into the electronic file in the EXACT system.

ARCPOH staff who were responsible for data collection received information of enrolled children from the EXACT system on a frequent basis. If no questionnaire was returned, the parent of the enrolled child was sent a reminder card and two subsequent follow-ups with packages containing the COHS questionnaire to maximise the response rate. Returned questionnaires were entered into a database on an ongoing basis. Caries experience data recorded in the EXACT system were delivered to ARCPOH every three months for management.

3.2.6.2 Perception questionnaire data collection

The fieldwork for the study commenced in February 2003. Names and addresses of a group of 1401 children born from 01 January 1989 to 31 December 1994 inclusive were selected from the pool of the COHS participants. Parents of those children were sent a package containing a primary approach letter, an information sheet, a consent form, a reply-paid envelope, and a parental and a child questionnaire. Non-respondents were sent a reminder card two weeks later. For those who were still yet to respond, two packages containing the above materials and a secondary approach letter were sent at four weeks and six weeks into the study period. Attempts were made to identify new addresses of those packages that were returned due to incorrect addresses. These attempts included consulting the School Dental Service's database and completed original COHS questionnaires. The above-mentioned method was in accordance with the Dillman's Total Design Method (TDM) to achieve a maximum response rate (Dillman, 1978).

Dispatch of the perception questionnaire was divided into three launches across 2003 (February, July and September), reflecting the accumulation of participants in the parent COHS. Each launch was conducted using similar strategies.

3.2.6.3 Dental caries data collection

Dental caries experience was collected from two sources of the SA SDS archive. Prior to the year 2000, caries data were recorded and stored in paper-based clinical case notes. The data management system EXACT was introduced in 2000 to record clinical examination information for each visit. Children were identified by unique patient numbers. Therefore, caries data of study participants were collected from the two sources with different strategies.

A Microsoft Access data entry screen was designed by the examiner/investigator based on paper-based examination record forms that were used in the SA SDS clinic. The screen had features that facilitated efficient on-site data collection. During clinic visits, the investigator collected paper-based case notes of study participants in each clinic with assistance from clinic staff. All data recorded in case notes were then transcribed into the laptop computer by the investigator.

Clinical data of children who made visits from 2000 onwards were accessed electronically. The caries data of study participants were collected from the SA SDS database using a unique identifier number to create a second data set of caries data. These data were then merged with the first data set that was collected from paper-based records using a unique identifier to form a complete data set of study participants. Cross-checking was performed to ensure no duplication of visits in the data set. The data set contained dates of examinations, assigned risk level for caries and surface-based records of caries experience, including decayed, filled and missing surfaces for each of the visits.

3.2.6.4 Fluorosis examination procedures

3.2.6.4.1 Appointment for examination

The completed perception questionnaires and consent forms were entered into a database when returned to the investigators. Clinic sessions were organised on an ongoing basis with assistance from South Australian (SA) School Dental Service (SDS) staff. Parents of participating children were contacted by phone to organise the most suitable time for them to attend an examination. After an appointment had been made, a confirmation card was sent to the participants before the agreed date. Children who failed to attend the examination appointment were contacted again to arrange another time. A maximum of three appointments for an examination were made.

3.2.6.4.2 Examiner training

It was planned that all examinations were to be conducted by a single examiner, Loc G Do (dentist and thesis author). Prior to the commencement of the fieldwork, an examination protocol had been completed. The examiner underwent protocol discussion and slide viewing sessions with Professor John Spencer and Dr Anna Puzio, who were experienced in conducting fluorosis assessment using the TF Index. Professor Steven Levy at the University of Iowa provided 35 mm slides with detailed descriptions for the FRI training. Several clinical sessions were organised for training in a School Dental Service clinic, which was not a study site for the study. The examiner conducted clinical examinations among children who attended the clinic under supervision of the two trainers, followed by group discussion of every case. Clinical photographs were also taken for each child in the training sessions.

3.2.6.4.3 Examination procedures

All examinations were conducted under SA SDS clinic conditions. Standard infection control guidelines for the School Dental Service were strictly applied. Children were examined in the supine position in the dental chair with the examiner sitting at the 11 o'clock position. Standard clinic lighting was used in all cases. Equipment included a disposable mouth mirror (Care Dental), a triplex syringe with a disposable tip Seal-Tight (Kerr Dental), and a plastic millimetre-grade measure cut down to 0.3 cm wide and 5 cm long. Cotton rolls were used to clean and isolate teeth for examination. A dental nurse assisted in each session to record examination data onto an examination form. Data were later transcribed into a laptop computer by the examiner.

The examination started with the Fluorosis Risk Index on all available Classification I and II surface zones, followed by the TF Index on permanent upper anterior teeth from the right first premolar (tooth 14) to the left first premolar (tooth 24), and finished with a scoring of the ten components of the DAI. First, the examiner quickly cleaned teeth with gauze and assessed the FRI surfaces starting from the upper right quadrant, moving clockwise to the upper left, then lower left and finished with the lower right quadrant. After the FRI assessment, upper anterior teeth were isolated with cotton rolls and air dried with compressed air for 30 seconds. Each present permanent tooth from 14 to 24 was then scored for TF index. The ten components of the DAI were then measured.

3.2.6.4.4 Reliability analysis

During the examination session, photographs of teeth were taken by the examiner using a digital clinical camera with fixed settings. Parents of children who had either fluorosis or non-fluorotic lesions were asked for permission to take photographs of their teeth. There were no refusals. The photographs were transferred and stored in a desktop computer.

After completion of all clinical examination sessions, reliability tests were taken by re-examining photographs of children using the TF Index. A decision was made to re-score two upper central teeth, which were used most in the analysis and which were most readily assessed from photographs. A layperson was asked to randomly select 50 cases from the pool of photographs. Each case could have had several photographs. Eight cases were excluded due to low quality photographs, or because photographs were taken of other teeth. The examiner screened all photographs of each case and scored each upper central incisor using the TF Index with a layperson recording the scores into a laptop computer. The scores were then pooled with the original scores to form a data set. Unweighted kappa scores were calculated for each tooth and for the highest score of the two teeth. Results are presented in Table 3.8.

The reliability scores were substantial. The kappa scores ranged from 0.74 for the highest score of two teeth to 0.79 for scores on the upper right central incisor. There was one case where the examiner scored tooth 21 with a TF score of 0 when the original score was 99 (tooth excluded for reasons such as tooth colour restoration). Other variations were within plus or minus one of each other.

Table 3.8: Reliability scores by the TF Index

Tooth 11

Scores from photographs		Original scores TF score 0	1	2	3	Total
TF score	0	14	1			**15**
	1	1	11	2		**14**
	2		2	9		**11**
	3				2	**2**
Total		**15**	**13**	**12**	**2**	**42**

Kappa=0.79, p<0.001

Tooth 21

Scores from photographs		Original scores TF score 0	1	2	3	99	Total
TF score	0	13	1			1	**15**
	1	1	9	2			**12**
	2		1	10			**11**
	3			1	2		**3**
	99					1	**1**
Total		**14**	**11**	**13**	**2**	**2**	**42**

Kappa=0.77, p<0.001

Highest score of two teeth

Scores from photographs		Original scores TF score 0	1	2	3	99	Total
TF score	0	12	1				**13**
	1	1	8	1		1	**11**
	2		3	10			**13**
	3			1	3		**4**
	99					1	**1**
Total		**13**	**12**	**12**	**3**	**2**	**42**

Kappa=0.74, p<0.001

3.3 Statistical approach

This section discusses the statistical approach adopted for this research by reviewing the dependent and independent variables to be used in the analyses, the data reduction techniques used to process the independent variables prior to statistical analysis, and finally an outline of the approach to the statistical models.

3.3.1 Data re-weighting

The sample selection scheme of this study was a complex, multistaged stratified random sample selection with different sampling ratios between strata (see Figure 3.1). Therefore, the study sample was not necessarily representative of the child population of the whole state. Corrections for those differing sampling ratios were required to produce representative estimates for the whole population. Also, unequal response rates were observed between groups of interest such as birth cohorts. Sample weights were therefore calculated to adjust for differences in selection ratios and response rates between clinics and age groups.

The weights were derived using sample counts by clinic from the fluorosis examination data set and population counts by school dental clinics supplied by SA SDS. Age adjustment was applied to this weight to ensure the age distribution of the sample reflected the age distribution of children attending the SA SDS clinics. Date of birth was used to calculate the age adjustment. This weight was then divided by the average weight across the sample to derive the final weight (this ensured that the final weights summed to the total sample size of 677 in the analysis).

3.3.2 Data management

3.3.2.1 Management of fluoride exposure measurements

The COHS questionnaire collected detailed information of the children's residential history, the sources of water used in each location, the percentage of public water use at each location, and the use of any filtration system for the treatment of water. Other data collected included toothpaste used in childhood and at present. Age started, frequency of brushing, amount of toothpaste used and type of toothpaste in terms of fluoride concentration were collected. If children used a fluoride supplement, parents were asked to indicate age started, age stopped and dosage of fluoride supplement at different ages. Also, use of infant formula and other processed children's foods was collected in detail. These data formed a comprehensive source of fluoride exposure history of children in this study.

3.3.2.1.1 Estimation of lifetime exposure to fluoride in water

Data pertaining to residential history and related water usage was used to calculate the lifetime exposure to fluoride. A postcode-fluoride database available in ARCPOH was used to map fluoride exposure to the residential history. The database provided three levels of fluoride in water: 1.0 for a fluoride level from 0.7 to 1.2ppm; 0.5 for a fluoride level from 0.3 to 0.7ppm; and 0 for a fluoride level <0.3ppm. A method of calculating lifetime fluoride exposure developed in ARCPOH (Slade et al., 1995a) and used previously (Singh, Spencer and Armfield, 2003) was adopted and modified to suit the current study's data. The data collected in this study facilitated a more detailed estimation of fluoride exposure from water. For example, the parents of the children were asked to estimate the proportion of public water usage at any residential location. Calculations were made to estimate lifetime exposure to fluoride and exposure during the period of life that might be susceptible for dental fluorosis on particular groups of teeth.

Factors used for the calculation of lifetime exposure to fluoride in water included the following:

- Residential location where a child had spent at least six months (questionnaire)
- Age period in months when the child lived at that location (questionnaire)
- Percentage of public water usage of total fluid intake at that location (questionnaire)
- Use of reverse osmosis filtration system (questionnaire)
- Fluoride level in public water at that location at that time (fluoride database)

Reverse osmosis filtration systems are known to reduce the amount of fluoride in water (Jobson et al., 2000). Therefore, if a family used this filtration system at a location, the fluoride level in the consumed water was expected to be reduced. A decision was made to adjust the water fluoride level down by one level. Hence, if the fluoride level were 1 at a location where use of this type of water filtration was reported, the fluoride level used in the calculation would be 0.5, and so on.

Given the residential history, the percentage of public water usage, the age period of the child living at different places, whether a reverse osmosis filtration system was used or not, and the fluoride level in the water, the lifetime exposure to fluoride in water could be calculated. The formula used in the calculation of lifetime exposure E was as below.

E = Σ (time at a residency during the age period i) × fluoride level in water (adjusted for filtration) × percentage of water usage) ÷ age in months × 100.

Example: lifetime exposure to fluoride was calculated for a 90-month-old child who first lived up to the age of 30 months in a location with a fluoride level of 0, then in another location until the age of 40 months with a fluoride level of 1ppm and where public water was 50% of fluid consumed, then in another location up to the age 70 months where fluoride in water was 1ppm and the family used public water only with reverse osmosis filtration fitted, then in another location until the time of the study where the fluoride level was 0.5 ppm and un-filtered public water was consumed only. The per cent lifetime exposure to fluoride for the child would therefore be:

$$E = (30 \times 0 + 10 \times 1 + 30 \times 0.5 + 20 \times 0.5)/ 90 \times 100 = (0 + 10 + 15 + 10)/ 90 \times 100 = 35/90 \times 100\% = 38.9\% \text{ lifetime.}$$

This formula was used to calculate both the lifetime exposure to fluoride and exposure to fluoride from birth to age six. This age was chosen as the age when the first permanent tooth erupts.

These two estimates could be used as continuous variables in analyses. They were also coded into categorical variables. The categories were 0% lifetime; more than 0% and less than or equal to 50% lifetime; and more than 50% lifetime exposure.

There was a small number of children who were born overseas. These children were excluded from calculations of fluoride exposure from water if there was no official information available on the fluoride level in the water supply in these overseas locations. If information on the fluoride level in those locations was available, calculation of exposure to fluoride of those children was conducted following the method described above.

3.3.2.1.2 Fluoride exposure from toothpaste

A series of questions asked parents of children about patterns of toothbrushing at three time points: 1) when brushing with toothpaste was started, 2) at age five and 3) at the time of the study in 2002/03. The age in months, when brushing with fluoride toothpaste started was collected. The frequency, type of toothpaste, amount of toothpaste used, and procedures after brushing were detailed for each point in time.

The age when toothbrushing with toothpaste commenced was categorised with different cut-off points to address the research questions and analyses conducted. For example, the age of commencement of brushing with toothpaste was categorised into brushing started in the: 1) first year, 2) second year and 3) from third to sixth year of life, to be used with the FRI classifications of cases.

The amount of toothpaste used was dichotomised into a small and a large amount of toothpaste. At the time of toothbrushing commencement, a small amount was considered to be a smear of toothpaste and a large amount was considered to be a pea size or larger. At age five, a small amount was considered to be a pea size or less, and a large amount was considered to be a full brush head size. This system helped to relate the amount of toothpaste used proportionately with the expected body weight of children at different ages.

3.3.2.2 Management of fluorosis data

Each examined subject had two sets of index scores of fluorosis: the FRI and the TF Index. The number of sites examined for the indices varied depending on the number of permanent teeth present and their predisposing conditions. Age was the main determinant for the difference in the number of teeth and the sites examined. Differences between birth cohorts, however, was the key factor in comparing the trend of fluorosis over time. Therefore, strategies were required to appropriately manage fluorosis data for testing the main hypothesis of the study.

The TF Index data were used for analysing the prevalence and severity of fluorosis. They enabled a comparison with other studies such as the fluorosis study in South Australia (Puzio, Spencer and Brennan, 1993). For the purpose of testing the difference between birth cohorts, the prevalence and severity of fluorosis on the two upper central incisors were used. This approach ensured subjects of different ages and hence tooth eruption would have a similar number of teeth present for examination.

The FRI data were managed as described by Pendrys (1990) to classify subjects into cases, controls and questionable for either classification. A child was considered as a case for a classification if the child had two or more surface zones of that classification with FRI score 1, 2 or 3. A child was defined as a control for a classification if the child had no surface zone of that classification with fluorosis and had no more than one surface zone of the other classification with FRI score 1. The remaining children were grouped in a questionable category for that classification.

3.3.2.3 Dental caries data management

Dental caries data collected from paper-based records and the EXACT system were combined as described in Section 3.2.6.3. Children in the study had caries data from at least one examination collected. Dental caries data were then managed to calculate deciduous dmfs and permanent DMFS scores.

For the purpose of hypothesis testing, a series of caries experience scores were calculated. Primary dmfs and DMFS scores were calculated for study participants at different anchor ages, six and eight. This helped the direct comparability of caries experience between different birth cohorts. Current caries experience was also calculated for the examination conducted at the time of the child's recruitment into the COHS.

The age of a child at a collected dental visit was calculated and used to determine if that visit was made at an anchor age. The period that defined an anchor age would need to be long enough to allow as high as possible a number of individuals to make a visit at the anchor age. On the other hand, that period must not be too long so that there would not be a significant effect of the time factor on caries observed within the period. Commonly, one calendar year would define an age period, e.g. age six would be defined from the sixth birthday to the day before the seventh birthday. However, a preliminary analysis showed that just over a half the children made a dental visit in any calendar-year period. This turnout rate was explained by the fact that the majority of children attending SA SDS have recall periods of from 15 to 24 months. Over 80% of children made at least one dental visit during a period of 18 months. Therefore, a time period of 18 months was used to define an anchor age. The anchor age six (the age when the first permanent tooth emerges) was defined from the age of 5.5 years to 6.9 years. Likewise, the anchor age eight (the age when deciduous caries often peaks) was defined from the age of 7.5 years to 8.9 years. An anchor age ten was also similarly defined. However, this anchor age was not commonly used in the analysis because it did not include many children of the latest birth cohort.

There was a possibility that a child might have several visits made in any time period which defined the anchor age. During data management process, a decision was made to select the first visit of a child in the time period. This procedure ensured that caries data of children with multiple visits during any age period, who often were high-risk patients, were not double-counted in one anchor age. For example, if a child had a visit at the age of six years and two months and another visit at the age of six years and eight months, both these visits would be similarly classified as dental visits at the anchor age six. However, only the first visit, i.e. visit at six years and two months, would be retained in the data set.

3.3.2.4 Perception questionnaire data management

3.3.2.4.1 Dental Aesthetic Index

The 10 measurements of the occlusal traits were analysed for their use in calculation of the DAI score for the sample. The fact that the majority of children in this study had a mixed dentition while the DAI was designed for use in permanent dentition was specially considered. Children from a later birth cohort might have higher number of missing teeth than children of the earlier cohort. Also, there might be some time lapsed since completion of the perception questionnaires until the examination when the occlusal traits were recorded. During that time some deciduous teeth might have exfoliated and some permanent teeth might have erupted. Therefore, a decision was made not to use the missing component in calculating the DAI score. The other nine components were used to calculate the DAI score for an individual. A similar approach was used in a study which tested the useability of the DAI in mixed dentition (Johnson et al., 2000). The calculated DAI score was compared between groups by their responses to items related to shape and alignment of teeth.

3.3.2.4.2 Dental appearance items

A number of items were asked in the questionnaire in the order from "worst" to "best" case scenario (questions No. 4, 6, 7, 8, and 9) (See Appendix 3). In the data management and analysis, this order was reversed for these particular questions to provide a uniform meaning to the ordinal responses. Therefore, when mean scale scores were reported, a lower value indicated better perception. There were four tooth colour-related items, two tooth shape-related items, and two tooth alignment-related items in the questionnaire. These items were described and cross-tabulated with other factors such as sex, residential location, SES status, the DAI score, and fluorosis experience on upper anterior teeth.

3.3.2.4.3 Dental health perception items

Items of the four domains of the Child and Parent Perception questionnaires were identified and used to calculate sum and mean scores for each domain. Since the numbers of items differed between Child Perception Questionnaires (CPQs) and Parent Perception Questionnaire (PPQ), the sums of domain scores were comparable within each questionnaire only. Therefore, correlation between CPQs and PPQ were tested using mean domain scores.

The PPQ utilised a "Don't know" response to facilitate response from parents who were unsure about any of the items. Although the response "Don't know" (DK) was legitimate, its inclusion in the domains could affect calculated scores. For example, a person who gave scores of 2 (meaning a condition happened "once or twice" during the reference period) to all items in a six-item scale had a sum of 12 for that scale, whereas another person who gave scores of 4 (meaning "very often") to three items and DK to the other three items could also have a score of 12 for that scale. Jokovic and co-workers assessed the issue of DK values and suggested several approaches to counter the problem (Jokovic, Locker and Guyatt, 2004). They are as follows:

- listwise deletion: cases with DK responses were excluded from the analysis;
- imputation of item means: each DK response was replaced with the item mean of the sample;
- replacement: DK responses were replaced with zero; and
- adjustment: scores were calculated for each participant to represent the mean response value for the items without a DK response.

The authors concluded that these approaches might have different advantages or disadvantages; however, they could have similar effects on construct validity of the questionnaire.

For this particular study, a decision was made to use a combination of the first and the fourth approach. First, those cases where DK responses comprised more than half of the sub-scale's number of items were excluded from the analysis (listwise deletion). Then, mean scores of scales were calculated based on only those items that had responses other than DK (adjustment). Therefore, these scores were adjusted for the number of items that contributed to the sub-scale's score. For example, if a case had six missing and/or DK responses to a 10-item scale (more than half of the items in the scale), the scale score of this case was omitted from the analysis. If a case had five missing and/or DK responses to a 10-item scale (just a half of the items in the scale), a mean scale score was calculated by summing the remaining five items and dividing by five.

3.3.3 Analytic plan

3.3.3.1 Plan to address specific aims of the study

Several analytical approaches were employed to achieve the main objectives of the study. The analytic methods employed to address each aim are summarised below:

Aim 1: Descriptive analysis was employed to describe the patterns of exposure to fluoride sources in the study sample. The data were stratified into groups by sex, current residential location, and other socioeconomic characteristics. Similar stratification was conducted by birth cohorts to identify the time trend of each fluoride exposure.

Aim 2: Descriptive analysis was employed to describe the prevalence and severity of dental fluorosis defined by the TF Index and the FRI case definitions among the study sample. The data were reported as weighted estimates to represent the South Australian child population. The case definitions described in Section 3.3.2.2 were used in the analysis of the prevalence of fluorosis. The data were further stratified into groups by sex and current living location.

Aim 3: Bivariate analysis of the prevalence and severity of fluorosis defined by the TF Index by birth cohorts was employed to detect any changes between cohorts. Further analyses evaluated associations between fluorosis and levels of exposure to fluoride in childhood. Factors such as lifetime exposure to fluoride in water up to a certain age (a biologically plausible risk period), exposures to other fluoride sources with detailed time and amount of exposures, and oral hygiene practices in childhood were used as independent variables. Crude odds ratios for each independent variable were calculated and reported together with their 95% confidence interval.

The results reported in the previous South Australian fluorosis study (Puzio, Spencer and Brennan, 1993) were used as an indirect comparison of the two studies to identify differences in the reported prevalence and severity of dental fluorosis over time. Identical case definitions were used in such a comparison.

Aim 4: The subjects were defined as cases for fluorosis defined by the TF index and the case definitions by the FRI classifications I and II. Multivariate models were generated for the case definitions with different sources and levels of fluoride exposures, sex, and birth cohorts as exploratory variables. Details of the modelling are described in Section 3.3.3.2.1.

The population attributable risk of each of the factors that were identified as risk factors for fluorosis were calculated using a theoretical framework from an epidemiological textbook (Rothman, 1986) and a methodology described in previous medical literature (Bruzzi et al., 1985). The methodology is detailed later in Section 3.3.3.2.4.

Aim 5: Scores for dental appearance, domains of dental health perception and oral health-related quality of life reported by children and parents were calculated and reported. Further stratification by age group, birth cohorts and socioeconomic status were made. Comparisons between groups defined by fluorosis and caries experience were made. Similar approaches were used for perception of dental appearance scores adjusting for occlusal traits. Linear regression models were generated for the dental health perception scale scores to identify contributing factors. Multivariate models are described in Section 3.3.3.2.3.

Aim 6: Caries experience using dmfs and DMFS scores were calculated and reported at ages six, and eight years, and at the time of the study. A comparison was made between birth cohorts at ages six and eight years to identify a time trend in caries. Linear regression models were generated for the dmfs and DMFS scores at the time of the study, and the dmfs score recorded at age eight (see Section 3.3.3.2.2). Fluoride exposures (time and amount), socioeconomic characteristics, dental health behaviours and dietary factors were included in the model.

Aim 7: The proportions of dental fluorosis and caries that were attributed by the main fluoride exposures were considered. The effects of an increase or decrease in fluoride exposure on patterns of dental fluorosis and caries experience were estimated. The benefits and risk balance were then evaluated.

3.3.3.2 Building multivariate models

Several multivariate models were generated for dental fluorosis, caries experience and perception of oral health. These models were used to achieve the analytic plan of the study's objectives as described above. The plan was for these models to be explanatory conceptual models to suit the study's objectives. Therefore, several approaches were employed in developing the models described below.

3.3.3.2.1 Multivariate models for dental fluorosis

The selection of factors to be included in the models for dental fluorosis was based on knowledge of possible fluoride exposure sources. The models included sources of fluoride exposure relevant to the developmental stages of included teeth. For example, when fluorosis on central incisors was considered, fluoride exposure during the development period of these teeth, such as toothbrushing practice when brushing was started and at age five, and exposure to fluoride in water until age six, was of interest.

Two variables were exceptions, sex and birth cohort. Sex was included based on the fact that boys and girls might have different levels of exposure to fluoride. Birth cohort groups also might have different levels of fluoride availability during their tooth development stages. Therefore, these two variables were included in the multivariate models.

After the selection of variables to be included in a model was made, these variables were entered in one block using the Enter method. This method was favoured over stepwise methods because the explanatory power of these models was preferred over the predictive power (Rothman, 1986). Interaction terms were also tested between likely inter-dependent factors to test their contribution to a model. If any interaction terms were contributory, they were retained and reported. Models were generated for the prevalence of fluorosis defined as having TF score 1+ and 2+ on the central incisors, and for cases of fluorosis by FRI Classification I and II.

Differences between birth cohorts were of interest in this study. Therefore, steps were taken to identify factors that were likely to be responsible for inter-cohort differences in dental fluorosis. Fluoride exposure variables were sequentially removed from each model to test whether their presence/absence in models would alter the cohort effect. If an exposure was found responsible for the inter-cohort difference, i.e. the inter-cohort difference was significant after removal of that exposure, then this was reported in the text.

3.3.3.2.2 Multivariate models for dental caries

For the multivariate models for dental caries experience, fluoride exposure sources were considered as contributory factors, and hence were selected for the models. The per cent of lifetime exposure to fluoride in water was used as a continuous variable to evaluate its linear relationship with caries experience. Age in months when toothbrushing with toothpaste was commenced was also used as a continuous variable. Sex and birth cohort were also selected as explanatory variables. Socioeconomic characteristics and dietary factors were included as other possible explanatory variables for dental caries. Models were generated for the deciduous dmfs score and permanent DMFS score at the time of the study to investigate risk factors for dental caries. Two other models were run for caries experience at age six and eight to evaluate the trend in caries experience between birth cohorts. The models were generated in a manner similar to that described above for models of fluorosis.

3.3.3.2.3 Multivariate models for perception of dental health

These models aimed to test the impact of the main oral diseases and conditions on both the child's and the parent's assessment of the oral health-related quality of life of the child. The two main factors of interest in this study were dental fluorosis and caries experience. Another condition that might have an impact on the oral health perception of this age group was tooth alignment and occlusion, which was measured by the Dental Aesthetic Index (DAI). Other contributory factors were sex, age and residential location. These models were generated in a manner similar to that described above. The parameters of each factor and their 95% confidence intervals were reported.

3.3.3.2.4 Population attributable risk calculation

Population attributable risk (PAR) is also termed *attributable proportion* or *attributable risk per cent.* PAR is a measure of the proportion of the disease among the exposed population that is related to an exposure (Rothman, 1986). It can be measured statistically when the absolute effect of the exposure is divided by the rate of occurrence among the exposed rather than non-exposed. When there is only one exposure, PAR of exposure E is calculated as follows:

$$\text{PARe} = \frac{I_1 - I_0}{I_1} \times 100 = 1 - \frac{1}{RR} \times 100$$

where I_1 is the incidence among exposed, I_0 is the incidence among unexposed, and RR is the rate ratio (Rothman, 1986).

In public health terms, PAR can be interpreted as the proportion of exposed cases attributable to the exposure. This interpretation conveys a sense of how much of the disease in an exposed population can be prevented when the exposure is eliminated (Rothman, 1986). Population attributable risk estimates are best used to prioritise public health interventions on the basis of the magnitude of the potential effect on the disease outcome in the population.

Diseases and conditions very often have multifactorial causality. Therefore, an estimate of the effect of any exposure must not be biased by effects of other exposures in a population. Population attributable risk estimates need to be adjusted for effects of other exposures, i.e. using a multivariate approach. A well-defined methodology of calculating PAR using estimates obtained from multivariate logistic regression models has been described (Bruzzi et al., 1985). The methodology involves the calculation of relative risks from the regression coefficients β for a factor in the logistic regression model.

Based on the above methodology, PAR for an exposure E can be calculated from a logistic regression model using following formula.

$$PAR_e = (1 - \sum (p_i R_i)) \times 100\%$$

where p_i is a proportion of cases that are in a categorical stratum i of the exposed group, (in short $p_i = x_i/x$, where x_i is number of cases in a category i and x is total number of cases).

R_i is the relative risk of a category i. The relative risks estimated from a logistic model are obtained by exponentiating the product of the regression coefficient β for a factor and the order number for a specified categorical stratum of the factor used in the model. For example, the order number of the reference category is 0, the order number of the next category is 1 and so on. The regression coefficients β were obtained using the *logit* command in Stata Version 8.0.

Population attributable risk estimates obtained from logistic regression models are not additive to 100% because factors involved are not mutually exclusive (Rockhill, Newman and Weinberg, 1998). In fact, the sum of these estimates can be greater than 100%.

This methodology was used to calculate population attributable risk estimates for factors that were significant in logistic regression models for the prevalence of fluorosis in this study population. The PAR estimates and their 95% confidence intervals are reported in the text as well as the calculated relative risks of each categorical stratum of factors.

Incidence rates available from longitudinal studies are normally required for PAR calculation (Rothman, 1986). However, calculation of population attributable risk was applicable despite the fact that this study was a cross-sectional investigation. This exception was based on the following factors. First, dental fluorosis is a developmental condition with a one-off onset. Secondly, fluorotic enamel may undergo various post-eruptive changes because of toothbrushing and/or dental treatment, and the presence/absence status of fluorosis is unlikely to be affected when fluorosis assessment is conducted a few years after eruption. Therefore, the prevalence of fluorosis recorded in adolescent years, done in this study, is very close to the incidence rate of fluorosis in the study population. In addition, relative comparisons between PAR estimates for different exposure sources would not be affected by the possibility of post-eruptive changes because those changes would equally affect PAR for those exposures.

4. Results

The results consist of six major sections, which are further divided into sub-sections, the results of which are then presented as tables or figures. Each section may contain descriptive, bivariate and multivariate statistics for the factor of interest in that section.

The major sections consist of:

1. Response rates and description of the COHS sample and this nested study sample: sub-headings 4.1 and 4.2
2. Fluoride exposures in the sample, population estimates and distribution: sub-heading 4.3
3. Dental fluorosis, population estimates and risk factors: sub-heading 4.5
4. Dental caries, population estimates and risk factors: sub-heading 4.6
5. Perception of dental appearance and oral health: sub-heading 4.7
6. Balance between fluoride exposure and caries and fluorosis: sub-heading 4.8

The data presented in the following results relate to information collected from the COHS questionnaire, the CPQ questionnaire and clinical examinations (Appendixes 1, 2 and 3).

Where indicated, the percentages or mean values shown in tables are weighted data (weighted per cent or w%) whereas numbers of individuals are unweighted figures. Therefore, percentage estimates in tables, when multiplied by the total sample size or group size, do not necessarily produce integers of individuals.

4.1 Response

Table 4.1 presents the enrolment rate, number of respondents and response rate of the COHS in South Australia at the time of the sample selection for this nested study. A response rate of 67.3% was achieved. The response was higher among children from the non-metro non-fluoridated area. A total of 3680 5–17-year-old South Australian children participated in the COHS up to September 2003.

Table 4.1: Enrolment rate and response rate to the Child Oral Health Study in South Australia up to September 2003

	Number enrolled [a]	Completed questionnaires [a]	Response rate [b]
Metro fluoridated	1892	1319	69.71
Metro non-fluoridated	2232	1330	59.59
Non-metro non-fluoridated	1343	1031	76.77
Total	**5467**	**3680**	**67.31**

[a] Children aged from 5 to 17 years old

[b] Unadjusted response rate

A total of 1401 children who were born from 01 January 1989 to 31 December 1994 inclusive were selected as the initially selected sample from the pool of respondents to the COHS questionnaire (Table 4.2). A total of 898 children and parents responded to the perception questionnaire. A small number of participants did not have contactable addresses or had moved out of the targeted locations and hence were excluded from the study. The adjusted response rate to the perception questionnaire round was 65.7%.

Over half of the initial sample attended the examination round. This final group also comprised over 80% of children who responded to the questionnaire. Children who reported having orthodontic braces when contacted to arrange an examination appointment were not invited to the examination. There were several study participants with braces and some with no permanent teeth present who also attended the examination. Their records, however, were not included in the final sample group for analysis.

Table 4.2: Response rate of the study by age group and residency

	Participants	Per cent
Selected from the COHS sample	1401	100.0
Incorrect addresses, changed address etc	34	2.4
Responded to perception questionnaire [a]	898	65.7
Contactable for examination appointment (phone number available)	873	63.9
Reported having braces, changed address etc	36	2.6
Attended examination [b]	684	52.7
Excluded after the examination (braces, no permanent teeth)	7	0.5
Valid examination (to initial sample) [c]	677	52.2
Valid examination (to perception questionnaire respondents) [d]	677	81.6

[a] Response rate = Valid responses ÷ (Selected sample – Incorrect addresses- changed address etc)

[b] Response rate = Attendants ÷ (Selected sample – Incorrect addresses- changed address etc –Non-contactable – having braces etc)

[c] Response rate = Attendants ÷ (Selected sample – Incorrect addresses- changed address etc –Non-contactable – having braces etc - Excluded)

[d] Response rate = Attendants ÷ (Survey respondents – Non-contactable – having braces etc – Excluded).

Boys and girls responded at a similar rate to the perception questionnaire and to the clinical examination for fluorosis (Table 4.3). The Adelaide group had a slightly lower response rate to the perception questionnaire compared to participants residing in the other areas. Participants from Mount Gambier had the highest rate in both rounds. There was a higher rate of failure to attend the examination among the group from the two smaller areas.

There was a higher number of younger children in the initial study sample. This group responded better than the other two cohort groups in both stages.

Table 4.3: Response rate of the study sample by sex, residential location and birth cohorts

	Initial sample	Perception questionnaire		Fluorosis examination		
	n	n	Response [a]	n	Response [b]	Response [c]
Sex						
Boys	711	454	65.4	349	52.9	83.1
Girls	690	444	66.0	328	51.3	80.0
Current residency						
Adelaide	645	399	63.3	299	49.8	81.0
Mt Gambier	583	383	67.4	310	57.6	87.8
Bordertown & Kingscote	173	116	68.6	68	42.2	63.0
Birth cohort						
Born 89/90	403	240	61.1	171	45.8	77.7
Born 91/92	474	304	65.8	224	50.9	79.4
Born 93/94	524	354	69.1	282	57.6	84.9

[a] Response rate to the initial study sample

[b] Response rate to the initial study sample

[c] Response rate to the perception questionnaire respondents

Response rates were adjusted for number of non-contactable individuals at each stage

Weights were calculated by clinics and birth cohort for the sample to represent the South Australian School Dental Service child population (Table 4.4). Children attending SA SDS clinics in Adelaide had higher weights compared to children who lived in other areas.

Table 4.4: Weights of the sample by birth cohort and clinics

	Birth cohorts		
Clinic	**89-90**	**91-92**	**93-94**
Adelaide			
Aberfoyle Park	1.73	1.52	1.27
Hallett Cove	1.63	1.43	1.20
Linden Park	2.84	2.49	2.08
Madison Park	2.93	2.57	2.15
Parafield Garden	1.49	1.31	1.09
Reynella South	2.54	2.23	1.86
Seaton Park	2.30	2.01	1.68
Wandana	2.40	2.11	1.76
Other areas			
Mt Gambier	0.49	0.43	0.36
Bordertown	0.43	0.38	0.32
Kingscote	1.42	1.24	1.04

4.2 The study sample description

4.2.1 The initial study sample

There were slightly more children from the later birth cohorts in the COHS sample, with 37.4% of the total sample from the 93/94 cohort compared to 28.8% from the 89/90 cohort (Table 4.5). Boy and girl distribution was similar between birth cohorts. There were slightly more boys in the sample than girls.

Children currently residing in Adelaide comprised less than half the sample, followed by children residing in Mount Gambier. The two older birth cohorts had a slightly higher proportion of children residing in Adelaide. This difference was not significant between cohorts.

Table 4.5: Distribution of the initial study sample by year of birth, sex and current residency (N=1401) (n, column % in brackets)

	Born 89/90	Born 91/92	Born 93/94	All
Sex				
Boy	205 (50.3)	241 (50.8)	265 (50.6)	**711 (50.7)**
Girl	198 (49.7)	233 (49.2)	259 (49.4)	**690 (49.3)**
Current residency				
Adelaide	198 (49.1)	214 (45.0)	233 (44.5)	**645 (46.5)**
Other areas	205 (50.9)	260 (55.0)	291 (55.5)	**756 (53.5)**
Total (row %)	**403 (28.8)**	**474 (33.8)**	**524 (37.4)**	**1401 (100)**

Chi-square, p>0.05
Other areas: Mount Gambier, Kingscote and Bordertown

Table 4.6 presents the mean and median ages of children in the three birth cohorts at the fluorosis examination.

Table 4.6: Age at fluorosis examination by birth cohorts

	Mean	Median
Birth cohorts		
Born 89/90	13.8	13.8
Born 91/92	11.6	11.5
Born 93/94	9.7	9.7

4.2.2 Dental visits collected from the School Dental Service archive

Dental caries data were available from over 3000 earlier dental examinations conducted by the SA School Dental Service when the study sample were six, eight and ten years (Table 4.7). Reasonably high numbers of children visited the school dental clinic at each anchor age. The proportions of children who made visits at different anchor ages were similar between birth cohorts. However, a higher number of visits made by children from the latest birth cohorts was recorded. This difference was not statistically significant.

Table 4.7: Number of SA SDS recorded examinations at different anchor ages by birth cohort (N and % of total numbers of children in each birth cohort in brackets)

Age at examination	Born 89/90	Born 91/92	Born 93/94	All
Age 6	312 (77.4)	378 (79.7)	419 (80.0)	**1109 (79.2)**
Age 8	315 (78.2)	316 (76.2)	443 (84.5)	**1119 (79.9)**
Age 10	314 (77.9)	387 (81.6)	276 (52.7)	**977 (69.7)**

The first two anchor ages, age six and eight, were used for direct comparisons between birth cohorts and in other analyses for caries. The anchor age ten was only occasionally used because this age did not include many of children of the latest birth cohort.

4.2.3 Respondents to the dental perception questionnaire

Respondents to the perception questionnaire were compared between groups by sex, current residential locations and birth cohorts (Table 4.8). There was no significant difference in sex and residential distribution among birth cohorts of the respondents to the perception questionnaire. The distribution was similar to that of the initial study sample as shown in the Table 4.5. There were relatively fewer participants born in 89/90 when the 93/94 birth cohort group had the largest number.

Birth cohorts varied slightly in the distribution of boys and girls. There were more boys in the cohort 91/92 whereas more girls were in the other two groups. The Adelaide group was the largest group in each of the three cohort groups. The observed distributions were not statistically significant.

Table 4.8: Distribution of the respondents to the perception questionnaire by birth cohorts, sex and current residency (N=898) (n, column % in brackets)

	Born 89/90	Born 91/92	Born 93/94	All
Sex				
Boys	118 (49.2)	158 (52.0)	178 (50.3)	**454 (50.6)**
Girls	122 (50.8)	146 (48.0)	176 (49.7)	**444 (49.4)**
Current residency				
Adelaide	109 (45.4)	132 (43.4)	158 (44.6)	**399 (44.4)**
Other areas	131 (54.6)	172 (56.6)	196 (53.4)	**499 (53.6)**
Total (row %)	**240 (26.7)**	**304 (33.9)**	**354 (39.4)**	**898 (100)**

Chi-square, p>0.05

Other areas: Mount Gambier, Kingscote and Bordertown

4.2.4 Fluorosis examination participants

Fluorosis examination participants (from hereon these participants are called the study participants or the study sample) were similar in terms of the sex distribution between birth cohorts. The younger two birth cohorts had a slightly higher proportion of Adelaide residents (Table 4.9). However, none of the differences were statistically significant.

The age composition of the sample changed slightly when compared to that of the initial study sample and respondents to the perception questionnaire. The later birth cohort comprised over 40% of the study sample while the earliest birth cohort comprised just over a quarter of the total study sample. The relative distribution between birth cohorts had changed in comparison to the initial study sample. The 89/90 cohort had been reduced by three per cent while the youngest cohort group had increased by almost four per cent of the sample.

Table 4.9: Distribution of the study participants by birth cohorts, sex and current residency (N=677) (n, column per cent in brackets)

	Born 89/90	Born 91/92	Born 93/94	All
Sex				
Boys	86 (50.3)	117 (52.2)	146 (51.8)	**349 (51.6)**
Girls	85 (49.7)	107 (47.8)	136 (48.2)	**328 (48.4)**
Current residency				
Adelaide	75 (43.9)	95 (42.4)	129 (45.7)	**299 (44.2)**
Other areas	96 (56.1)	129 (57.6)	153 (54.3)	**378 (55.8)**
Total (row %)	**171 (25.3)**	**224 (33.1)**	**282 (41.7)**	**677 (100)**

Chi-square, $p>0.05$

Other areas: Mount Gambier, Kingscote and Bordertown

4.2.5 Comparison of study participants and the initial study sample

Deciduous and permanent caries experience was calculated and compared between the initial study sample, the group who did not attend a fluorosis examination, and the group who attended a fluorosis examination, using the caries data collected from the SA SDS archive. Caries experience was similar between the three groups. The non-participant group had a slightly lower mean deciduous dmfs score and slightly higher mean permanent DMFS score. There was a slight difference in permanent caries experience by sex, where girls attending fluorosis examination had a lower mean DMFS compared to boys, while the reverse was true for the initial study sample. There were also some differences in DMFS scores between the two groups. Overall, the study sample had a slightly better oral health status than the initial study sample when caries experience in the permanent dentition was taken into account. However, none of the differences were statistically significant.

Table 4.10: The initial study sample, non-participants, and fluorosis examination participants by dental caries experience (unweighted mean deciduous dmfs and permanent DMFS, SD in brackets)

	Deciduous dmfs			Permanent DMFS		
	Initial sample	Non-participants	Study sample	Initial sample	Non-participants	Study sample
Total	**2.40 (4.53)**	**2.32 (4.43)**	**2.47 (4.64)**	**1.04 (2.12)**	**1.11 (2.19)**	**0.96 (2.04)**
Sex						
Boys	2.51 (4.91)	2.34 (4.84)	2.67 (4.98)	1.00 (2.10)	0.99 (1.90)	1.00 (2.29)
Girls	2.27 (4.09)	2.30 (3.96)	2.26 (4.24)	1.07 (2.13)	1.23 (2.45)	0.92 (1.74)
Current residency						
Adelaide	1.70 (3.54)	1.60 (3.39)	1.83 (3.95)	1.02 (2.21)	1.12 (2.39)	0.87 (1.84)
Other areas	2.98 (5.04)	3.02 (5.14)	3.00 (5.08)	1.13 (2.09)	1.11 (1.97)	1.04 (2.20)
Birth cohort						
Born 89/90	0.53 (1.70)	0.67 (1.87)	0.35 (1.42)	1.67 (2.80)	1.58 (2.81)	1.59 (2.72)
Born 91/92	2.20 (3.94)	2.25 (4.57)	2.14 (3.97)	1.07 (2.11)	1.11 (2.04)	0.94 (2.09)
Born 93/94	4.12 (5.60)	4.04 (5.35)	4.00 (5.72)	0.63 (1.36)	0.64 (1.40)	0.61 (1.33)

T test, p>0.05

Other areas: Mount Gambier, Kingscote and Bordertown

4.2.6 Socioeconomic status of the study sample

The socioeconomic status of the sample is presented in the Table 4.11. Birth cohorts did not differ significantly on levels of annual household income. The percentage of children from households with the lowest income level fluctuated at 40%, while for the highest income level the percentage was around 14%.

Female parents of the study sample differed between cohorts in terms of level of education attainment. Those parents of children born in the 89/90 birth cohort were more likely to have a university education. This proportion was lowest in the latest birth cohort. The level of education attained by male parents did not differ between cohorts. When the highest level of education by the two parents was compared, parents of the earliest birth cohort were more likely to be university educated than parents of the youngest children.

Forty per cent of the female parents of the latest birth cohort were not in the labour force, whereas this figure was lower among the other birth cohorts. Less than one fifth of the female parents worked full-time in 2002/03 while just less than half had part-time employment. The male parents did not differ between cohorts in terms of employment status. The majority of those parents worked full–time in the labour force. Only few worked part-time or did not work at all. When the highest employment status of the two parents were analysed, there were some differences between cohorts in proportion of parents who worked part-time or who were not in the labour force. Just less than 7% of parents of children in the latest birth cohort were part-time workers compared with over 15% of the other birth cohorts. On the other hand, 14.7% of parents of children in the latest birth cohort did not work compared with 9.1% of the earliest birth cohort. The difference was statistically significant.

Table 4.11: Socioeconomic status of the study sample by birth cohorts (unweighted n, weighted column %)

	Born 89/90	Born 91/92	Born 93/94	All
Annual family income (n=598)				
<AU$40k	60 (40.6)	84 (42.4)	103 (41.5)	**247 (41.5)**
AU$40k to 80k	74 (46.3)	85 (43.8)	112 (43.9)	**271 (44.6)**
>AU$80k	19 (13.1)	28 (13.8)	33 (14.6)	**80 (13.9)**
Education attainment, female parent * (n=627)				
High school	86 (50.0)	122 (58.8)	167 (61.0)	**375 (57.1)**
Vocational training	22 (12.9)	37 (15.8)	41 (17.4)	**100 (15.6)**
University	48 (37.1)	52 (25.3)	50 (21.6)	**150 (27.4)**
Education attainment, male parent (n=627)				
High school	54 (40.1)	78 (47.9)	119 (50.5)	**251 (46.6)**
Vocational training	39 (29.9)	52 (27.9)	52 (23.9)	**143 (27.0)**
University	38 (29.9)	35 (24.2)	49 (25.5)	**122 (26.4)**
Education attainment, highest of the two parents * (n=627)				
High school	55 (33.3)	87 (42.1)	130 (47.7)	**272 (41.6)**
Vocational training	39 (19.8)	56 (24.0)	60 (22.3)	**155 (22.2)**
University	62 (46.9)	68 (33.9)	70 (30.0)	**200 (36.2)**
Employment status, female parent * (n=618)				
Working full-time	29 (17.7)	46 (18.5)	51 (21.1)	**126 (19.2)**
Working part-time	85 (58.9)	100 (47.7)	112 (38.1)	**297 (47.5)**
Currently not working	39 (23.4)	62 (33.8)	94 (40.8)	**195 (33.3)**
Employment status, male parent (n=515)				
Working full-time	113 (83.3)	128 (77.2)	187 (83.7)	**428 (81.4)**
Working part-time	8 (9.3)	14 (9.0)	9 (4.9)	**31 (7.6)**
Currently not working	10 (7.3)	23 (13.8)	23 (11.4)	**56 (11.0)**
Employment status, highest of two parents *				
Working full-time	123 (75.6)	152 (69.1)	206 (78.4)	**481 (74.3)**
Working part-time	19 (15.3)	28 (17.1)	22 (6.9)	**69 (12.9)**
Currently not working	12 (9.1)	28 (13.8)	31 (14.7)	**71 (12.8)**

* Chi-square, p<0.05

4.3 Dietary pattern of the study population

The dietary pattern for several foods and drinks consumed is presented in Table 4.12. More than a third of children reported using sugar and soft drinks daily during the daytime. Some reported using it before going to bed. A fifth of the children reported having soft drinks before going to bed and just fewer than 14% of children used sugar at night. A quarter had chocolate daily during daytime and less than 10% had chocolate at night. Milk was used by a third of the children both during the daytime and at night.

Table 4.12: Frequency of several foods and drinks consumed in the study population in 2002/03 (unweighted n, weighted %)

	Daytime use (n=1240)		Use before going to bed (n=894)	
	n	w%	n	w%
Sugar				
Not used	719	58.0	771	86.2
Used	521	42.0	124	13.8
Soft drinks				
Not used	686	55.3	734	80.0
Used	555	44.7	183	20.0
Sweetened soft drinks				
Not used	809	65.2	762	87.9
Used	432	34.8	105	12.1
Milk				
Not used	776	55.4	653	69.4
Used	464	37.4	288	30.6
Chocolate				
Not used	931	75.1	801	91.4
Used	309	24.9	75	8.6

Daytime use: Not used: once a day or less; Used: Twice a day or more
Before bed use: Not used: not used at all; Used: Once a day or more

4.4 Fluoride exposures among South Australian children

4.4.1 Exposure to fluoride from water

Table 4.13 presents the proportion of lifetime the children spent in a fluoridated area by sex, residential location, and birth cohort. Some 19% of the children had virtually never lived in a fluoridated area, whereas 63% had lived all their life in a fluoridated area. Another 10% of the children had 50% or less of their lifetime in a fluoridated area.

There was no significant difference in proportion of lifetime living in a fluoridated area between groups by sex. There were slightly more girls living in a fluoridated area for their whole lifetime compared to boys, but the difference was not significant.

The children from different residential locations differed significantly in proportion of lifetime spent in a fluoridated area. Some 84% of the children from fluoridated Adelaide had lived all their life in an area with water fluoridation, whereas two-thirds of the children residing in other areas had 0% lifetime living in a fluoridated area.

Birth cohorts did not significantly differ in proportion of lifetime living in a fluoridated area. There were slightly more children of the earliest birth cohort who were lifelong residents in a fluoridated area compared to other two birth cohorts. However, the difference was not significant.

Table 4.13: Proportion of lifetime of South Australian children spent in a fluoridated area by sex, residential location, and birth cohorts (n=625) (weighted %)

	Proportion of lifetime living in a fluoridated area			
	Almost 0%	Some but less than or equal to 50%	More than 50%	Almost 100%
Total	**18.5**	**10.0**	**8.9**	**62.6**
Sex				
Boys	18.6	9.7	11.3	60.4
Girls	18.5	10.2	6.3	65.0
Residential location *				
Adelaide	0.0	6.9	9.3	83.8
Other areas	73.2	19.1	7.0	0.6
Birth cohort				
Born 89/90	20.8	5.1	6.7	67.4
Born 91/92	16.7	13.1	10.4	59.9
Born 93/94	18.6	10.9	9.0	61.5

* Chi square, $p<0.05$

Table 4.14 presents the proportion of public water consumed by South Australian children. One fifth of the population did not consume public water at all, whereas a similar proportion of the children consumed public water only. There were no differences in public water consumption between boys and girls. However, children from different residential areas differed significantly in the proportion of public water usage. Birth cohorts did not significantly differ in terms of public water consumption.

Table 4.14: Public water consumption by South Australian children (n=623)

	Proportion of public water consumption				
	Almost none	Less than half	About half	More than half	Almost all
Total	**19.7**	**20.9**	**18.6%**	**21.5**	**19.2**
Sex					
Boys	18.1	22.9	18.4	20.3	20.3
Girls	21.4	19.0	18.7	22.8	18.0
Residential location *					
Adelaide	16.9	22.8	19.3	22.6	18.4
Other areas	28.0	15.3	16.6	18.5	21.7
Birth cohort					
Born 89/90	19.5	23.6	19.5	19.0	18.4
Born 91/92	19.1	16.8	20.5	21.8	21.8
Born 93/94	20.5	22.8	16.0	23.3	17.4

* Chi square, $p<0.05$

The estimated lifetime exposure to fluoride in the water supply was cross-tabulated with the calculated per cent of exposure to fluoride in water until the child's sixth birthday (Table 4.15). A total of 270 children did not have any exposure to fluoride in water in the first six years of life or during their lifetime. A group of children who were not exposed to fluoridated water until age six had been exposed to fluoride subsequently. Some 112 children were exposed to fluoridated water for more than 50% of their lifetime both in the first six years and the whole lifetime.

Table 4.15: Cross-tabulation of lifetime exposure to fluoride in water and exposure to fluoride until age six (n=623) (unweighted n)

	Exposure until age six			
Lifetime exposure	**0% lifetime**	**>0 & ≤50% lifetime**	**>50% lifetime**	**Total**
0% lifetime	270	0	0	**270**
>0 & ≤50% lifetime	20	165	23	**208**
>50% lifetime	0	33	112	**145**
Total	**290**	**198**	**135**	**623**

Boys and girls did not differ significantly in proportion of lifetime exposure to fluoride in water for the whole lifetime or before the sixth birthday. However, there were still some variations. Slightly more girls were exposed to fluoridated water for more than 50% of their lifetime up to age six as compared to boys. Over 35% of girls had more than 50% of their first six years exposed to fluoride in water compared to less than 30% of boys.

Children from different residential locations, however, differed significantly in lifetime exposure to fluoride in water. Only a few children from Adelaide, the fluoridated area, had no exposure to fluoride. Over 37% had more than 50% of their lifetime exposed to optimal fluoride level. A slightly lower proportion was exposed to fluoridated water for more than half of their first six years. This proportion was low in the areas other than Adelaide, where the vast majority had no exposure or less than a half of lifetime exposure to fluoride in water.

Patterns of lifetime exposure to fluoride were also not significantly different between children born in the three birth cohorts. The earliest birth cohorts (born in 89/90) had a higher proportion of subjects who had no exposure but fewer children with less than 50% lifetime exposed to fluoride in water. The distribution in the upper end of the exposure pattern was similar between cohorts. The distribution of exposure to fluoride until age six was similar across the birth cohorts.

There were variations in levels of lifetime exposure to water fluoridation between groups by socioeconomic status. The three income groups were similar in terms of the proportion of children who had no exposure to fluoride during their entire lifetime. However, children from households with a lower income were more likely to have more than 50% of their lifetime exposed to fluoride in water. Children from households with a high income were more likely to have some but less than or equal to 50% of their lifetime exposed to fluoride.

When fluoride exposure until age six was considered, the proportion of children who had no exposure and who had more than 50% exposure were inversely related to levels of household income. The percentage of children who had some but less than 50% of their first six years of life exposed to fluoride increased as household income levels increased.

Likewise, the proportion of children who had some but less than 50% of their lifetime or the first six years of life exposed to fluoride was higher among participants whose parents had a university education. A higher percentage of children with no exposure to fluoride in water were from families where parents had a high school education or lower. The observed patterns of the association between income, parental education and exposure to fluoride were similar when lifetime exposure or exposure until age six was considered. There were no consistent patterns of association between fluoride exposure and parental employment status.

Table 4.16: Study participants by lifetime exposure to fluoride in water and exposure to fluoride in water until age six (n=631) (unweighted n, weighted row %)

	Lifetime exposure to fluoride in water			Exposure to fluoride in water until age six		
	0% lifetime	>0 & ≤50% lifetime	>50% lifetime	0% lifetime	>0 & ≤50% lifetime	>50% lifetime
Total	**270 (19.8)**	**216 (42.8)**	**145 (37.5)**	**295 (26.2)**	**198 (41.6)**	**134 (32.2)**
Sex						
Boys	140 (19.4)	110 (44.2)	71 (36.4)	154 (26.2)	107 (44.9)	61 (28.9)
Girls	130 (20.1)	106 (41.3)	71 (38.6)	141 (25.9)	91 (38.4)	73 (35.7)
Current residency						
Adelaide	*4 (1.5)	136 (49.2)	133 (49.2)	* 25 (9.5)	130 (48.9)	114 (41.6)
Other areas	266 (73.0)	80 (23.9)	12 (3.1)	270 (73.8)	68 (20.9)	20 (5.3)
Birth cohort						
Born 89/90	74 (22.9)	47 (39.1)	36 (38.0)	79 (28.4)	41 (38.5)	37 (33.1)
Born 91/92	84 (17.6)	76 (41.9)	53 (40.5)	93 (24.9)	73 (41.5)	46 (33.6)
Born 93/94	112 (19.0)	93 (47.1)	56 (33.9)	123 (25.3)	84 (44.6)	51 (30.2)
Household income						
<AU$40k	* 101 (18.7)	81 (37.4)	65 (43.9)	* 113 (26.3)	76 (38.1)	56 (35.6)
AU$40k to 80k	117 (20.5)	93 (43.7)	61 (35.7)	125 (24.8)	90 (43.9)	56 (31.3)
>AU$80k	34 (17.1)	32 (54.9)	14 (28.0)	37 (22.7)	24 (48.5)	17 (28.8)
Parent highest education attainment						
High school	* 132 (23.4)	76 (36.3)	64 (40.2)	142 (29.6)	75 (37.8)	52 (32.6)
Vocational	70 (23.0)	58 (48.9)	27 (28.1)	74 (27.0)	51 (42.1)	30 (30.9)
University	67 (13.5)	79 (46.2)	54 (40.4)	78 (21.6)	72 (46.3)	50 (32.1)
Parent employment status						
Work full-time	219 (21.4)	159 (43.0)	103 (35.7)	232 (25.8)	152 (43.9)	94 (30.2)
Work part-time	24 (14.1)	23 (35.9)	22 (50.0)	28 (22.0)	20 (34.0)	21 (44.0)
Currently not working	24 (15.2)	28 (46.8)	19 (38.0)	31 (30.3)	22 (36.4)	17 (33.3)

* Chi-square p<0.01

Table 4.17 presents the distribution of study participants' place of birth by sex, current residence and birth cohort. Similarly to the lifetime exposure, the majority of Adelaide participants were born in fluoridated areas, while the reverse was true for other areas. Place of birth in relation to water fluoridation did not significantly differ between sexes and birth cohorts.

Table 4.17: Study participants' place of birth by sex, current residence and birth cohort (n=605) (unweighted n, weighted row %)

	Born in a non-fluoridated area	Born in a fluoridated area
Total	**284 (24.1)**	**321 (75.9)**
Sex		
Boys	145 (24.2)	164 (75.8)
Girls	139 (23.8)	157 (76.2)
Current residency *		
Adelaide	15 (5.9)	244 (94.1)
Mt Gambier	219 (78.9)	59 (21.1)
Bordertown & Kingscote	50 (66.7)	18 (33.3)
Birth cohort		
Born 89/90	77 (27.0)	75 (73.0)
Born 91/92	88 (25.5)	115 (77.5)
Born 93/94	119 (22.3)	131 (76.7)

* Chi-square p<0.01

4.4.2 Exposure to fluoridated toothpaste

Just over a quarter of children started toothbrushing with toothpaste in the first year of life, while 45% started brushing in the second year (Table 4.18). Some 12.2% of children reported that they started brushing after the third birthday. Overall, over 70% of children commenced their toothbrushing with toothpaste before their second birthday.

Girls were more likely to start toothbrushing with toothpaste before their first birthday and after their third birthday, while slightly more boys started brushing during their second and third years of life. But the differences were not statistically significant.

There was no significant difference in terms of age of commencement of toothbrushing between residential locations. However, a higher percentage of children residing in areas other than Adelaide started toothbrushing either early or after 36 months of age. Children residing in Adelaide were more likely to start brushing with toothpaste between their first birthday and third birthday compared to their regional counterparts.

There was a significant difference in age when toothbrushing with toothpaste commenced between birth cohorts. More children who were born in 89/90 started brushing early. The proportion of children who started brushing in the second year of life increased from the earliest cohort to the latest cohort. There were more children from the 91/92 birth cohort who started their toothbrushing in the second year compared to the other two cohorts.

Children from families with different household incomes differed slightly in age when they started toothbrushing with toothpaste. There were only a few children from the high-income group who started brushing after their third birthday, whereas there were higher percentages for lower income groups.

Children whose parents attained a university education were more likely to start brushing in the first year of life. However, the variations between education attainment groups were not statistically significant.

Parental employment status was significantly related to the age when toothbrushing commenced. Children whose parents were full-time workers were more likely to commence brushing in their first year of life and least likely to start after 36 months of age. Almost 40% of children whose parents were not currently working started toothbrushing after their second birthday.

Table 4.18: Age when brushing with toothpaste started (n=596) (unweighted n, weighted row % in brackets)

	Age when brushing with toothpaste started			
	≤12 months	13 to 24 months	25 to 36 months	After 36 months
Total	**178 (27.2)**	**258 (45.6)**	**75 (15.0)**	**95 (12.2)**
Sex				
Boy	87 (24.1)	134 (47.1)	44 (17.9)	40 (11.0)
Girl	91 (30.4)	124 (44.2)	31 (12.0)	45 (13.4)
Current residency				
Adelaide	65 (25.4)	117 (47.3)	40 (16.4)	27 (10.9)
Other places	113 (31.8)	141 (41.2)	35 (11.0)	58 (16.0)
Birth cohort *				
Born 89/90	47 (34.7)	66 (41.9)	12 (12.5)	20 (10.9)
Born 91/92	56 (21.2)	86 (46.1)	34 (20.8)	26 (11.9)
Born 93/94	75 (27.1)	106 (48.1)	29 (11.2)	39 (13.6)
Household income				
<AU$40k	64 (27.9)	99 (43.2)	26 (13.0)	40 (17.1)
AU$40k to 80k	85 (32.6)	114 (43.7)	31 (12.4)	31 (9.9)
>AU$80k	24 (31.2)	34 (44.2)	10 (19.6)	9 (7.0)
Parent highest education attainment				
High school	62 (23.2)	116 (47.0)	39 (17.5)	39 (12.3)
Vocational training	43 (27.7)	68 (50.2)	16 (10.7)	18 (11.4)
University	73 (31.5)	74 (41.8)	18 (14.0)	27 (12.6)
Parent employment status *				
Work full-time	148 (29.2)	197 (45.7)	57 (15.3)	58 (9.9)
Work part-time	19 (27.7)	30 (45.4)	8 (14.2)	9 (12.7)
Currently not working	9 (12.4)	28 (45.8)	9 (14.5)	16 (27.3)

* Chi-square, $p<0.05$

Table 4.19 shows frequency of toothbrushing at different time points. Around 60% of children brushed their teeth once a day or less when they started toothbrushing. This percentage decreased as children got older, with almost 60% brushing twice a day or more at age five, and almost 70% reported brushing at least twice a day at the time of the study in 2002/03.

There was no significant difference between sex and residential locations in frequency of brushing. More girls started toothbrushing once a day or less. However, at age five and at the time of the study, a greater proportion of girls brushed more times a day when compared to their boy counterparts. More children residing in Adelaide brushed their teeth at least twice a day at each time point (i.e. when started, at age five and at the time of the study).

The birth cohorts differed significantly in frequency of toothbrushing at age five. The pattern was not clear, however. Children of the 91/92 birth cohort brushed their teeth less frequently than the other two cohorts. A similar pattern of brushing frequency was observed among birth cohorts at the time of the study.

Children from households with a higher income level tended to brush more frequently. This trend was statistically significant with the frequency of brushing at the time of the study.

There was no clear pattern of association between parental education level and frequency of brushing. Children whose parents had a university education tended to brush less frequently when they commenced brushing. However, this group tended to brush more frequently at the present time.

Parental employment status was significantly related to frequency of brushing. However, the pattern was not clear. Children whose parents were not working tended to brush less frequently when they started toothbrushing. At the time of the study, children from families where parents were working part-time brushed less frequently than the other two groups.

Table 4.19: Frequency of brushing when toothbrushing started, at age 5 and at the time of the study (2002/03) (weighted row % for each time point)

	Frequency of brushing					
	When brushing started (n=611)		At age 5 (n=614)		In 2002/03 (n=611)	
	≤1/day	2+/day	≤1/day	2+/day	≤1/day	2+/day
Total	**59.9**	**40.1**	**38.1**	**61.9**	**30.1**	**69.9**
Sex						
Boys	58.1	41.9	39.9	60.1	36.2	63.8
Girls	61.9	38.1	36.2	63.8	23.9	76.1
Current residency						
Adelaide	58.5	41.5	37.2	62.8	29.0	71.0
Other places	64.5	35.5	40.4	59.6	33.3	66.7
Birth cohort						
Born 89/90	60.6	39.4	* 31.2	68.8	30.4	69.6
Born 91/92	58.5	41.5	47.9	52.1	35.2	64.8
Born 93/94	60.6	39.4	33.8	66.2	24.7	75.3
Household income						
<AU$40k	63.5	36.5	42.7	57.3	* 36.2	63.8
AU$40k to 80k	60.2	39.8	36.4	63.6	28.5	71.5
>AU$80k	53.2	46.8	27.8	72.2	21.5	78.5
Parent highest education attainment						
High school	59.3	40.7	41.6	58.4	* 32.9	67.1
Vocational training	60.9	39.1	38.5	61.5	38.2	61.8
University	60.9	39.1	34.1	65.9	22.3	77.7
Parent employment status						
Work full time	* 59.5	40.5	36.9	63.1	* 28.8	71.2
Work part-time	51.3	48.7	38.5	61.5	43.6	56.4
Currently not working	76.8	23.2	46.3	53.7	25.4	74.6

* Chi-square, p<0.05

Girls were more likely to use standard concentration fluoride toothpaste (with 1000 ppm of fluoride) when they started brushing, at age five and at the time of the study (Table 4.20). The difference between sexes in the type of toothpaste used was statistically significant.

Children from different residential locations did not differ in their reported type of toothpaste used in childhood and at present. Almost 65% of the children reported using a children's low concentration fluoride toothpaste (from 400 to 550 ppm of fluoride) when they started brushing.

Children born in the earliest birth cohorts were significantly more likely to use standard toothpaste when they started brushing. The difference was still significant at age five. At the time of the study, almost all children from the earliest birth cohort brushed their teeth with standard toothpaste, whereas just less than 20% of children in the latest birth cohort still used low concentration fluoride toothpaste.

There was a similar pattern of type of toothpaste used between household income levels. There were fewer children from the moderate-income group who reported using standard toothpaste when they started brushing and at age five.

There was no significant difference in reported type of toothpaste used between groups by parental education. At age five, children whose parents had a university education tended to use a children's toothpaste. No variations were observed when toothbrushing commenced or at the time of the study.

Similarly, there was no significant difference in using standard or children's toothpaste between groups by parental employment status. Children whose parents were currently not working were more likely to use standard toothpaste at age five and at the time of the study.

Table 4.20: Type of toothpaste used when toothbrushing started, at age 5 and at the time of the study (2002/03) (weighted row %)

	Type of toothpaste					
	When brushing started (n=593)		At age 5 (n=599)		In 2002/03 (n=596)	
	Standard	Children	Standard	Children	Standard	Children
Total	**35.6**	**64.4**	**63.3**	**36.7**	**86.5**	**13.5**
Sex						
Boys	* 30.6	69.4	60.0	40.0	* 83.3	16.7
Girls	40.7	59.3	66.7	33.3	89.6	10.4
Current residency						
Adelaide	35.3	64.7	61.8	38.2	85.8	14.2
Other places	36.4	63.6	67.3	32.7	88.7	11.3
Birth cohort						
Born 89/90	* 71.8	28.2	* 92.4	7.6	* 95.0	5.0
Born 91/92	25.5	74.5	64.6	35.4	85.0	15.0
Born 93/94	17.1	82.9	39.0	61.0	81.7	18.3
Household income						
<AU$40k	36.5	63.5	69.1	30.9	86.0	14.0
AU$40k to 80k	35.3	64.7	58.5	41.5	85.7	14.3
>AU$80k	39.7	60.3	64.1	35.9	90.4	9.6
Parent highest education attainment						
High school	32.4	67.6	60.0	40.0	86.9	13.1
Vocational training	39.3	60.7	66.9	33.1	87.1	12.9
University	36.7	63.3	64.8	35.2	85.3	14.7
Parent employment status						
Work full-time	35.7	64.3	62.1	37.9	86.7	13.3
Work part-time	43.0	57.0	71.8	28.2	82.9	17.1
Currently not working	29.0	71.0	63.8	36.2	91.2	8.8

* Chi square $p<0.05$

Standard toothpaste: 1000-ppm fluoride toothpaste

Children toothpaste: 400-550-ppm fluoride toothpaste

About two-thirds of the sample used a smear of toothpaste for each brush when they first started toothbrushing, while only a few used a full brush head of toothpaste (Table 4.21). At age five, just under 60% reported using a pea-sized amount of toothpaste. At the time of the study, around 40% of the children used a full brush head amount of toothpaste for each brush. There was no notable difference in the reported amount of toothpaste used between boys and girls.

There was a slightly higher proportion of residents from places other than Adelaide who reported using a full brush head of toothpaste when they first started toothbrushing, at age five and at the time of the study. At age five, children who resided in Adelaide were more likely to use a smear amount and less likely to use a full brush head amount of toothpaste. The proportion of children using a pea-sized amount of toothpaste per brush was similar between groups by current residency when toothbrushing started and at age five.

Birth cohorts varied in terms of reported amount of toothpaste used. There were fewer children from the 93/94 birth cohort who used a full brush head of toothpaste at commencement of toothbrushing. At age five, more children from the earliest birth cohort reported using a large amount of toothpaste compared to the other two cohorts. There were just under 3% of children in the earliest birth cohort who used a smear of toothpaste at the time of the study, whereas over 10% of children in the other two cohorts did so. This difference was as expected, since children were from 8 to 13 years of age (i.e. a six-year age span).

The reported amount of toothpaste used in early childhood was related to household income. When children from the lower income groups started brushing with toothpaste they were more likely to use a smear amount of toothpaste compared to the high-income group who more frequently reported using a pea-sized amount of toothpaste. This difference diminished, as children got older.

There were no statistically significant differences between groups by parental education and employment status. Children whose parents attained a university education tended to use a pea-sized amount of toothpaste. There was no clear pattern of toothpaste use between groups by employment status.

Table 4.21: Amount of toothpaste used when toothbrushing started, at age 5 and at the time of the study (2002/03) (n=600) (weighted row %)

	Amount of toothpaste used for each brush								
	When brushing started (n=596)			At age 5 (n=600)			In 2002/03 (n=600)		
	Smear	Pea size	Full brush	Smear	Pea size	Full brush	Smear	Pea size	Full brush
Sex									
Boys	67.4	28.6	3.9	28.8	58.5	12.7	9.2	48.4	42.4
Girls	68.9	25.5	5.5	29.5	59.7	10.8	8.5	52.9	38.6
Current residency									
Adelaide	68.8	27.8	3.4	31.0	58.7	10.3	9.0	52.3	38.7
Other areas	66.7	27.2	7.8	23.2	60.6	16.1	8.4	45.8	45.8
Birth cohort									
Born 89/90	68.6	25.4	5.9	30.6	52.9	16.5	*2.9	47.1	50.0
Born 91/92	66.2	28.6	5.2	28.8	61.8	9.4	11.0	45.2	43.8
Born 93/94	70.2	27.0	2.8	28.6	61.3	10.1	11.5	58.7	29.8
Household income									
<AU$40k	* 66.2	29.9	3.9	27.4	62.4	10.3	8.5	50.0	41.5
AU$40k-80k	74.1	20.8	5.0	32.6	54.7	12.8	8.9	52.7	38.4
>AU$80k	56.4	37.2	6.4	21.8	62.8	15.4	7.8	45.5	46.8
Parental education									
High school	66.8	28.3	4.9	31.8	58.4	9.8	11.8	45.3	42.9
Vocational	75.0	19.1	5.9	25.0	63.2	11.8	8.1	48.1	43.7
University	65.6	30.7	3.7	28.7	57.4	13.9	6.1	57.5	36.4
Parental employment									
Work full-time	70.2	25.1	4.7	29.1	59.2	11.7	9.1	51.2	39.7
Work part-time	55.1	39.7	5.1	28.2	52.6	19.2	11.4	51.9	36.7
Currently not working	67.2	28.4	4.5	27.5	66.7	5.8	4.3	49.3	46.4

* Chi square p<0.05

Table 4.22 presents the proportion of children with a habit of eating and/or licking toothpaste. Girls were significantly more likely to have this habit when they started toothbrushing. Residents from Adelaide were significantly less likely to eat and/or lick toothpaste compared to children from other areas. There was no significant difference between birth cohorts when toothbrushing was commenced. However, children from the latest birth cohort were more likely to report having that habit at age five. There were more children from families where parents had vocational training that had this habit when they started toothbrushing.

Table 4.22: Eating and/or licking toothpaste habit when brushing started, and at age five
(n=600) (weighted row %)

	Eating and/or licking toothpaste habit			
	When brushing started (n=595)		**At age 5** (n=599)	
	Yes	**No**	**Yes**	**No**
Total	**48.9**	**51.1**	**38.4**	**61.6**
Sex				
Boy	* 44.5	55.5	36.9	63.1
Girl	53.4	46.6	39.9	60.1
Current residency				
Adelaide	* 46.2	53.8	* 36.1	63.9
Other places	56.8	43.2	45.2	54.8
Birth cohort				
Born 89/90	49.4	50.6	* 35.9	64.1
Born 91/92	42.7	57.3	29.1	70.9
Born 93/94	54.6	45.4	49.5	50.5
Household income				
<AU$40k	52.2	47.8	42.9	57.1
AU$40k-80k	47.5	52.5	34.1	65.9
>AU$80k	51.3	48.7	41.0	59.0
Parental education				
High school	* 42.9	57.1	35.4	64.6
Vocational	55.6	44.4	38.2	61.8
University	52.4	47.6	42.6	57.4
Parental employment				
Work full-time	50.0	50.0	40.8	59.2
Work part-time	48.7	51.3	33.3	66.7
Currently not working	47.8	52.2	32.8	67.2

* Chi-square, p<0.05

The components of toothbrushing practice were cross-tabulated with groups by lifetime exposure to fluoride in water (Table 4.23). There were no significant differences in age when toothbrushing was commenced between groups by exposure to fluoride in water. Some 57% of children who had 0% exposure used standard concentration fluoride toothpaste. However, there was a similar proportion of children who had more than 50% lifetime exposure who reported using standard concentration fluoride toothpaste. Children in the group with some but less than or equal to 50% lifetime exposure tended to use low concentration fluoride toothpaste, and were less likely to use a larger amount of toothpaste or swallow toothpaste after toothbrushing. Children who had no exposure to fluoridated water were more likely to use a larger amount of toothpaste at the two time points. This difference was significant at age five compared with children who had some but less than 50% lifetime exposure. After-toothbrushing routine did not significantly differ between exposure groups.

Table 4.23: Components of toothbrushing practice by lifetime exposure to fluoride in water (n=594) (weighted column %)

	Lifetime exposure to fluoride in water		
	0% lifetime	>0 and ≤50% lifetime	>50% lifetime
Age started toothbrushing with toothpaste			
Before 24 months	71.4	70.8	75.9
After 24 months	28.6	29.2	24.1
Toothpaste use when brushing started			
Standard F toothpaste	57.8	46.1	56.4
Low F toothpaste	42.2	53.9	43.6
Toothpaste use at age five			
Standard F toothpaste	47.0	35.5	46.3
Low F toothpaste	53.0	64.5	53.7
Amount of toothpaste when brushing started			
Pea-sized or larger	37.8	30.0	33.2
Smear size	62.2	70.0	66.8
Amount of toothpaste at age five			
Full brush head	* 73.3	67.0	73.7
Pea-sized or less	26.7	33.0	26.3
After-brushing routine when brushing started			
Swallowed toothpaste	52.9	47.5	48.0
Rinsed and spat out	47.1	52.5	52.0
After-brushing routine at age five			
Swallowed toothpaste	28.4	20.1	24.6
Rinsed and spat out	71.6	79.9	75.4

* Chi-square, $p<0.05$

4.4.3 Exposure to other sources of fluoride

Only a small proportion of the children reported using fluoride supplements in childhood (Table 4.24). There was no significant difference between boys and girls. Residents from areas other than Adelaide were significantly more likely to use fluoride supplements (13.8% versus 2.4%). Children from the earliest birth cohort were more likely to have used fluoride supplements. However, the difference was not statistically significant. A similar pattern was observed in the use of a fluoride mouth rinse, with over 8% of the sample reporting using fluoride mouth rinse. Children residing in regional areas were more likely to use a fluoride mouth rinse. However, the difference was not statistically significant.

Table 4.24: Use of fluoride supplement and fluoride mouth rinsing in the childhood (n=617) (unweighted n, weighted % of the sample used)

	Use fluoride supplement (n, w %)	Use fluoride mouth rinsing (n, w %)
Total	**48 (5.5)**	**51 (8.3)**
Sex		
Boys	21 (4.4)	24 (7.9)
Girls	27 (6.5)	27 (8.7)
Current residency		
Adelaide	* 6 (2.4)	22 (7.9)
Other areas	42 (13.8)	29 (9.4)
Birth cohort		
Born 89/90	19 (10.8)	14 (7.3)
Born 91/92	14 (6.2)	21 (10.5)
Born 93/94	15 (4.7)	16 (6.8)

* Chi-square, $p<0.05$

Table 4.25 reports the percentage of children who used infant formula and the type of water used to reconstitute infant formula powder. More than 60% of the sample used infant formula. Around 70% of them used tap water to reconstitute it. The pattern of infant formula usage was not significantly related to sex. Significantly more parents of children from regional areas reported using other water to reconstitute infant formula. While fewer children in the 91/92 birth cohort were reported to reconstitute infant formula with water other than tap water, the percentage using tap water to reconstitute infant formula appeared to be similar across birth cohorts.

Table 4.25: Use of infant formula in the study sample (n=613) (unweighted n, weighted % of the sample used formula and type of reconstitution)

	Use of infant formula		
Reconstituted	**with other water**	**with tap water**	**Total used**
Sex			
Boys	65 (14.0)	130 (47.1)	**200 (61.4)**
Girls	44 (9.7)	152 (55.0)	**199 (64.9)**
Current residency			
Adelaide	21 (7.1)	* 150 (56.1)	**174 (63.5)**
Other areas	88 (25.6)	132 (35.9)	**225 (62.0)**
Birth cohort			
Born 89/90	26 (12.0)	64 (49.7)	**91 (61.7)**
Born 91/92	33 (9.6)	90 (50.9)	**129 (60.9)**
Born 93/94	50 (14.4)	125 (51.4)	**179 (66.2)**

* Chi-square, p<0.05

4.5 Dental fluorosis among South Australian children

4.5.1 Fluorosis examination data using the TF Index

Table 4.26 presents the percentage of teeth that were examined for the TF index. Homologous pairs of teeth were similarly available for scoring. The central incisors were available in around 94% of cases, followed by lateral incisors. Canines were the least examined, with less than a third of cases having their canines assessed. The first premolars were examined in just less than half of the children. None of the comparisons of teeth examined by sex were statistically significant.

Children from different regions differed only slightly in terms of number of individual teeth available for assessment. The Adelaide group had slightly more of the anterior teeth and fewer posterior pairs of teeth.

The availability of individual teeth for the TF index was related to age of the children at fluorosis examination. Children of the earliest birth cohort had significantly more later erupting teeth present at examination. Only 15% of the latest birth cohort had their first premolars erupted and less than five per cent had canines in their mouth compared to around 80% of the earliest cohort. The difference in the number of anterior teeth was not so critical. At least 90% of cases in any birth cohort group had their incisors present.

Table 4.26: Per cent of teeth examined for the TF index (mean per cent of teeth that were examined for fluorosis)

Tooth	T14	T13	T12	T11	T21	T22	T23	T24
Total	**46.7**	**32.9**	**88.0**	**94.4**	**94.2**	**89.5**	**35.2**	**46.5**
Sex								
Boys	45.3	29.2	89.1	95.4	95.1	90.8	30.4	45.6
Girls	48.2	36.9	86.9	93.3	93.3	88.1	40.2	47.6
Current residency								
Adelaide	43.1	32.4	87.6	95.3	95.0	89.6	34.1	43.8
Other areas	49.5	33.3	88.4	93.7	93.7	89.4	36.0	48.7
Birth cohort								
Born 89/90	86.0	77.8	92.4	91.8	90.6	92.4	83.6	87.7
Born 91/92	56.3	34.8	92.9	94.2	94.2	93.3	36.6	55.8
Born 93/94	15.2	4.3	81.6	96.1	96.5	84.8	4.6	14.2

Table 4.27 presents the distribution of TF scores on central incisors. Almost 15% of children had a TF score of 1 on their central incisors while less than 10% presented with a TF score of 2. Only a few children were assessed as having a TF score of 3 on these two teeth. There were no children with a TF score higher than 3.

The severity scores by the TF index were related to sex and current residential location. Significantly more girls had fluorosis with a TF score of 1 and 2 compared with their boy counterparts. This difference was more than two-fold when only a TF score of 2 was considered. The proportion of children having a TF score of 3 was similar between boys and girls. Almost 16% of the children from Adelaide had a TF score of 1 compared to 10% of the children from other areas. The difference in proportion having a TF score of 2 was more than three-fold between the two groups. Differences between birth cohorts will be presented later, in Section 4.5.5.

Table 4.27: Distribution of participants with different severity scores of TF index (unweighted n, weighted %, TF score 0 not shown)

	TF score on central incisors		
	TF Score 1	TF Score 2	TF Score 3
Total	**88 (14.4)**	**47 (9.5)**	**10 (1.8)**
Sex *			
Boys	39 (12.9)	15 (6.3)	6 (2.0)
Girls	49 (16.2)	32 (13.0)	4 (1.7)
Current residency *			
Adelaide	49 (16.0)	32 (11.4)	7 (2.1)
Other areas	39 (10.1)	15 (3.7)	3 (1.2)

* Chi-square $p<0.05$

4.5.2 Fluorosis examination data using the Fluorosis Risk Index

Almost all assigned Classification I surface zones were assessed in this study sample for the presence and severity of fluorosis using the FRI criteria (Table 4.28). Boys and girls did not differ in the percentage of examined surface zones for this classification. There was also a similarity in the percentage of available surface zones between groups by residential locations. The earliest birth cohort had a slightly lower percentage, but not significantly lower, of Classification I surfaces zones examined.

On the other hand, just less than half of the surface zones which are classified as being mineralised during the period between the second and the sixth birthday were examined. This meant that an average of around 23 Classification II surface zones were included in the assessment. Girls had more of those surface zones present for examination compared to boys. Birth cohort was strongly related to percentage of Classification II surface zones present at examination. Children in the 89/90 birth cohort (i.e. aged 12/13 at examination) had four times the percentage of available surface zones for this classification present compared to children in the latest birth cohort.

Table 4.28: Percentage of FRI classification I and II surface zones examined for fluorosis (mean per cent of surfaces that were examined for fluorosis out of the total required surfaces)

	FRI classification I	FRI classification II
Total	**97.3**	**48.6**
Sex		
Boys	97.8	46.2
Girls	96.8	51.1
Current residency		
Adelaide	96.8	46.3
Other areas	97.7	50.4
Birth cohort		
Born 89/90	94.9	85.9
Born 91/92	98.5	52.5
Born 93/94	97.8	22.9

Total assigned surface zones: Classification I: 10 surface zones; Classification II: 48 surface zones

Less than one fifth of the sample had a FRI score of 1 on at least one of their Classification I surface zones, whereas 10% had a FRI score of 2 and only two children (0.4%) had a FRI score of 3 on those surfaces (Table 4.29). Girls were significantly more likely to have a FRI score of 1 on early-mineralised surface zones compared to boys. However, no such variation was observed when FRI score 2 or more was considered. There were significantly more children from the Adelaide group who appeared to have a FRI score of 1 or 2 for fluorosis on Classification I surface zones. Differences between birth cohorts will be presented later, in Section 4.5.5.

Table 4.29: Distribution of children with different FRI scores on Classification I surface zones (unweighted n, weighted %)

	FRI scores on Classification I surfaces		
	FRI Score 1	FRI Score 2	FRI Score 3
Total	**136 (22.0)**	**48 (9.9)**	**2 (0.4)**
Sex *			
Boys	60 (18.1)	26 (9.9)	2 (1.1)
Girls	76 (26.2)	22 (9.6)	0 (0.0)
Current residency *			
Adelaide	73 (23.7)	35 (12.0)	2 (0.8)
Other areas	63 (16.2)	13 (3.6)	0 (0.0)

* Chi-square, p<0.05

Table 4.30 presents findings observed on Classification II surface zones. The percentage of children who had different FRI fluorosis scores was similar to those of the Classification I surface zones. Sex again was related to distribution of FRI scores. There were significantly more girls with a FRI score of 1 and 2 on Classification II surface zones. However, no notable differences between residents of fluoridated Adelaide and other non-fluoridated areas were observed.

Table 4.30: Distribution of children with different FRI scores on Classification II surface zones (unweighted n, weighted %)

	FRI scores on Classification II surfaces		
	FRI Score 1	FRI Score 2	FRI Score 3
Total	**148 (24.3)**	**48 (7.8)**	**2 (0.1)**
Sex *			
Boys	69 (21.2)	17 (5.4)	0 (0.0)
Girls	79 (27.5)	30 (10.5)	2 (0.6)
Current residency			
Adelaide	71 (24.7)	23 (8.0)	1 (0.2)
Other areas	77 (22.8)	24 (7.2)	1 (0.1)

* Chi-square, p<0.05

4.5.3 The prevalence of dental fluorosis

The prevalence of dental fluorosis is measured by the percentage of children (weighted) having fluorosis as defined by the case definition (see Section 3.3.2.2). The prevalence of fluorosis in South Australian children as defined by the TF index is reported in Table 4.31 and Table 4.32. The prevalence of fluorosis as defined by the FRI Classification I and II is reported in Table 4.33 and Table 4.34.

4.5.3.1 The prevalence of dental fluorosis defined by the TF index

Children with fluorosis were defined as having a TF score of 1 or higher, and having a TF score of 2 or higher on their upper tooth across 14 to 24. The prevalence of fluorosis is presented in Table 4.31. Almost 30% of the sample had at least one tooth with fluorosis. Over 12% of subjects had a TF score of 2 or more on at least one of their upper teeth.

Girls were significantly more likely to have fluorosis on the examined teeth. There is over a 40% difference between the sexes in the prevalence of fluorosis defined by either of the case definitions. Children living in Adelaide had a significantly higher prevalence of fluorosis compared to children from other areas. There was almost a 60% difference in the prevalence of fluorosis defined as having a TF score of 2 or more on upper teeth.

Table 4.31: The prevalence of dental fluorosis defined as having one or more upper teeth with different TF scores (teeth examined: 14 to 24, unweighted n, weighted % of group number)

	TF score 1+			TF score 2+		
	n	w %	Crude OR (95% CI)	n	w %	Crude OR (95% CI)
Total	**170**	**29.6**		**64**	**12.6**	
Sex						
Boys	75	* 26.0	1	24	* 9.7	1
Girls	95	35.4	1.48 (1.02-1.24)	40	16.4	1.75 (1.10-2.79)
Current residency						
Adelaide	98	* 34.0	1.84 (1.29-2.62)	42	* 15.0	2.25 (1.24-4.10)
Other areas	72	19.5	1	22	6.2	1

* Chi-square, p<0.01

Table 4.32 presents the prevalence of dental fluorosis which was defined as having a TF score of 1+ and 2+ on their central incisors. A quarter of subjects had a TF score 1 or more on their central incisors, while just over 10% had a TF score of 2 or more on at least one of those two teeth.

Similarly, girls were more likely to have fluorosis as compared to boys, especially in terms of a TF score of 2 or more. Children currently residing in Adelaide had a significantly higher prevalence of fluorosis as defined by the case definitions applied to the two teeth. The difference was more pronounced when TF score of 2+ were considered as the case definition.

Table 4.32: The prevalence of dental fluorosis defined as having one or more central incisors with different TF scores (teeth examined: 11 & 21, unweighted n, weighted % of group number)

	TF score 1+			TF score 2+		
	n	w %	Crude OR (95% CI)	n	w %	Crude OR (95% CI)
Total	**145**	**26.9**		**57**	**11.8**	
Sex						
Boys	60	* 21.5	1	21	* 8.4	1
Girls	85	32.3	1.73 (1.22-2.46)	36	15.3	2.00 (1.23-3.26)
Current residency						
Adelaide	88	** 30.2	1.97 (1.33-2.91)	39	** 13.8	2.53 (1.30-4.95)
Other areas	57	15.5	1	18	5.0	1

* Chi-square, $p<0.05$

** Chi-square, $p<0.01$

4.5.3.2 The prevalence of dental fluorosis defined by the FRI

The proportion of children who were defined as having fluorosis by the FRI Classification I and II case definitions are reported in Table 4.33. More than one fifth of children satisfied the criteria for the FRI Classification I case definition. A slightly lower per cent of children were cases by the FRI Classification II case definition.

Study participants did not differ significantly in terms of case status by the FRI Classification I case definition when sex was considered. There were slightly more cases among girls, however. There was a significantly higher proportion of girl participants who satisfied the case definition of FRI Classification II. Over 30% of girls were cases compared to 20% of boys. The crude odds ratio was 1.75.

Over 30% of Adelaide participants were cases according to the FRI Classification I case definition, whereas just over 15% of their counterparts from other areas were considered cases, with the crude odds ratio of 0.46. This difference was statistically significant. The difference was still observed in the Classification II cases. However, the difference was not significant.

Table 4.33: The FRI Classification I and II cases by sex and current residence (unweighted n, weighted row % in brackets)

	FRI classification status					
	Classification I case			Classification II case		
	n	w%	Crude OR (95% CI)	n	w%	Crude OR (95% CI)
Total	**108**	**27.5**		**109**	**25.1**	
Sex						
Boys	53	24.1	1	46	20.1	1
Girls	55	31.8	1.47 (0.98-2.20)	63	30.5	1.75 (1.16-2.64)
Current residency						
Adelaide	* 68	30.5	1.87 (1.18-2.98)	55	26.6	1.27 (0.87-1.84)
Other areas	40	16.8	1	54	20.9	1

[a] Number of cases include subjects defined as cases for both classification I & II

* Chi-square, $p<0.05$

A total of 41 children satisfied the case definition for both FRI Classifications I and II (Table 4.34). The total numbers of cases in each of the two classifications were almost identical. Just fewer than 300 children served as controls for both case definitions.

Table 4.34: Fluorosis Risk Index Classification I by Classification II status (n of subjects)

Classification II	Classification I			
	Case	Control	Questionable	**Total**
Case	41	0	68	**109**
Control	0	297	101	**398**
Questionable	67	63	40	**170**
Total	**108**	**360**	**209**	**677**

4.5.4 Comparison of the two indices

Table 4.35 presents a comparison of the two indices. The vast majority of controls for FRI Classification I and II were classified as not having fluorosis by the TF Index case definition. Just over 10% of children who were defined as controls had fluorosis on their upper anterior teeth. Likewise, a lower percentage of children without fluorosis as assessed by the TF Index were classified as case for the FRI, around 8% for both FRI case definitions. Less than half of the children with fluorosis as defined by the TF Index were cases for the FRI Classification I, and an even lower per cent were cases for the FRI Classification II. Around a third of this group were classified as questionable for the FRI. High proportions of the questionable group did not have fluorosis on their upper anterior teeth.

Table 4.35: Cross-tabulation of cases and control defined by the two indices (unweighted n, weighted row and column %)

	TFI case definition [a]					
	No fluorosis			With fluorosis		
FRI case definition	n	Row w %	Col w %	n	Row w %	Col w%
FRI Classification I						
Control	323	86.9	63.1	37	13.1	22.7
Case	34	28.5	7.8	74	71.5	46.8
Questionable	150	69.4	29.0	59	30.6	30.5
FRI Classification II						
Control	358	87.8	68.8	40	12.2	22.7
Case	40	31.2	8.2	69	68.8	43.2
Questionable	109	61.6	23.0	61	38.4	34.2

[a] Defined as having TF 1+ on teeth from 14 to 24

4.5.5 Time trend of dental fluorosis

Table 4.36 presents a comparison of the prevalence of dental fluorosis defined as having different threshold TF scores on upper anterior teeth across the birth cohorts. The earliest birth cohort had a significantly higher prevalence of fluorosis as compared with the latest birth cohorts. More than a third of children who were born in 89/90 had a TF score of 1 or higher on one of their examined teeth. This prevalence was lower among children in the later birth cohorts. Crude odds ratios indicate that children who were born in the earliest two birth cohorts had significantly higher chances of having fluorosis compared to the latest birth cohort. The 91/92 birth cohort had a higher odds compared to the latest birth cohort, but the 95% CI included unity.

There was a marked difference in the percentage of children between the birth cohorts with one or more upper anterior teeth with TF score 2 or higher. The prevalence of fluorosis classified with this case definition in the earliest birth cohort was more than twice as high as that in the latest birth cohort. The prevalence of fluorosis in the 91/92 birth cohort was intermediate compared with the other two groups. The observed differences were statistically significant between the earliest and latest birth cohorts. The earliest birth cohort had almost a 1.7 odds of having fluorosis compared to the latest birth cohort.

Table 4.36: Trend in the prevalence of dental fluorosis defined as having one or more teeth with different TF scores (teeth examined: 14 to 24, unweighted n, weighted % of group number)

	TF score 1+			TF score 2+		
	n	w %	Crude OR (95% CI) [a]	n	w %	Crude OR (95% CI) [a]
Birth cohorts						
Born 89/90	55	* 38.3	1.34 (1.09-1.65)	23	** 19.7	1.68 (1.18-2.40)
Born 91/92	54	26.9	1.05 (0.86-1.29)	21	10.5	1.14 (0.82-1.58)
Born 93/94	61	25.2	1	20	8.6	1

* Chi-square, $p<0.05$

** Chi-square, $p<0.01$

[a] Crude odds ratios were calculated on 2×2 tables with the 93/94 birth cohort as reference group

The fluorosis cases defined as having one or more upper central incisors with a TF score of 1 or more, and having a TF score of 2 or more, are presented in Table 4.37. The difference in the prevalence of fluorosis defined by either case definition was statistically significant between the earliest and the latest birth cohorts. There was a clear trend of decreasing prevalence from the earliest birth cohort toward the latest birth cohorts. The earliest birth cohorts had significantly higher odds of having fluorosis defined as having a TF score of 1 or higher on their upper central incisors.

A total of 17.9% of the children born in 89/90 had at least one upper central incisor with TF score of 2 or more, which was significantly higher than that of the latest birth cohorts. Observed crude odds ratios were again significant with the 89/90 birth cohort having 1.6 higher odds of having fluorosis compared to the latest birth cohort. The 91/92 birth cohort had a higher odds compared to the latest birth cohort, but the difference was not statistically significant.

Table 4.37: Trend in the prevalence of dental fluorosis defined as having one or more upper central incisors with different TF scores (teeth examined: 11 & 21, unweighted n, weighted % of group number)

	TF score 1+			TF score 2+		
	n	w %	Crude OR (95% CI) [a]	n	w %	Crude OR (95% CI) [a]
Birth cohorts						
Born 89/90	44	* 34.7	1.30 (1.05-1.61)	19	** 17.9	1.58 (1.11-2.25)
Born 91/92	48	25.4	1.08 (0.87-1.33)	19	10.7	1.16 (0.83-1.62)
Born 93/94	53	22.1	1	19	8.3	1

* Chi-square, p<0.05

** Chi-square, p<0.01

[a] Crude odds ratios were calculated on 2×2 tables with the 93/94 birth cohort as reference group

Table 4.38 shows the severity of dental fluorosis on the central incisors by birth cohorts. There was no difference in the proportion of the children in the three birth cohort groups who had a TF score of 1 on their central incisors. However, the 89/90 birth cohort was significantly more likely to have a TF score of 2 compared to the latest birth cohort (16.3% versus 6.7%). The cohorts did not differ statistically in terms of more severe fluorosis, i.e. TF score of 3.

Table 4.38: Trend in severity of fluorosis defined as TF scores on the central incisors (unweighted n, weighted row %, TF score 0 is not shown)

	TF score on central incisors					
	TF Score 1		TF Score 2		TF Score 3	
	n	w%	n	w%	n	w%
Birth cohort						
Born 89/90	25	15.9	17	* 16.3	2	1.7
Born 91/92	29	14.9	15	8.1	4	2.5
Born 93/94	34	14.5	15	6.7	4	1.5

* Chi-square, p<0.05

The prevalence of dental fluorosis defined by the FRI Classification case definitions is presented in Table 4.39. Children in the 93/94 birth cohort had a slightly lower prevalence of fluorosis defined by the FRI Classification I case definition compared to the other two cohort groups. However, that difference was not statistically significant as indicated by chi-square test and 95% CI of crude odds ratios. The FRI Classification II case definition was strongly related to birth cohort. Just under half of the earliest birth cohort were cases for the FRI Classification II, whereas the percentages were much lower for the later two birth cohorts.

Table 4.39: Trend in the prevalence of dental fluorosis defined by FRI classification I and II case definitions

	FRI Classification I			FRI Classification II		
	n	w %	Crude OR (95% CI) [a]	n	w %	Crude OR (95% CI) [a]
Birth cohorts						
Born 89/90	23	27.6	1.03 (0.84-1.26)	51	* 47.3	2.83 (1.95-4.12)
Born 91/92	39	28.7	1.06 (0.84-1.34)	36	20.6	1.42 (1.01-1.99)
Born 93/94	46	26.2	1	22	11.8	1

* Chi-square, p<0.05

** Chi-square, p<0.01

[a] Crude odds ratios were calculated on 2×2 tables with the 93/94 birth cohort as reference group

4.5.6 The relationship of fluoride exposure with the prevalence and severity of fluorosis

4.5.6.1 The effects of frequency and amount of fluoride exposure on the experience of fluorosis

4.5.6.1.1 The prevalence and severity of fluorosis defined by the TF index and exposure to fluoride

Table 4.40 presents the bivariate associations between the prevalence of fluorosis defined as having a TF score of 1+ and a TF score of 2+ on the central incisors with patterns of toothpaste use. Children who started toothbrushing with toothpaste in the first three years had a higher prevalence of fluorosis on the central incisors compared with children who commenced toothbrushing after the third birthday. However, the differences were not statistically significant. When the age of commencement of toothbrushing was dichotomised at the age of 24 months, commencement of toothbrushing was found associated with the prevalence of fluorosis. Children who started toothbrushing before the age of 24 months had significantly higher odds of having fluorosis compared to children who commenced toothbrushing after this age.

More frequent brushing when toothbrushing started increased the chance of having a TF score of 1. More frequent brushing at age five was associated with a higher prevalence of fluorosis. But the differences were not statistically significant.

Starting toothbrushing with standard fluoride toothpaste was not associated with having a TF score of 1 or higher on the central incisors. However, when a higher case threshold was considered (TF score 2+), commencement of brushing with standard fluoride toothpaste resulted in significantly higher prevalence of fluorosis. The type of toothpaste used at age of five was not significantly associated with increased fluorosis defined as having a TF score of 1+. However, there was significantly higher prevalence of cases with a TF score of 2 and higher among children who reported using standard toothpaste at this age as compared to low concentration fluoride toothpaste users.

Using a pea-sized or larger amount of toothpaste when toothbrushing commenced significantly increased the crude odds ratios of having fluorosis defined a TF score of 1+. No significant difference was observed between the amount of toothpaste used and fluorosis defined as a TF score of 2 or higher. There was no association between fluorosis and the amount of toothpaste used at age five.

Table 4.40: Prevalence of fluorosis defined as having different TF score on the central incisors by use of toothpaste (unweighted n, weighted % of group number)

	TF score 1+			TF score 2+		
	n	w %	Crude OR (95% CI)	n	w %	Crude OR (95% CI)
Age when toothbrushing with toothpaste started [a]						
Before 1st birthday	39	28.3	1.34 (0.81-2.22)	15	13.2	1.38 (0.67-2.86)
From 1st to 2nd birthday	62	31.0	1.56 (0.91-2.67)	26	13.7	1.50 (0.69-3.24)
From 2nd to 3rd birthday	15	20.9	1.01 (0.65-1.57)	4	4.7	0.72 (0.42-1.23)
After 3rd birthday	13	20.6	1	5	8.8	1
Age when toothbrushing with toothpaste started [a] (dichotomised at age 24 months)						
Before 2nd birthday	101	* 30.0	1.44 (1.02-2.03)	41	* 13.4	1.88 (1.05-3.38)
After 2nd birthday	28	20.9	1	9	6.5	1
Frequency of brushing when toothbrushing started						
Once/day or less	73	24.7	1	32	11.1	1
Twice/day or more	60	28.9	1.23 (0.84-1.78)	19	11.0	0.96 (0.57-1.62)
Frequency of brushing at age five						
Once/day or less	41	23.5	1	15	8.6	1
Twice/day or more	93	30.4	1.44 (0.98-2.12)	36	13.3	1.61 (0.92-2.82)
Type of toothpaste when toothbrushing started						
Standard fluoride toothpaste	75	29.3	1	34	* 16.2	1
Low fluoride toothpaste	58	26.9	0.89 (0.61-1.30)	17	6.4	0.55 (0.33-0.93)
Type of toothpaste at age five						
Standard fluoride toothpaste	54	29.5	1	24	* 14.1	1
Low fluoride toothpaste	79	24.5	0.78 (0.53-1.14)	27	7.3	0.49 (0.27-0.86)
Amount of toothpaste when toothbrushing started						
Smear size	83	* 24.5	1	18	13.4	1
Pea size or larger	49	34.2	1.60 (1.10-2.34)	33	10.6	1.31 (0.77-2.22)
Amount of toothpaste at age five						
Pea size or smaller	101	28.8	1	14	12.9	1
Full brush head size	31	24.5	0.80 (0.53-1.21)	37	10.9	1.24 (0.72-2.15)

* Chi-square, $p<0.05$

[a] Crude odds ratios were calculated on 2×2 tables with starting toothbrushing after the 3rd birthday as reference group

Two measures of exposure to fluoride in water: lifetime exposure to fluoridated water from birth to the time of the study and exposure to fluoridated water from birth to age six, the use of fluoride supplements and infant formula, were evaluated against the prevalence of fluorosis defined as having different TF score thresholds on the upper central incisors (Table 4.41). Some 14% of children who were not exposed to fluoride in water presented with a fluorosis score of 1 or more on their central incisors. The prevalence of fluorosis defined by the same case definition among children who had more than 50% of their lifetime exposure was twice as high. The prevalence among children who had some but less than or equal to 50% of their lifetime exposure was intermediate to the prevalence of the other two birth cohorts. The difference was statistically significant. The relationship between exposure until age six and the prevalence of a TF score of 1+ on the central incisors was similar. The crude odds ratios for having fluorosis defined by this case definition were significant for groups with exposure to fluoride in water when compared to having zero per cent of lifetime exposure.

Some 14% of children who were exposed to water fluoridation for more than half of their life presented with a TF score of 2+ on their upper central teeth. This figure was lower among children who were exposed to fluoride to a lesser extent or not exposed at all. Children with exposure to fluoridated water had three to six times higher the odds of having fluorosis when compared to those with zero lifetime exposure.

There was no clear relationship between the use of infant formula or fluoride supplements and the prevalence of fluorosis. Children who did not use fluoride supplements had a slightly higher prevalence of fluorosis.

Table 4.41: Prevalence of fluorosis defined as TF score 1+ on central incisors by exposure to fluoride in water and other sources of fluoride (unweighted n, weighted % of group number, crude odds ratios (95% CI))

	TF score 1+			TF score 2+		
	n	w %	Crude OR (95% CI)	n	w %	Crude OR (95% CI)
Lifetime exposure to F in water [a]						
0% lifetime	35	**14.6	1	10	** 3.4	1
>0 and ≤50% lifetime	52	26.8	2.16 (1.21-3.88)	20	10.9	3.66 (1.26-10.66)
>50% lifetime	48	33.7	2.98 (1.66-5.34)	21	14.0	4.83 (1.67-13.99)
Exposure to F in water until age six [a]						
0% lifetime	37	** 14.2	1	10	** 2.7	1
>0 and ≤50% lifetime	53	30.5	2.65 (1.55-4.53)	23	11.5	4.63 (1.56-13.74)
>50% lifetime	41	31.3	2.75 (1.58-4.78)	16	14.8	6.22 (2.17-17.85)
Use of fluoride supplement						
Yes	12	24.2	1	4	6.1	1
No	121	26.2	1.13 (0.50-2.57)	45	10.6	1.88 (0.44-8.04)
Use of infant formula						
Yes	95	27.4	1	34	11.0	1
No	38	23.5	0.83 (0.58-1.17)	16	12.9	1.20 (0.74-1.93)

Chi-square: * p<0.05 ** p<0.001

[a] Crude odds ratios were calculated on 2×2 tables with having 0% lifetime exposure as reference group

The pattern of association between toothbrushing practice and the severity of fluorosis on the central incisors is presented in Table 4.42. Commencing toothbrushing in the first three years of age resulted in a higher chance of having a TF score of 1 or 2 on those teeth compared to starting brushing after the third birthday. There was a higher per cent of children who started brushing before the second birthday who had a TF score of 2 than that of children who started brushing after this time. There were only a few children with a TF score of 3 and the pattern of any association with age of commencement of brushing was not clear.

Brushing twice a day or more when toothbrushing started or at age five appeared to result in a higher chance of having a TF score of 1 or 3 on the upper centrals. Its effect on the chance of having a TF score of 2 was not clear. The differences were not significant, however.

Children who used standard concentration fluoride toothpaste when they commenced brushing were more likely to have a TF score of 2 and 3 but less likely to have having a TF score of 1. A similar pattern was observed when the type of toothpaste at age five was considered. However, none of these associations was statistically significant.

Children who reported using a pea-sized or larger amount of toothpaste when toothbrushing commenced were more likely to have a TF score of 1 or 2. However, the difference was not statistically significant. There was no consistent association between fluorosis scores and the amount of toothpaste used at age five.

Table 4.42: Distribution of TF scores on central incisors by pattern of toothpaste use (unweighted n, weighted row % in bracket, TF score 0 is not shown)

	TF score on central incisors					
	TF Score 1		TF Score 2		TF Score 3	
Age started brushing	n	w%	n	w%	n	w%
Before 1st birthday	24	15.1	14	12.7	1	0.3
From 1st to 2nd birthday	36	17.4	21	11.3	5	2.3
From 2nd to 3rd birthday	16	18.5	6	6.3	1	1.0
After 3rd birthday	3	3.0	1	1.2	1	3.0
Frequency of brushing when toothbrushing started						
Once/day or less	41	14.2	28	10.4	4	1.3
Twice/day or more	41	18.6	14	8.5	5	2.9
Frequency of brushing at age five						
Once/day or less	26	14.8	14	8.1	1	0.5
Twice/day or more	57	17.1	28	10.5	8	2.8
Type of toothpaste when toothbrushing started						
Standard fluoride toothpaste	41	15.5	27	13.4	7	2.7
Low fluoride toothpaste	41	17.0	15	5.7	2	1.1
Type of toothpaste at age five						
Standard fluoride toothpaste	30	13.6	19	13.1	5	3.0
Low fluoride toothpaste	52	17.6	23	7.7	4	1.6
Amount of toothpaste when toothbrushing started						
Smear	50	13.9	27	8.5	6	2.2
Pea-sized or larger	31	20.9	15	11.9	3	1.4
Amount of toothpaste at age five						
Pea-sized or smaller	64	17.9	33	10.1	4	0.8
Full brush head size	17	11.6	9	8.1	5	4.7

* Chi-square $p<0.05$

Table 4.43 presents the distribution of the TF score on the upper central incisors by exposure to fluoride in water and other fluoride sources. The per cent of lifetime exposure to fluoride in water was significantly associated with the TF score. Having some but less than or equal to 50% of the lifetime exposed to fluoride in water was associated with a 5% increase of a TF score of 1 or a TF score of 2 compared with having 0% lifetime exposure. Children who had been exposed to fluoride in water for more than 50% of their lifetime had around a 9% increase of a TF score of 1 or 2 on the central incisors. There was a similar association between exposure to fluoridated water until age six and distribution of TF scores on central incisors.

Children living in a non-fluoridated area who used fluoride supplements had a higher risk of having fluorosis on their central incisors. However, this difference was not statistically significant. The percentage of children with a TF score of 1 or higher on the central incisors was not different between children who used and did not use infant formula.

Table 4.43: Distribution of TF scores on central incisors by exposure to fluoride in water and other discretionary fluoride (unweighted n, weighted row % in bracket, TF score 0 is not shown)

	TF score on central incisors					
	TF Score 1		TF Score 2		TF Score 3	
Lifetime exposure to fluoridated water *	n	w%	n	w%	n	w%
0% lifetime	25	10.9	9	3.4	2	0.6
>0 and ≤50% lifetime	32	15.3	17	9.3	3	2.2
>50% lifetime	27	19.3	16	12.1	5	2.3
Exposure to fluoridated water until age six *						
0% lifetime	27	11.5	9	2.7	1	0.2
>0 and ≤50% lifetime	30	15.6	19	9.3	4	2.5
>50% lifetime	25	19.7	12	12.3	4	2.6
Use of fluoride supplement [a]						
Yes	6	15.9	3	6.9	1	1.7
No	30	9.8	11	3.4	8	1.3
Use of infant formula						
Yes	61	17.5	28	8.9	6	2.2
No	22	13.1	13	9.8	3	1.4

* Chi-square p<0.05

[a] Comparison made among residents from non-fluoridated area only

4.5.6.1.2 The prevalence and severity of fluorosis defined by the Fluorosis Risk Index and exposure to fluoride

Table 4.44 presents the percentage of FRI Classification I and II cases by toothbrushing practice. Starting toothbrushing early did not have a clear effect on the chance of being a FRI Classification I case. However, age of commencement of toothbrushing was associated with the chance of being a FRI Classification II case. Crude odds ratios showed that commencing toothbrushing in the first and second years of age significantly increased the odds of having fluorosis on those surface zones compared to commencing toothbrushing after the age of 24 months.

The frequency of brushing when toothbrushing commenced did not have a significant effect on the early forming enamel surface zones. However, brushing twice a day or more significantly increased the chance of having fluorosis on later forming enamel surface zones. The crude odds indicated that more frequent brushing was associated with almost two times the odds of having fluorosis. The difference was slightly higher when frequency of brushing at age five was considered.

Using standard concentration fluoride toothpaste when toothbrushing started significantly increased the chance of being a case of fluorosis by FRI case definitions. More than 30% of children who used standard concentration fluoride toothpaste were cases for either of the case definitions compared to just over 20% of children who used low concentration fluoride toothpaste. The crude odds ratios of having fluorosis related to the use of standard concentration fluoride toothpaste ranged from 1.6 to 3.7 compared with the use of low concentration fluoride toothpaste.

The amount of toothpaste used was not associated with the chance of being a case defined by either of the FRI case definitions. Using more than a smear of toothpaste resulted in slightly higher crude odds ratios of having fluorosis, but these differences were not statistically significant. There was no significant association between amount of toothpaste used at age five and distribution of FRI cases of fluorosis.

Table 4.44: Distribution of FRI cases by patterns of toothbrushing practice at different times (unweighted n, weighted row % in bracket, control not shown)

	FRI Classification I case			FRI Classification II case		
	n	w %	Crude OR (95%CI)	n	w %	Crude OR (95%CI)
Age started brushing [a]						
Before 1st birthday	30	28.4	1.17 (0.84-1.62)	32	* 27.8	1.89 (1.17-3.05)
From 1st to 2nd birthday	42	26.7	1.18 (0.81-1.68)	42	26.3	2.03 (1.22-3.38)
After 2nd birthday	21	22.8	1	13	11.2	1
Frequency of brushing when toothbrushing started						
Once/day or less	52	25.2	1	49	* 19.3	1
Twice/day or more	43	28.9	1.21 (0.78-1.87)	43	30.1	1.80 (1.15-2.81)
Frequency of brushing at age 5						
Once/day or less	29	23.0	1	22	* 16.0	1
Twice/day or more	67	29.1	1.37 (0.88-2.15)	70	28.5	2.12 (1.30-3.46)
Type of toothpaste when toothbrushing started						
Low fluoride toothpaste	60	23.7	1	58	* 17.1	1
Standard fluoride toothpaste	29	32.1	1.53 (0.98-2.39)	30	35.6	2.64 (1.68-4.16)
Type of toothpaste at age 5						
Low fluoride toothpaste	45	* 21.0	1	49	* 10.1	1
Standard fluoride toothpaste	47	32.9	1.60 (1.01-2.52)	42	31.4	3.76 (2.16-6.53)
Amount of toothpaste when toothbrushing started						
Smear	61	24.7	1	63	22.7	1
Pea-sized or larger	33	29.9	1.30 (0.83-2.03)	29	25.5	1.16 (0.73-1.86)
Amount of toothpaste at age five						
Pea-sized or smaller	69	26.3	1	72	24.8	1
Full brush head size	26	26.9	1.03 (0.64-1.66)	20	20.4	0.78 (0.47-1.29)

* Chi-square, p<0.05

[a] Crude odds ratios were calculated on 2×2 tables with commencing toothbrushing after 2nd birthday as reference group

Having some exposure to fluoride in the water significantly increased the chance of being a FRI Classification I case (Table 4.45). Children who were exposed to fluoride in the water had about a two-fold higher prevalence of being a FRI Classification I case compared to children who had 0% lifetime exposure. The percentage of FRI Classification II cases were also higher among children who had more than 0% of their lifetime exposed to fluoridated water, but the difference was not statistically significant. Exposure to fluoride in the water from birth to age six had a similar relationship with the prevalence of cases by the FRI classification case definitions. Crude odds ratios showed significant associations between exposure to fluoridated water during this period of life and fluorosis.

The use of fluoride supplements in non-fluoridated areas resulted in a lower prevalence of FRI Classification I cases but a higher prevalence of FRI Classification II cases. However, neither of the associations was statistically significant. The use of infant formula did not affect the chance of being a case by either of the FRI case definitions.

Table 4.45: Distribution of FRI cases by exposure to fluoride in water and other discretionary fluoride (unweighted n, weighted row % in bracket, Control not shown)

	FRI classification I case			FRI classification II case		
	n	w %	Crude OR (95%CI)	n	w %	Crude OR (95%CI)
Lifetime exposure to F in water [a]						
0% lifetime	24	* 14.7	1	34	19.0	1
>0 and ≤50% lifetime	44	30.7	2.54 (1.28-5.03)	34	23.7	1.36 (0.74-2.50)
>50% lifetime	32	28.8	2.31 (1.15-4.65)	28	27.5	1.64 (0.88-3.04)
Exposure to F in water until age six						
0% lifetime	31	* 21.1	1	35	* 16.6	1
>0 and ≤50% lifetime	35	26.7	1.85 (1.00-3.43)	37	28.4	2.18 (1.21-3.93)
>50% lifetime	33	31.7	2.40 (1.29-4.49)	24	25.2	1.93 (1.02-3.63)
Use of fluoride supplement [b]						
Yes	5	14.6	1	9	25.6	1
No	32	17.1	1.10 (0.22-5.52)	39	20.0	0.70 (0.23-2.17)
Use of infant formula						
Yes	67	27.8	1	62	23.3	1
No	31	25.4	0.95 (0.63-1.43)	33	25.7	1.25 (0.83-1.88)

* Chi-square, p<0.05

[a] Crude odds ratios were calculated on 2×2 tables with having 0% lifetime exposure as reference group

[b] Comparison made among residents from non-fluoridated area only

4.5.6.2 *Stratified analyses of the prevalence of fluorosis by lifetime exposure to fluoride in water and toothbrushing practice*

Presented in Table 4.46 through to Table 4.50 are analyses of associations between the prevalence of fluorosis and patterns of toothbrushing practice when toothbrushing started, stratified by the three levels of exposure to fluoride in water from birth to age six. Fluorosis is defined as having a TF score of 1+ or 2+ on the upper central incisors.

The age when brushing with toothpaste commenced was related to the prevalence of fluorosis but this relationship depended on the exposure to fluoridated water (Table 4.46). Children with 0% exposure to fluoride in the water had a similar prevalence of fluorosis regardless of when they commenced their toothbrushing with toothpaste. Among children with exposure to fluoride in water, commencing brushing before the second birthday was associated with higher prevalence of fluorosis. Children with more than 50% lifetime exposure who started brushing before the second birthday had significantly higher prevalence of fluorosis defined as having a TF score of 2+ on the central incisors.

Table 4.46: The prevalence of fluorosis by lifetime exposure until age six and age started brushing (w% of group number)

		Prevalence of fluorosis [a]			
		TF score 1+		TF score 2+	
Exposure to F in water to age six	Age when brushing with toothpaste started	w%	Crude OR (95% CI)	w%	Crude OR (95% CI)
0% lifetime	Before 2nd birthday	15.1	1	3.2	1
	After 2nd birthday	14.0	0.92 (0.33-2.57)	2.3	0.99 (0.93-1.05)
>0 and ≤50% lifetime	Before 2nd birthday	31.3	1	11.8	1
	After 2nd birthday	23.7	0.68 (0.34-1.36)	13.3	1.15 (0.42-3.15)
>50% lifetime	Before 2nd birthday	35.8	1	* 19.0	1
	After 2nd birthday	26.1	0.63 (0.30-1.34)	5.0	0.24 (0.07-0.76)

* Chi-square, p<0.05

[a] Defined as having TF score of 1+ or 2+ on central incisors

Table 4.47 presents a stratification of children by lifetime exposure to water fluoridation from birth to age six and type of toothpaste used when toothbrushing started. There was no clear relationship between the type of toothpaste and fluorosis among children who had 0% of their lifetime exposed to fluoridated water. Using standard concentration fluoride toothpaste when toothbrushing started among children with some exposure to fluoride in the water was associated with higher odds of having fluorosis. Using standard toothpaste when being exposed to fluoride in water for more than 50% of lifetime increased the risk of having a TF score of 2+ on the central incisors for almost three times.

Table 4.47: The prevalence of fluorosis by lifetime exposure and type of toothpaste used when brushing started (w% of group number)

Exposure to F in water to age six	Toothpaste type when brushing started	Prevalence of fluorosis			
		TF score 1+		TF score 2+	
		w%	Crude OR (95% CI)	w%	Crude OR (95% CI)
0% lifetime	Low F toothpaste	18.1	1	3.6	1
	Standard F toothpaste	8.9	0.44 (0.15-1.30)	3.6	1.00 (0.16-6.18)
>0 and ≤50% lifetime	Low F toothpaste	28.9	1	8.3	1
	Standard F toothpaste	36.1	1.39 (0.75-2.57)	16.7	2.20 (0.89-5.44)
>50% lifetime	Low F toothpaste	28.4	1	* 11.5	1
	Standard F toothpaste	37.2	1.49 (0.80-2.77)	27.4	2.91 (1.41-6.02)

* Chi-square, $p<0.05$

[a] Defined as having a TF score of 1+ or 2+ on central incisors

More frequent brushing was not associated with the prevalence of fluorosis irrespective of the per cent of lifetime exposure to fluoride in water (Table 4.48). Brushing twice a day or more when toothbrushing started did not significantly increase the risk of having fluorosis among children with or without an exposure to fluoride in the water.

Table 4.48: The prevalence of fluorosis by lifetime exposure and frequency of brushing when brushing started (w% of group number)

Exposure to F in water to age six	Frequency of brushing when brushing started	Prevalence of fluorosis [a]			
		TF score 1+		TF score 2+	
		w%	Crude OR (95% CI)	w%	Crude OR (95% CI)
0% lifetime	≤ 1 time/day	10.8	1	3.2	1
	2+ times/day	23.4	2.54 (0.98-6.50)	4.3	1.35 (0.22-8.36)
>0 and ≤50% lifetime	≤ 1 time/day	32.4	1	17.6	1
	2+ times/day	25.9	0.73 (0.40-1.32)	11.8	0.63 (0.29-1.37)
>50% lifetime	≤ 1 time/day	30.0	1	11.0	1
	2+ times/day	34.9	1.25 (0.68-2.32)	12.6	1.17 (0.48-2.85)

Chi-square, $p>0.05$

[a] Defined as having TF score of 1+ or 2+ on central incisors

The amount of toothpaste used had a varying effect on the prevalence of fluorosis at different levels of exposure to water fluoridation (Table 4.49). Among children with 0% of the lifetime exposure to fluoridated water, the amount of toothpaste used per brushing was associated with a slightly higher prevalence of fluorosis but the differences were not significant. Children with more than 50% lifetime exposure to fluoride in the water who used more than a smear of toothpaste when toothbrushing commenced had a significantly higher prevalence of fluorosis defined as having a TF score of 1+ on the central incisors. Using more than a smear of toothpaste among children with some but less than or equal 50% of their lifetime exposed to fluoridated water was associated with a higher prevalence of fluorosis but the differences were not significant.

Table 4.49: The prevalence of fluorosis by lifetime exposure and amount of toothpaste used when brushing started (w% of group number)

Exposure to F in water to age six	Toothpaste amount when brushing started	Prevalence of fluorosis [a]			
		TF score 1+		Tf score 2+	
		w%	Crude OR (95% CI)	w%	Crude OR (95% CI)
0% lifetime	Smear	13.7	1	3.2	1
	Pea-sized or larger	17.8	1.36 (0.52-3.57)	4.4	1.42 (0.23-8.85)
>0 and ≤50% lifetime	Smear	29.1	1	13.3	1
	Pea-sized or larger	34.3	1.27 (0.70-2.31)	21.1	1.74 (0.84-3.60)
>50% lifetime	Smear	* 25.4	1	11.4	1
	Pea-sized or larger	46.0	2.50 (1.32-4.76)	14.1	1.27 (0.52-3.13)

* Chi-square, $p<0.05$

[a] Defined as having TF score of 1+ or 2+ on central incisors

Children with an eating and/or licking toothpaste habit had an increased risk of having fluorosis, which was more pronounced among children with exposure to fluoride in water (Table 4.50). Children with 0% of lifetime exposure to fluoride in the water who had this habit had a higher prevalence of fluorosis but the difference was not significant. Children with some exposure to fluoridated water who had this habit had a significantly higher prevalence of fluorosis defined as having a TF score of 1+. Among children with more than 50% of their lifetime exposed to fluoride in the water, having the eating and/or licking toothpaste habit was associated with 3.7 times higher the likelihood of having a TF score of 2+ on their central incisors compared to children who did not have that habit.

Table 4.50: The prevalence of fluorosis by lifetime exposure and an eating and/or licking toothpaste habit when brushing started (w% of group number)

Exposure to F in water to age six	Eating and/or licking toothpaste when brushing started	Prevalence of fluorosis [a]			
		TF score 1+		TF score 2+	
		w%	Crude OR (95% CI)	w%	Crude OR (95% CI)
0% lifetime	Never	12.9	1	3.2	1
	Eating and/or licking	16.9	1.37 (0.53-3.55)	3.9	1.24 (0.20-7.64)
>0 and ≤50% lifetime	Never	* 22.3	1	13.3	1
	Eating and/or licking	38.8	2.21 (1.24-3.93))	18.2	1.45 (0.71-2.96)
>50% lifetime	Never	* 26.4	1	* 6.4	1
	Eating and/or licking	41.3	1.97 (105-3.68)	20.0	3.68 (1.42-9.53)

* Chi-square, $p<0.05$

[a] Defined as having TF score of 1+ or 2+ on central incisors

4.5.7 Risk factors for dental fluorosis

4.5.7.1 Logistic regression models for having dental fluorosis defined by the TF index

Binary logistic regression models using the Enter method were generated for the prevalence of dental fluorosis defined as having a TF score of 1+ or 2+ on the upper central incisors. The results are presented in Table 4.51 to Table 4.53. Independent variables were entered into the models as a block. Odds ratios and 95% confidence intervals are reported in the tables. Variables are indicated as significant or non-significant based on 95% confidence intervals of odds ratios. A variable was statistically significant if its 95% CI did not include unity.

Table 4.51 presents the logistic regression model for the prevalence of fluorosis defined as having a TF score of 1+ on the central incisors. Sex, lifetime exposure to fluoride in water, and several patterns of use of toothpaste were contributing factors to the model. Birth cohort was not significant in the presence of all other factors in the model.

Being a girl was associated with a significantly higher likelihood of having fluorosis compared to being a boy. Lifetime exposure to fluoride in water was a significant contributor in the model. Children with exposure to water fluoridation had just less than three times the odds of having fluorosis compared to children with 0% lifetime exposure.

Children who commenced toothbrushing in the first three years of life had a higher likelihood of having the condition. The odds ratios for these three groups were not significant. But the lower end of the 95% CI was close to unity. The ranges of the 95% confidence intervals of these odds ratios were relatively wide, showing the likely effect of a low number of cases in these groups.

Using more than a smear amount of toothpaste when toothbrushing commenced had an odds ratio of 1.8 over use of a smear amount only. An eating and/or licking toothpaste habit resulted in a significantly higher likelihood (odds ratio: 2.6) of having the condition on the central incisors.

Table 4.51: Logistic regression of prevalence of fluorosis defined as TF score 1+ on central incisors

Explanatory variables	Odds Ratio (95% CI)
1. Sex	
Boys	Ref
Girls	** 1.94 (1.26-2.98)
2. Birth cohorts	
Born 89/90	^{ns} 1.27 (0.63-2.57)
Born 91/92	^{ns} 1.15 (0.64-2.07)
Born 93/94	Ref
3. Lifetime exposure to F, birth to age six	
50%< lifetime	**2.89 (1.54-5.42)
0< and ≤50% lifetime	**2.83 (1.47-5.45)
0% lifetime	Ref
4. Age brushing started	
Before 1st birthday	^{ns} 3.61 (0.87-14.88)
From 1st to 2nd birthday	^{ns} 3.88 (0.97-15.56)
From 2nd to 3rd birthday	^{ns} 3.98 (0.95-16.74)
After 3rd birthday	Ref
5. Infant formula use	
Used	^{ns} 0.91 (0.58-1.42)
Not used	Ref
6. Brushing frequency when brushing started	
Once a day or less	^{ns} 0.80 (0.49-1.31)
Twice a day or more	Ref
7. Brushing frequency at age five	
Once a day or less	^{ns} 0.79 (0.46-1.34)
Twice a day or more	Ref
8. Type of toothpaste when brushing started	
Standard toothpaste	^{ns} 1.29 (0.77-2.16)
Low F toothpaste	Ref
9. Type of toothpaste at age five	
Standard toothpaste	^{ns} 0.72 (0.40-1.30)
Low F toothpaste	Ref
10. Toothpaste amount when brushing started	
Pea size or larger	*1.79 (1.08-2.98)
Smear size	Ref
11. Toothpaste amount at age five	
Full brush head size	^{ns} 1.17 (0.59-2.31)
Pea size or smaller	Ref
12. After brush routine when brushing started	
Swallowed toothpaste	^{ns} 0.99 (0.58-1.69)
Rinsed and spat	Ref
13. After brush routine at age five	
Swallowed toothpaste	^{ns} 1.44 (0.82-2.55)
Rinsed and spat	Ref
14. Eating/licking toothpaste when brushing started	
Yes	**2.61 (1.52-4.48)
No	Ref
15. Eating/licking toothpaste at age five	
Yes	^{ns} 0.90 (0.50-1.53)
No	Ref
16. Use F supplement	
Yes	^{ns} 0.98 (0.38-2.57)
No	Ref

Analysis using n=530 with complete data on all variables, Nagelkerke R^2=0.21

ns: p>0.05; *: p<0.05; **: p<0.001; Ref: Reference category for odds ratios

Table 4.52 presents the logistic regression model for the prevalence of fluorosis defined as having a TF score of 2+ on the central incisors. Sex was a significant factor in the model, with girls having higher odds of having a TF score of 2 or higher. Having more than 50% or some but less than or equal to 50% of the first six years of life exposed to fluoride in the water significantly increased the odds of having fluorosis compared with having 0% lifetime exposure.

Using standard concentration fluoride toothpaste when toothbrushing commenced increased the likelihood of having a TF score of 2 or more on the central incisors by 2.7 times, compared to using low concentration fluoride toothpaste. Having an eating and/or licking toothpaste habit in the early years was also a significant risk factor for having fluorosis, defined by this case definition. Patterns of the use of toothpaste at age five were not significant factors to the model.

Birth cohort was not significant in the model. Children who were born in different birth cohorts were similar in their likelihood of having fluorosis on their upper central incisors when all other variables were in the model. The use of fluoride supplements in childhood and the use of infant formula were not significant factors for the condition.

Table 4.52: Logistic regression model of prevalence of dental fluorosis defined as TF score 2+ on central incisors

Explanatory variables	Odds Ratio (95% CI)
1. Sex	
Boys	Ref
Girls	* 2.06 (1.11-3.83)
2. Birth cohorts	
Born 89/90	ns 0.94 (0.34-2.52)
Born 91/92	ns 1.02 (0.41-2.52)
Born 93/94	Ref
3. Lifetime exposure to F, birth to age six	
50%< lifetime	** 7.81 (2.44-24.96)
0< and ≤50% lifetime	* 5.22 (1.56-17.42)
0% lifetime	Ref
4. Age brushing started	
Before 1st birthday	ns 1.16 (0.15-8.94)
1st to 2nd birthday	ns 1.35 (0.18-10.07)
2nd to 3rd birthday	ns 0.96 (0.11-8.26)
After 3rd birthday	Ref
5. Infant formula use	
Used	ns 1.00 (0.56-1.82)
Not used	Ref
6. Brushing frequency when brushing started	
Once a day or less	ns 1.73 (0.88-3.43)
Twice a day or more	Ref
7. Brushing frequency at age five	
Once a day or less	ns 0.53 (0.26-1.09)
Twice a day or more	Ref
8. Type of toothpaste when brushing started	
Standard toothpaste	**2.70 (1.37-5.34)
Low F toothpaste	Ref
9. Type of toothpaste at age five	
Standard toothpaste	ns 0.76 (0.32-1.79)
Low F toothpaste	Ref
10. Toothpaste amount when brushing started	
Pea size or larger	ns 1.50 (0.76-2.95)
Smear size	Ref
10. Toothpaste amount at age five	
Full brush	ns 0.60 (0.21-1.70)
Pea size or smaller	Ref
11. After brushing routine when brushing started	
Swallowed toothpaste	ns 1.06 (0.51-2.23)
Rinsed and spat	Ref
11. After brushing routine at age five	
Swallowed toothpaste	ns 1.04 (0.47-2.29)
Rinsed and spat	Ref
12. Eating/licking toothpaste when brushing started	
Yes	* 2.27 (1.03-5.03)
No	Ref
13. Eating/licking toothpaste at age five	
Yes	ns 1.71 (0.82-3.57)
No	Ref
14. Use fluoride supplement	
Yes	ns 0.70 (0.13-3.69)
No	Ref

Analysis using N=512 with complete data on all variables, Nagelkerke R^2=0.26

ns: p>0.05; *: p<0.05; **: p<0.001; Ref: Reference category for odds ratios

Table 4.53 presents the logistic regression model for the prevalence of fluorosis defined as having a TF score 2+ on the central incisors without type of toothpaste used when toothbrushing started and at age five. The cohort effect was significant. Children who were in the 89/90 birth cohort had significantly higher odds of having fluorosis compared to the latest cohort. Other factors remained almost unchanged compared to the model where type of toothpaste was included.

Table 4.53: Logistic regression model of prevalence of dental fluorosis defined as TF score 2+ on central incisors without type of toothpaste when toothbrushing started and at age five

Explanatory variables	Odds Ratio (95% CI)
1. Sex	
Boys	Ref
Girls	* 2.24 (1.22-4.12)
2. Birth cohorts	
Born 89/90	* 2.71 (1.27-5.78)
Born 91/92	ns 1.94 (0.88-4.29)
Born 93/94	Ref
3. Lifetime exposure to F, birth to age six	
50%< lifetime	** 7.14 (2.27-22.40)
0< and ≤50% lifetime	* 5.19 (1.57-17.13)
0% lifetime	Ref
4. Age brushing started	
Before 1st birthday	ns 1.71 (0.24-12.35)
1st to 2nd birthday	ns 1.90 (0.27-13.17)
2nd to 3rd birthday	ns 1.00 (0.12-8.07)
After 3rd birthday	Ref
5. Infant formula use	
Used	ns 0.80 (0.43-1.50)
Not used	Ref
6. Brushing frequency when brushing started	
Once a day or less	ns 1.46 (0.71-3.00)
Twice a day or more	Ref
7. Brushing frequency at age five	
Once a day or less	ns 0.56 (0.26-1.19)
Twice a day or more	Ref

Explanatory variables	Odds Ratio (95% CI)
8. Toothpaste amount when brushing started	
Pea size or larger	* 2.04 (1.07-3.91)
Smear size	Ref
9. Toothpaste amount at age five	
Full brush	ns 0.65 (0.23-1.84)
Pea size or smaller	Ref
10. After brushing routine when brushing started	
Swallowed toothpaste	ns 1.04 (0.49-2.20)
Rinsed and spat	Ref
11. After brushing routine at age five	
Swallowed toothpaste	ns 1.46 (0.68-3.15)
Rinsed and spat	Ref
12. Eating/licking toothpaste when brushing started	
Yes	* 2.15 (1.00-4.64)
No	Ref
13. Eating/licking toothpaste at age five	
Yes	ns 1.40 (0.68-2.92)
No	Ref
14. Use fluoride supplement	
Yes	ns 0.64 (0.12-3.43)
No	Ref

Analysis using N=512 with complete data on all variables, Nagelkerke R^2=0.23

ns: p>0.05; *: p<0.05; **: p<0.001; Ref: Reference category for odds ratios

4.5.7.2 Logistic regression models for having dental fluorosis defined by the FRI Classification I and II

Binary logistic regression models using the Enter method were generated for cases of dental fluorosis defined by the FRI Classification I and II case definitions. The results are presented in Table 4.54 through to Table 4.56. Independent variables were entered into the models as a block. The odds ratios and their 95% confidence intervals are reported in tables. The variables are indicated as significant if their 95% CI did not include unity.

Table 4.54 presents the results of the logistic regression model for the FRI Classification I case definition. Girls had a significantly higher odds ratio of being cases compared to boys. Having exposure to fluoride in water for more than 50% of the first six years of life resulted in 2.4 times the likelihood of having the condition. Birth cohorts were not a significant variable in the model.

Commencing toothbrushing during the second year of life resulted in a significantly higher likelihood of having the condition on early forming surfaces. Also, using standard concentration fluoride toothpaste when brushing started was associated with a 2.6 times higher chance of being a case. Other components of toothbrushing practice were not significant in the model.

Table 4.54: Logistic regression model of FRI Classification I cases of fluorosis

Explanatory variables	Odds Ratio (95% CI)
1. Sex	
Boys	Ref
Girls	* 1.77 (1.07-2.93)
2. Birth cohorts	
Born 89/90	ns 0.98 (0.52-1.85)
Born 91/92	ns 1.04 (0.60-1.80)
Born 93/94	Ref
3. Lifetime exposure to fluoride, birth until age six	
50%< lifetime	**2.41 (1.18-4.91)
0< and ≤50% lifetime	ns 1.60 (0.78-3.62)
0% lifetime	Ref
4. Age brushing started	
Before 12 months	ns 1.47 (0.59-3.65)
12 to 24 months	* 1.66 (1.05-3.04)
After 24 months	Ref
5. Infant formula use	
Used	ns 1.15 (0.68-1.94)
Not used	Ref

Explanatory variables	Odds Ratio (95% CI)
6. Brushing frequency when brushing started	
Once a day or less	ns 0.96 (0.57-1.63)
Twice a day or more	Ref
7. Type of toothpaste when brushing started	
Standard	** 2.56 (1.46-4.50)
Low F toothpaste	Ref
8. Toothpaste amount when brushing started	
Pea size or larger	ns 1.35 (0.80-2.30)
Smear size	Ref
9. After brush routine when brushing started	
Swallowed toothpaste	ns 1.18 (0.68-2.05)
Rinsed and spat	Ref
10. Eating/licking toothpaste when brushing started	
Yes	ns 1.27 (0.75-2.17)
No	Ref
11. Use of F supplement	
Yes	ns 0.22 (0.02-2.18)
No	Ref

Analysis using N=396 with complete data on all variables, Nagelkerke R^2=0.14

ns: p>0.05; *: p<0.05; **: p<0.001; Ref: Reference category for odds ratios

Table 4.55 presents the logistic regression model for FRI Classification II cases of fluorosis. Thirty per cent of variance was explained by the model. Being a girl significantly increased the chance of being a case of fluorosis according to this case definition compared to being a boy. Children who were born in 89/90 had significantly higher odds of being cases in this model compared to children from the latest birth cohort. The middle birth cohort group was not significantly different compared with the latest birth cohort.

Lifetime exposure to fluoride was not a significant factor for being case by this case definition. Having some exposure to fluoride in water resulted in higher odds of being a case, but this was not significant. The use of infant formula and fluoride supplements were also not significant factors in the model.

Children who commenced their brushing with toothpaste before their second birthday had a significantly higher likelihood of being cases in this model. Compared to children who commenced brushing after the second birthday, commencing toothbrushing in the first year of life and in the second year resulted in three times and two times higher odds respectively of having the condition on enamel surfaces that formed after 24 months of age.

Brushing frequency when toothbrushing was commenced was related to the chance of having fluorosis on these later forming surfaces. Brushing teeth once a day or less halved the chance of having fluorosis on later forming enamel surface zones in this model compared to brushing twice a day or more. Brushing frequency at age five was not a significant predictor.

Another component of toothbrushing practice, the type of toothpaste used when brushing started, was also a significant factor in the model. Children who reported using standard concentration fluoride toothpaste at an early age had three times the odds of having fluorosis on later forming enamel surface zones. The type of toothpaste used at age five was not significant in the model.

Table 4.55: Logistic regression model of FRI Classification II cases of fluorosis

Explanatory variables	Odds Ratio (95% CI)
1. Sex	
Boys	Ref
Girls	* 2.18 (1.21-3.92)
2. Birth cohorts	
Born 89/90	** 5.40 (2.60-11.19)
Born 91/92	ns 2.06 (0.98-4.33)
Born 93/94	Ref
3. Lifetime exposure to fluoride in water	
50%< lifetime	ns 1.71 (0.77-3.3)
0< and ≤50% lifetime	ns 1.14 (0.52-2.51)
0% lifetime	Ref
4. Age brushing started	
Before 12 months	* 3.07 (1.20-7.84)
From 12 to 24 months	* 1.99 (1.09-3.63)
After 24 months	Ref
5. Infant formula use	
Used	ns 0.7 (0.40-1.23)
Not used	Ref
6. Brushing frequency when brushing started	
Once a day or less	* 0.48 (0.25-0.92)
Twice a day or more	Ref
7. Brushing frequency at age five	
Once a day or less	ns 0.55 (0.27-1.13)
Twice a day or more	Ref
8. Type of toothpaste when brushing started	
Standard toothpaste	* 3.01 (1.21-7.49)
Low F toothpaste	Ref
9. Type of toothpaste at age five	
Standard toothpaste	ns 0.69 (0.30-1.56)
Low F toothpaste	Ref
10. Toothpaste amount when brushing started	
Pea size or larger	ns 1.41 (0.70-2.86)
Smear	Ref
10. Toothpaste amount at age five	
Full brush	ns 1.15 (0.40-3.36)
Pea size	ns 1.34 (0.67-2.67)
Smear	Ref
11. After brush routine when brushing started	
Swallowed toothpaste	ns 1.50 (0.76-2.94)
Rinsed and spat	Ref
11. After brush routine at age five	
Swallowed toothpaste	ns 0.89 (0.42-1.90)
Rinsed and spat	Ref
12. Eating/licking toothpaste when brushing started	
Yes	ns 1.33 (0.64-2.74)
No	Ref
13. Eating toothpaste at age five	
Yes	ns 1.72 (0.84-3.54)
No	Ref
14. Use of F supplement	
Yes	ns 0.88 (0.27-2.88)
No	Ref

Analysis using N=416 with complete data on all variables, Nagelkerke R^2=0.30

ns: p>0.05; *: p<0.05; **: p<0.001; Ref: Reference category for odds ratios

The logistic regression model for all FRI Classification I and II cases for fluorosis is presented in Table 4.56. Sex, birth cohorts, lifetime exposure to fluoride in water and several components of toothbrushing practice were significant explanatory factors in the model.

Being a girl was associated with significantly higher odds of being a case for either of the case definitions. Children who were born in the earliest birth cohort were significantly more likely to be cases compared to the latest birth cohort. The middle cohort did not significantly differ from the latest one.

Having exposure to fluoride in water was associated with a higher likelihood of having fluorosis on early or later forming enamel surface zones combined. The odds were almost two times higher among children who had more than 50% of their lifetime exposed to fluoride in water.

Use of standard fluoride toothpaste and having an eating and/or licking toothpaste habit when toothbrushing commenced was associated with a significantly higher likelihood of being fluorosis cases as defined by either of these case definitions. Other components of toothbrushing practice were not significant factors in the model.

Table 4.56: Logistic regression model of FRI Classification I and II cases of fluorosis

Explanatory variables	Odds Ratio (95% CI)
1. Sex	
Boys	Ref
Girls	* 1.70 (1.08-2.67)
2. Birth cohorts	
Born 89/90	* 1.81 (1.03-3.19)
Born 91/92	ns 1.10 (0.64-1.89)
Born 93/94	Ref
3. Lifetime exposure to fluoride in water	
>50% lifetime	* 1.98 (1.03-3.79)
0< and ≤50% lifetime	* 1.80 (1.00-3.45)
0% lifetime	Ref
4. Age brushing started	
Before 12 months	ns 1.73 (0.76-3.96)
From 12 to 24 months	ns 1.48 (0.92-2.37)
After 24 months	Ref
5. Infant formula use	
Used	ns 0.89 (0.56-1.41)
Not used	Ref
6. Brushing frequency when brushing started	
Once a day or less	ns 0.71 (0.42-1.21)
Twice a day or more	Ref
7. Brushing frequency at age five	
Once a day or less	* 0.57 (0.37-0.90)
Twice a day or more	Ref

Explanatory variables	Odds Ratio (95% CI)
8. Type of toothpaste when brushing started	
Standard toothpaste	* 2.29 (1.14-4.61)
Low F toothpaste	Ref
9. Type of toothpaste at age five	
Standard toothpaste	ns 1.06 (0.58-1.93)
Low F toothpaste	Ref
10. Toothpaste amount when brushing started	
Pea size or larger	ns 1.28 (0.75-2.18)
Smear	Ref
10. Toothpaste amount at age five	
Full brush	ns 1.13 (0.47-2.69)
Pea size	ns 1.16 (0.66-2.05)
Smear	Ref
11. After brush routine when brushing started	
Swallowed toothpaste	ns 1.31 (0.76-2.26)
Rinsed and spat	Ref
11. After brush routine at age five	
Swallowed toothpaste	ns 1.20 (0.67-2.15)
Rinsed and spat	Ref
12. Eating/licking toothpaste when brushing started	
Yes	* 1.80 (1.01-3.21)
No	Ref
13. Eating/licking toothpaste at age five	
Yes	ns 0.82 (0.46-1.45)
No	Ref
14. Use of F supplement	
Yes	ns 0.77 (0.26-2.28)
No	Ref

Analysis using N=391 with complete data on all variables, Nagelkerke R^2=0.17

Logistic Regression: ns: p>0.05; *: p<0.05; **: p<0.001 Ref: Reference category for odds ratios

4.5.7.3 *Summary of risk factors for dental fluorosis*

Summaries of the models for cases of dental fluorosis defined by the TF score and FRI case definitions are presented in Table 4.57. Significant factors are indicated by odds ratios and 95% CI. Non-significant factors are indicated by ns. Sex was significant in all models, with being a girl associated with higher odds of having fluorosis. The per cent of lifetime exposure to fluoride in water was significant in five models.

Table 4.57: Summary of all logistic regression models for fluorosis (odds ratios, 95% CI in brackets)

Model	TF 1+	TF 2+ (with toothpaste type)	TF 2+ (without toothpaste type)
Sex			
Boys	Ref	Ref	Ref
Girls	1.94 (1.26-2.98)	2.06 (1.11-3.83)	2.24 (1.22-4.12)
Lifetime exposure to fluoride in water [a]			
>50% lifetime	2.89 (1.54-5.42)	7.81 (2.44-24.96)	7.14 (2.27-22.40)
>0 & ≤50% lifetime	2.83 (1.47-5.55)	5.22 (1.56-17.42)	5.19 (1.57-17.13)
0% lifetime	Ref	Ref	Ref
Toothpaste used when brushing started			
1000-ppm fluoride	ns	2.70 (1.37-5.34)	NA
<550-ppm fluoride	Ref	Ref	NA
Eating/licking toothpaste when brushing started			
Yes	2.61 (1.52-4.48)	2.27 (1.03-5.03)	2.15 (1.00-4.64)
No	Ref	Ref	Ref
Amount of toothpaste used when brushing started			
Pea size or larger	1.79 (1.08-2.98)	ns	2.04 (1.07-3.91)
Smear size	Ref	Ref	Ref
Birth cohorts			
Born 89/90	ns	ns	2.71 (1.27-5.78)
Born 91/92	ns	ns	ns
Born 93/94	Ref	Ref	Ref
Age brushing started			
Before 1st birthday	3.80 (1.00-15.59)	ns	ns
From 1st to 2nd birthday	4.56 (1.14-18.19)	ns	ns
From 2nd to 3rd birthday	4.30 (1.02-18.06)	ns	ns
After 3rd birthday	Ref	Ref	Ref
Model summaries	**R^2=0.21**	**R^2=0.26**	**R^2=0.21**

[a] For models TF 1+, TF 2+, and FRI Cl. I: Lifetime exposure from birth to age six.
For models FRI Cl. II and FRI Cl. I & II: Lifetime exposure from birth to the time of the study

Table 4.57 (cont.): Summary of all logistic regression models for fluorosis (odds ratios, 95% CI in brackets)

Model	FRI Cl. I	FRI Cl. II	FRI Cl. I & II
Sex			
Boys	Ref	Ref	Ref
Girls	1.77 (1.07-2.93)	2.18 (1.21-3.92)	1.70 (1.08-2.67)
Lifetime exposure to fluoride in water [a]			
>50% lifetime	2.41 (1.18-4.91)	ns	1.98 (1.03-3.79)
>0 & ≤50% lifetime	ns	ns	1.80 (1.00-3.45)
0% lifetime	Ref	Ref	Ref
Toothpaste used when brushing started			
1000-ppm fluoride	2.56 (1.46-4.50)	3.01 (1.21-7.49)	2.29 (1.14-4.61)
<550-ppm fluoride	Ref	Ref	Ref
Eating/licking toothpaste when brushing started			
Yes	ns	ns	1.80 (1.01-3.21)
No	Ref	Ref	Ref
Amount of toothpaste used when brushing started			
Pea size or larger	ns	ns	ns
Smear size	Ref	Ref	Ref
Birth cohorts			
Born 89/90	ns	5.40 (2.60-11.19)	1.81 (1.03-3.19)
Born 91/92	ns	ns	ns
Born 93/94	Ref	Ref	Ref
Age brushing started			
Before 1st birthday	ns	3.07 (1.20-7.84)	ns
From 1st to 2nd birthday	1.66 (1.05-3.04)	1.99 (1.09-3.63)	ns
After 2nd birthday	Ref	Ref	Ref
Model summaries	**R^2=0.14**	**R^2=0.30**	**R^2=0.17**

[a] For models TF 1+, TF 2+, and FRI Cl. I: Lifetime exposure from birth to age six.
For models FRI Cl. II and FRI Cl. I & II: Lifetime exposure from birth to the time of the study

4.5.7.4 Population attributable risk for dental fluorosis

Estimates from the logistic regression models were used to calculate population attributable risk (PAR) for significant factors in the models. The results for the prevalence of fluorosis defined as having a TF score of 1+ on the central incisors are presented in Table 4.58. Since PAR was derived from multivariate models and factors were not mutually exclusive, it was not additive to 100%.

Population attributable risk for three modifiable factors (lifetime exposure to fluoride in water, two components of toothbrushing practice) and one unmodifiable factor (sex) were calculated and reported. Lifetime exposure to fluoride was the factor with the highest PAR estimate. However, use of toothpaste combined was attributed to more than 50% of preventable cases of fluorosis in the population.

Some 36% of fluorosis cases were explained by an eating and/or licking toothpaste habit when toothbrushing commenced. The other component of toothbrushing practice, the use of more than a smear of toothpaste per brushing, explained 16% of the cases of fluorosis, defined as having a TF score of 1 on the central incisors, in the population.

Table 4.58: Estimated population attributable risk (PAR) for specific fluoride sources associated with the prevalence of fluorosis defined as TF score 1+ on the central incisors

	N of cases (col %)	N of control (col %)	Relative risk	PAR % * (95% CI)
Exposure to F in water until age six years				**40 (19-45)**
0% lifetime	37 (28.2)	231 (47.3)	1	
>0 and ≤50% lifetime	53 (40.5)	152 (31.1)	1.46	
>50% lifetime	41 (31.3)	105 (21.5)	2.14	
Eating and/or licking toothpaste when brushing started				**36 (21-45)**
No	19 (48.5)	257 (37.3)	1	
Yes	32 (51.5)	273 (62.7)	2.64	
Toothpaste amount when brushing started				**16 (3-25)**
Smear size	49 (37.1)	157 (43.7)	1	
Pea-sized or larger	83 (62.9)	192(56.3)	1.62	
Sex				**29 (13-40)**
Boys	60 (41.4)	276 (55.0)	1	
Girls	85 (58.6)	226 (45.0)	1.99	

Fluorosis cases are defined as having TF score 1+ on the central incisors

* PAR was derived from logistic regression, and therefore is not additive

Table 4.59 presents calculated the population attributable risk for fluorosis that was defined as having a TF score of 2+ on the central incisors. The highest population attributable risk was associated with exposure to fluoride in water. Just less than a third of fluorosis cases was attributed to sex. Two components of toothbrushing practice were associated with less than half of the population attributable risk. PAR associated with an eating and licking toothpaste habit when children started brushing was at the same level of population risk as was reported in Table 4.58. Some 22% of the population risk estimates for fluorosis defined as having a TF score of 2+ were attributed to the use of standard concentration fluoride toothpaste.

Table 4.59: Estimated population attributable risk (PAR) for specific fluoride sources associated with the prevalence of fluorosis defined as TF score 2+ on the central incisors

	N of cases (col %)	N of control (col %)	Relative risk	PAR % * (95% CI)
Exposure to F in water until age six years				**53 (23-66)**
0% lifetime	10 (18.5)	269 (48.8)	1	
>0 and ≤50% lifetime	23 (42.6)	163 (29.5)	2.81	
>50% lifetime	21 (38.9)	119 (21.7)	7.87	
Type of toothpaste when brushing started				**22 (9-29)**
Low concentration fluoride toothpaste	34 (66.7)	402 (80.2)	1	
Standard concentration fluoride toothpaste	17 (33.3)	129 (19.8)	1.63	
Eating and/or licking toothpaste when brushing started				
No	19 (37.3)	257 (48.5)	1	**36 (3-50)**
Yes	32 (62.7)	273 (51.5)	2.30	
Sex				
Boys	21 (36.8)	315 (53.4)	1	**32 (5-47)**
Girls	36 (63.2)	275 (46.6)	2.04	

Fluorosis cases are defined as having TF score 2+ on the central incisors

* PAR was derived from logistic regression, and therefore is not additive

4.6 Dental caries among South Australian children

Data on caries experience of the initial study sample (n=1401) whose dental visits to South Australian School Dental Service clinics were collected from paper-based and computerised clinical records were analysed to describe the prevalence and severity of caries at different ages and at the time of the study. Data were weighted to represent the South Australian child population. The results are reported by socioeconomic characteristics and fluoride exposures.

4.6.1 The prevalence and severity of dental caries

4.6.1.1 The prevalence and severity of dental caries among 8–13-year-old South Australian children

Over 35% of children age 8–13 years old had deciduous caries. A slightly lower proportion of the children had dental caries on their permanent teeth, as shown in the Table 4.60. Boys and girls had a similar prevalence of deciduous caries, while girls had slightly higher prevalence of caries on their permanent teeth. The prevalence of deciduous caries was significantly lower among Adelaide participants compared with their counterparts from other areas. There was a difference of 5% in the prevalence of permanent caries between these two groups by residential location. However, this difference was not statistically significant. The prevalence of deciduous caries decreased from the earliest to the latest birth cohorts and vice versa for the prevalence of permanent caries.

Table 4.60: Prevalence of dental caries in SA children in 2002/03 (n=1285) (unweighted n, w%)

	Deciduous caries		Permanent caries	
	n	w %	n	w %
Total	**536**	**36.7**	**460**	**35.2**
Sex				
Boys	278	35.9	217	31.6
Girls	258	35.4	243	36.5
Residential location				
Adelaide	211	* 34.8	205	33.8
Other areas	325	47.6	255	37.6
Birth cohorts [a]				
Born 89/90	53	* 11.1	176	* 43.6
Born 91/92	196	37.5	154	32.0
Born 93/94	287	54.9	130	27.8

* Chi-square, p<0.01

[a] Children from different birth cohorts formed a six-year age span in 2002/03

Table 4.61 presents the deciduous and permanent caries experience of children aged 8–13 years in 2002/03. Boys and girls did not differ significantly in their deciduous and permanent dmfs/DMFS scores. Adelaide residents had a significantly lower mean deciduous dmfs scores. These children also had a lower mean permanent decayed, filled and missing surfaces, but this difference was not significant. Mean deciduous dmfs at the time of the study decreased from the earliest to the latest birth cohorts. On the other hand, permanent caries experience at the time of the study increased from the earliest to the latest birth cohorts.

Table 4.61: Mean dental caries of the South Australian children aged 8–13 years in 2002/03

	Deciduous caries		Permanent caries	
	dmfs	SD	DMFS	SD
Total (n=1285)	**1.79**	**3.78**	**1.00**	**2.15**
Sex (n=1285)				
Boys	1.91	4.07	0.95	2.03
Girls	1.67	3.47	1.06	2.26
Residential location (n=1285)				
Adelaide	* 1.71	3.66	1.00	2.15
Other areas	3.01	5.14	1.07	2.10
Birth cohort (n=1285) [a]				
Born 89/90	* 0.39	1.50	1.59	* 2.92
Born 91/92	1.59	3.30	0.90	1.92
Born 93/94	3.16	4.91	0.60	1.30

* ANOVA, p<0.01

[a] Children from different birth cohorts formed a six-year age span in 2002/03

4.6.1.2 Dental caries experience at different anchor ages

Table 4.62 presents deciduous and permanent dental caries experience of the study population at different anchor ages. Mean deciduous and permanent caries experience was generally low at age six. Girls had slightly higher mean deciduous dmfs at this age, but the difference was not statistically significant. Children from fluoridated Adelaide had significantly lower mean dmfs compared to children from other areas (1.36 versus 2.67).

At age eight, girls had slightly lower mean deciduous dmfs, but higher mean DMFS scores compared to boys. Children from fluoridated Adelaide had significantly lower mean deciduous caries experience. These children also had a lower mean of DMFS scores compared to their regional non-fluoridated counterparts, but the difference was not statistically significant.

Mean dmfs at age 10 was slightly higher compared to that at age eight, whereas permanent caries was notably higher at this age. Sex was significantly associated with deciduous caries at age ten, with girls having significantly lower dmfs score. However, girls had higher mean DMFS compared to boys. This difference was not statistically significant. Children from fluoridated Adelaide were better off compared to children from other areas in terms of both deciduous and permanent caries experience recorded at this age.

The anchor ages six and eight will be routinely used in this section. The anchor age 10 will be used only occasionally because it did not have the majority of children of the latest birth cohort.

Table 4.62: Dental caries experience among South Australian children at different ages by sex and residential location (means dmfs and DMFS, SD)

	Deciduous dmfs		Permanent DMFS	
At age six (n=1109)	Mean	SD	Mean	SD
Total	**1.45**	**3.11**	**0.02**	**0.14**
Sex				
Boys	1.43	3.10	0.02	0.13
Girls	1.48	3.13	0.02	0.15
Residential location				
Adelaide	* 1.36	2.97	0.02	0.13
Other areas	2.67	4.46	0.03	0.27
At age eight (n=1119)				
Total	**2.46**	**3.93**	**0.23**	**0.75**
Sex				
Boys	2.62	4.71	0.22	0.72
Girls	2.30	3.93	0.24	0.79
Residential location				
Adelaide	** 2.33	4.21	0.22	0.75
Other areas	4.11	5.56	0.31	0.88
At age ten (n=977) [a]				
Total	**2.69**	**4.18**	**0.63**	**1.55**
Sex				
Boys	* 3.09	4.82	0.55	1.42
Girls	2.29	4.08	0.71	1.66
Residential location				
Adelaide	** 2.39	3.94	0.54	1.37
Other areas	3.54	4.70	0.71	1.68

ANOVA, *: p<0.05; **: p<0.01

[a] Only children who turned ten years old in their visits before or at the time of the study were included

4.6.1.3 Dental caries experience of the study sample by fluoride exposure status

4.6.1.3.1 Caries experience by fluoride exposure status at the time of the study in 2002/03

Children who started toothbrushing early had significantly lower caries experience (Table 4.63). Those who started brushing in the first year of life had on average one fewer decayed, filled or missing deciduous tooth surface compared to children who started brushing in the third year or later. There was no significant relationship between caries experience and frequency of brushing when brushing started. However, children who brushed twice a day or more at age five and at the time of the study had significantly lower caries experience compared to children who brushed less frequently.

The type of toothpaste used earlier or at the time of the study was not significantly associated with the dental caries experience of the children. Children who reported using standard concentration fluoride toothpaste had lower mean deciduous dmfs compared to children who used low concentration fluoride toothpaste, but no consistent difference in mean permanent DMFS was observed.

There was no consistent pattern of association between the amount of toothpaste used when toothbrushing commenced and caries experience. However, using a full brush head of toothpaste at age five was associated with higher mean permanent DMFS in this bivariate analysis.

The association between the amount of toothpaste used at the time of the study and caries experience was significant in this study sample. Using a larger amount of toothpaste per brush was associated with significantly lower mean deciduous and permanent decayed, missing and filled surfaces.

Table 4.63: Dental caries experience in South Australian children aged 8–13 years old in 2002/03 by toothbrushing practice

	Deciduous caries		Permanent caries	
	Mean	SD	Mean	SD
Age brushing started (n=1092)				
First year	* 1.30	2.75	* 0.88	1.73
Second year	1.48	3.43	0.76	1.56
Third year and later	2.38	4.95	1.23	2.79
Frequency of brushing when brushing started (n=1125)				
Once/day or less	1.68	3.50	0.92	1.74
Twice/day or more	1.66	4.15	1.09	2.63
Frequency of brushing at age 5 (n=1126)				
Once/day or less	* 2.08	4.47	1.08	1.94
Twice/day or more	1.43	3.25	0.87	2.04
Frequency of brushing in 2002/03 (1128)				
Once/day or less	1.56	3.40	* 1.18	2.24
Twice/day or more	1.72	3.91	0.87	2.04
Type of toothpaste when brushing started (n=1090)				
Low concentration fluoride toothpaste	2.00	3.77	0.84	1.90
Standard concentration fluoride toothpaste	1.33	3.64	0.96	1.66
Type of toothpaste at age 5 (n=1107)				
Low concentration fluoride toothpaste	1.82	3.68	0.85	1.91
Standard concentration fluoride toothpaste	1.77	3.82	0.87	1.91
Type of toothpaste in 2002/03 (n=1107)				
Low concentration fluoride toothpaste	2.25	3.73	0.80	1.78
Standard concentration fluoride toothpaste	1.73	3.73	0.85	1.82
Amount of toothpaste used when brushing started (n=1120)				
Smear	1.75	3.65	0.94	2.06
Pea-sized	2.31	5.02	0.84	1.77
Full brush head	1.78	3.43	1.08	1.42
Amount of toothpaste used at age five (n=1124)				
Smear	1.44	3.10	* 0.86	2.07
Pea-sized	2.16	4.57	0.81	1.73
Full brush head	1.72	3.22	1.55	2.53
Amount of toothpaste used in 2002/03 (n=1128)				
Smear	* 2.84	4.29	1.49	2.75
Pea-sized	2.13	4.60	0.88	1.91
Full brush head	1.37	2.99	0.84	1.80

* ANOVA, p<0.01

Caries experience of the children at the time of the study by exposure to fluoride in the water and other discretionary fluoride sources is reported in Table 4.64. There was a significant association between lifetime exposure to water fluoridation and deciduous caries experience. Children who had more than 50% of their lifetime exposed to fluoride in the water had mean deciduous dmfs equal to less than half of that of children who had no exposure. Having some but less than or equal to 50% of lifetime exposure also reduced mean deciduous dmfs. No difference in mean permanent DMFS was observed between exposure groups.

Residents of non-fluoridated areas who used fluoride supplements had lower mean deciduous and permanent decay experience compared with children from the same area who did not use it. This difference was, however, not significant.

Infant formula users had slightly lower caries experience compared with non-users. However, neither of the differences was statistically significant.

Table 4.64: Dental caries experience among South Australian children aged 8–13 years old in 2002/2003 by exposure to fluoride in water and other sources of fluoride

	Deciduous caries		**Permanent caries**	
	Mean	SD	Mean	SD
Lifetime exposure to F in water (n=1168)				
Exposure = 0	* 2.54	4.86	0.89	1.93
>0 and ≤50% lifetime	2.09	4.56	0.90	2.13
>50% lifetime	1.16	2.51	1.08	2.13
Use of fluoride supplement (n=684) [a]				
Yes	2.63	4.92	0.63	1.54
No	3.02	5.09	1.09	2.19
Use of infant formula (n=1153)				
Yes	1.56	3.31	0.94	1.90
No	2.00	4.71	0.96	2.30

[a] Comparison made within residents from non-fluoridated areas only

* ANOVA, p<0.01

4.6.1.3.2 Caries experience by fluoride exposure status at age six

Mean deciduous and permanent caries experience when children were six years old was calculated and compared between groups by fluoride exposure. Table 4.65 presents mean dmfs and DMFS by patterns of toothbrushing practice, per cent of lifetime exposure to fluoridated water, the use of fluoride supplements and infant formula. Mean permanent DFMS was negligible. Children who commenced their brushing early had a lower mean dmfs score compared to children who started brushing after their second birthday. However, the difference was not statistically significant.

Brushing more frequently reduced dental caries experience in this study population. Children who brushed twice a day or more when toothbrushing started had a non-significantly lower mean dmfs score. Doing the same at age five significantly reduced mean dmfs compared to children who brushed less frequently at that age.

Standard toothpaste users when brushing started and at age five had a lower mean dmfs score. However, these differences were not statistically significant. There was no clear pattern of any association between the amount of toothpaste used when brushing started and at age five with caries experience at age six.

Having exposure to fluoride in the water was significantly related to dental caries experience at age six among this study sample. Children who did not have any exposure to water fluoridation had more than twice as high a mean deciduous dmfs compared to children who had an exposure of more than half their lifetime. Having less than half a lifetime exposure resulted in almost one fewer decayed, missing or filled deciduous surface at this age. Children who had more than 50% lifetime exposure had no permanent decay at age six. However, the difference in permanent caries experience was not statistically significant.

Using fluoride supplement in non-fluoridated areas did not significantly affect dental caries experience. Infant formula users had slightly lower mean deciduous dmfs, but the difference was not significant.

Table 4.65: Caries experience among South Australian children at age six by exposure to fluoride (means dmfs and DMFS, SD)

	Deciduous caries		Permanent caries	
	Mean	SD	Mean	SD
Age started brushing (n=947)				
First year	1.67	3.14	0.04	0.35
Second year	1.90	3.53	0.01	0.13
Third year and later	2.41	4.60	0.02	0.17
Frequency of brushing when brushing started (n=940)				
Once/day or less	2.11	3.90	0.03	0.26
Twice/day or more	1.79	3.56	0.01	0.12
Frequency of brushing at age 5 (n=983)				
Once/day or less	* 2.32	4.21	0.02	0.15
Twice/day or more	1.78	3.46	0.03	0.26
Type of toothpaste when brushing started (n=952)				
Standard concentration fluoride toothpaste	1.45	3.25	0.01	0.11
Low fluoride concentration fluoride toothpaste	1.34	2.92	0.02	0.16
Type of toothpaste at age 5 (n=969)				
Standard concentration fluoride toothpaste	1.38	3.10	0.02	0.17
Low fluoride concentration fluoride toothpaste	1.36	2.97	0.01	0.11
Amount of toothpaste used when brushing started (n=978)				
Smear	1.81	3.47	0.02	0.23
Pea-sized	2.48	4.61	0.04	0.24
Full brush head	1.85	2.88	0.00	0.00
Amount of toothpaste used at age five (n=980)				
Smear	1.71	3.45	0.02	0.12
Pea-sized	2.12	3.99	0.03	0.27
Full brush head	1.87	3.33	0.01	0.09
Lifetime exposure to F in water (n=1018)				
0% lifetime	* 2.75	4.39	0.03	0.30
>0 and ≤50% lifetime	1.77	3.55	0.03	0.18
>50% lifetime	0.92	2.30	0.00	0.06
Use of fluoride supplement (n=322) [a]				
Yes	2.54	4.66	0.00	0.00
No	2.60	4.26	0.04	0.30
Use of infant formula (n=1005)				
Yes	1.98	3.72	0.03	0.26
No	2.04	3.95	0.02	0.14

[a] Comparison made within residents from non-fluoridated areas only

* ANOVA, $p<0.01$

4.6.1.3.3 Caries experience by fluoride exposure status at age eight

Caries experience at age eight was calculated and compared between groups by exposure to different fluoride sources (Table 4.66). Associations between caries experience at age eight and patterns of toothbrushing practice, lifetime exposure to fluoridated water, the use of supplements and infant formula are presented. Commencing toothbrushing early reduced both deciduous and permanent caries experience at this age. Children who started brushing in the first year of life had almost 0.9 fewer deciduous surfaces with caries compared to children who started brushing after their second birthday. The mean permanent DMFS of the former group was almost half that of the latter one. However, none of the observed differences were statistically significant.

Brushing more frequently when toothbrushing started and at age five was associated with lower mean deciduous and permanent decayed, missing and filled surfaces. The observed differences were not statistically significant.

There was no clear pattern of association between types of toothpaste used with dental caries experience. Standard toothpaste users generally had slightly higher mean caries scores.

Lifetime exposure to fluoride in the water was significantly associated with deciduous caries experience at age eight. Having less than or equal to 50% of the lifetime exposed to fluoride resulted in one lower deciduous surface with caries experience. Having more than half of the lifetime exposed to water fluoridation reduced the mean deciduous dmfs more than three times. Children who were exposed to fluoride in the water had a lower mean permanent DMFS compared to that of children without any exposure. However, the difference was not statistically significant.

Children from non-fluoridated areas who used fluoride supplements compared to those who did not use them did not differ in terms of dental caries experience at age eight. There was no clear pattern of any association between infant formula use and caries at age eight among the children.

Table 4.66: Caries experience among South Australian children at age eight by exposure to fluoride (means dmfs and DMFS, SD)

	Deciduous caries		Permanent caries	
	Mean	SD	Mean	SD
Age started brushing (n=961)				
First year	2.78	4.09	0.17	0.56
Second year	3.30	5.02	0.29	0.91
Third year and later	3.67	5.86	0.32	0.93
Frequency of brushing when brushing started (n=993)				
Once/day or less	3.33	4.96	0.29	0.90
Twice/day or more	3.12	5.11	0.23	0.68
Frequency of brushing at age 5 (n=995)				
Once/day or less	3.50	5.24	0.30	0.90
Twice/day or more	3.08	4.85	0.23	0.74
Type of toothpaste when brushing started (n=962)				
Standard concentration fluoride toothpaste	3.29	4.72	0.24	0.76
Low fluoride concentration fluoride toothpaste	3.21	4.72	0.36	0.97
Type of toothpaste at age 5 (n=977)				
Standard concentration fluoride toothpaste	3.07	4.76	0.22	0.71
Low fluoride concentration fluoride toothpaste	3.43	5.05	0.32	0.92
Amount of toothpaste used when brushing started (n=990)				
Smear	3.15	4.77	0.22	0.68
Pea-sized	3.67	5.76	0.31	0.89
Full brush head	2.75	4.31	0.48	1.38
Amount of toothpaste used at age five (n=991)				
Smear	3.06	4.15	0.15	0.45
Pea-sized	3.31	5.35	0.22	0.73
Full brush head	3.17	4.85	0.26	0.60
Lifetime exposure to F in water (n=1027)				
0% lifetime	* 4.22	5.29	0.31	0.85
>0 and ≤50% lifetime	3.24	5.68	0.23	0.81
>50% lifetime	1.61	3.12	0.25	0.82
Use of fluoride supplement (n=1004) [a]				
Yes	4.28	5.82	0.30	1.05
No	4.04	5.36	0.30	0.85
Use of infant formula (n=1017)				
Yes	3.18	5.09	0.28	0.85
No	3.55	5.17	0.24	0.79

[a] Comparison made within residents from non-fluoridated areas only

* ANOVA, p<0.01

4.6.2 Cohort trend of dental caries

The caries experience of children in the three birth cohorts was compared at different anchor ages. The results are presented in Table 4.67 and Table 4.68.

The prevalence of deciduous and permanent caries at age six, eight and ten is tabulated in Table 4.67. There was no clear trend of change between birth cohorts when dental caries at age six was considered. The prevalence of permanent caries was negligibly low at this age.

There was a trend of increasing prevalence of deciduous and permanent caries at age eight from the earliest birth cohort to the latest birth cohort. The prevalence of deciduous caries in the cohort born in 1993/94 was higher compared to the other two groups. More than 20% of children in the latest birth cohort had permanent dental caries, whereas the prevalence was less then 10% in the other two birth cohorts.

The cohort trend was more pronounced when the prevalence of dental caries at age ten was considered. The earliest birth cohort had notably lower prevalence of deciduous caries compared to the later birth cohorts. Birth cohort was significantly related to increasing trend of the prevalence of permanent dental caries at age ten. The per cent of children in the 89/90 birth cohort who had the disease was less than half that of the other two cohorts.

Table 4.67: Prevalence of dental caries by birth cohort (unweighted n, weighted % of group numbers)

	Deciduous caries		Permanent caries	
	n	w%	n	w%
At age 6				
Born 89/90	114	29.3	2	0.6
Born 91/92	147	32.6	7	2.2
Born 93/94	178	30.7	9	1.9
At age 8				
Born 89/90	163	* 39.0	27	* 7.3
Born 91/92	182	43.6	34	6.4
Born 93/94	255	50.0	93	20.3
At age 10				
Born 89/90	157	* 42.6	56	* 10.4
Born 91/92	198	43.3	106	27.4
Born 93/94 [a]	165	54.1	80	30.1

* Chi-square, p<0.01

[a] Only children who turned ten years old at their dental visits were included in this group for the analysis

Table 4.68 presents mean deciduous and permanent decayed, missing and filled surfaces by birth cohort groups at three ages. Caries experience at age six was similar between cohorts. The latest birth cohort had slightly higher mean deciduous dmfs. However, this difference was not statistically significant.

At age eight, children who were born in 1993/94 had a significantly higher mean deciduous dmfs and permanent DMFS. This birth cohort had 0.9 more decayed, missing or filled deciduous surfaces compared to the other two cohorts. This birth cohort also had significantly higher permanent DMFS score compared to that of the earlier birth cohorts.

A similar trend was observed when caries experience at age ten was compared between cohorts. Children in the latest birth cohort had mean dmfs of 3.9 compared to only 2.6 to 2.8 surfaces of the two earlier birth cohorts. The mean DMFS score of children who were born in 1989/90 was less than half of that of the later two cohorts. All differences between cohorts at age ten were statistically significant.

Table 4.68: Dental caries experience at different ages by birth cohort (means dmfs and DMFS, SD)

	Deciduous caries		Permanent caries	
	Mean	SD	Mean	SD
At age six (n=1190)				
Born 89/90	1.43	2.89	0.01	0.08
Born 91/92	1.39	3.12	0.02	0.15
Born 93/94	1.54	3.30	0.02	0.17
At age eight (n=1119)				
Born 89/90	* 2.97	4.46	** 0.15	0.58
Born 91/92	2.96	4.59	0.19	0.69
Born 93/94	3.86	5.75	0.42	1.01
At age ten (n=977)				
Born 89/90	** 2.59	3.88	** 0.33	0.89
Born 91/92	2.77	4.25	0.77	1.82
Born 93/94 [a]	3.95	5.27	0.76	1.67

ANOVA, * p<0.01; ** p<0.001

[a]: Only children who turned ten years old in their dental visits were included in this analysis

4.6.3 Stratified analysis of dental caries experience by lifetime exposure to fluoride in water and toothbrushing practice

Deciduous caries experience of the children at age eight was stratified by exposure to fluoride in the water in the first six years of life and components of toothbrushing practice. The results are reported in Table 4.69 through to Table 4.73. The statistical significance of differences involved was tested with Two-way ANOVA.

Among children who had no exposure to fluoride, commencing toothbrushing after 24 months of age was associated with higher mean dmfs scores at age six and eight compared with commencing brushing earlier than this age (Table 4.69). Children who had less than 50% of their first six years exposed to fluoride had lower mean dmfs than the former group, even if the latter group commenced brushing after the second birthday. Among this exposure group, commencing brushing early significantly reduced caries experience. The age when toothbrushing started did not have a pronounced effect on deciduous caries experience among children who had more than 50% lifetime exposure to fluoride. This exposure group had the lowest mean caries at age eight.

Table 4.69: Deciduous caries experience at age six and eight by lifetime exposure to fluoride to age six and age started toothbrushing (mean dmfs, SD)

Lifetime exposure to fluoride in water until age six	Age started brushing with toothpaste	Deciduous caries at age 6	
		Mean dmfs	SD
0% lifetime (n=442)	Before 24 months	2.27	3.51
	After 24 months	3.69	6.41
>0 and ≤50% lifetime (n=298)	Before 24 months	0.88	2.27
	After 24 months	1.53	2.80
>50% lifetime (n=221)	Before 24 months	0.92	2.17
	After 24 months	1.39	2.67

Two-way ANOVA, Lifetime exposure to F: p<0.001; Age started brushing: p<0.05

Lifetime exposure to fluoride in water until age six	Age started brushing with toothpaste	Deciduous caries at age 8	
		Mean dmfs	SD
0% lifetime (n=442)	Before 24 months	3.89	5.05
	After 24 months	4.88	6.59
>0 and ≤50% lifetime (n=298)	Before 24 months	1.94	3.48
	After 24 months	3.54	6.32
>50% lifetime (n=221)	Before 24 months	1.68	2.77
	After 24 months	1.73	2.44

Two-way ANOVA, Lifetime exposure to F: p<0.001; Age started brushing: p<0.05

The per cent of lifetime exposure to fluoride in the water was strongly and inversely related to the mean deciduous caries experience at age six and eight (Table 4.70). The use of standard toothpaste for brushing did not consistently lower mean dmfs among children who had no exposure to fluoride and among children with different degrees of exposure to fluoride. There was no difference in caries experience at age six and eight between children who used standard fluoride and low concentration fluoride toothpaste if they had more than 50% lifetime exposure to fluoridated water.

Table 4.70: Deciduous caries experience at age six and eight by lifetime exposure to fluoride to age six and type of toothpaste used when brushing started and at age five (mean dmfs, SD)

Lifetime exposure to fluoride in water until age six	Toothpaste used	Deciduous dmfs (SD) at age six			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Standard	2.50	4.67	2.59	4.60
	Low F	2.88	4.57	2.86	4.60
>0 and ≤50% lifetime	Standard	1.53	3.28	1.41	2.84
	Low F	0.96	2.14	0.87	2.21
>50% lifetime	Standard	1.02	2.41	0.91	2.21
	Low F	1.00	2.15	1.13	2.35

Two-way ANOVA, Lifetime exposure to F: $p<0.001$; Type of toothpaste: $p>0.05$

Lifetime exposure to fluoride in water until age six	Toothpaste used	Deciduous dmfs (SD) at age eight			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Standard	4.25	5.62	4.55	6.07
	Low F	4.68	5.81	4.36	5.16
>0 and ≤50% lifetime	Standard	2.67	4.56	2.72	4.15
	Low F	2.62	4.64	2.56	4.98
>50% lifetime	Standard	1.46	2.75	1.68	2.81
	Low F	2.15	2.76	2.02	2.72

Two-way ANOVA, Lifetime exposure to F: $p<0.001$; Type of toothpaste: $p>0.05$

Brushing teeth more frequently did not consistently reduce caries experience at age six and eight (Table 4.71). The direction of differences in deciduous caries experience at age six and eight was inconsistent; both for more frequent brushing when brushing started and at age five. There was a tendency that having exposure to fluoridated water and brushing teeth more frequently when toothbrushing started was associated with lower caries experience at age six. However, the difference between the groups by frequency of toothbrushing was not statistically significant.

Table 4.71: Deciduous caries experience at age six and eight by lifetime exposure to fluoride and frequency of brushing when brushing started and at age five (mean dmfs, SD)

Lifetime exposure to fluoride in water until age six	Frequency of brushing	Deciduous dmfs (SD) at age six			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Once a day or less	2.68	4.53	3.27	4.95
	Twice a day or more	2.73	4.77	2.30	4.29
≤50% lifetime	Once a day or less	1.24	2.67	1.05	2.30
	Twice a day or more	0.94	2.31	1.19	2.70
>50% lifetime	Once a day or less	1.09	2.48	1.26	2.72
	Twice a day or more	0.92	2.04	0.86	1.98

Two-way ANOVA, Lifetime exposure to F: $p<0.001$; Frequency of brushing: $p>0.05$

Lifetime exposure to fluoride in water until age six	Frequency of brushing	Deciduous dmfs (SD) at age eight			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Once a day or less	4.10	5.46	4.58	5.16
	Twice a day or more	4.26	5.63	3.89	5.71
≤50% lifetime	Once a day or less	2.62	3.93	1.98	3.50
	Twice a day or more	2.12	5.41	2.68	4.92
>50% lifetime	Once a day or less	1.74	2.92	1.82	3.01
	Twice a day or more	1.48	2.33	1.50	2.42

Two-way ANOVA, Lifetime exposure to F: $p<0.001$; Frequency of brushing: $p>0.05$

Table 4.72 presents an analysis of caries experience at age six and eight stratified by exposure to fluoride and the amount of toothpaste used. Using a larger amount of toothpaste when toothbrushing commenced and at age five was not statistically associated with deciduous caries at age six and eight.

Table 4.72: Deciduous caries experience at age six and eight by lifetime exposure to fluoride and amount of toothpaste used when brushing started and at age five (mean dmfs, SD)

Lifetime exposure to fluoride in water until age six	Amount of toothpaste [c]	Deciduous dmfs (SD) at age six			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Larger	3.82	6.36	2.95	4.93
	Smaller	2.17	3.37	1.91	3.20
≤50% lifetime	Larger	1.07	2.08	1.19	2.72
	Smaller	1.17	2.72	1.00	2.09
>50% lifetime	Larger	1.33	2.66	1.14	2.36
	Smaller	0.82	1.99	0.57	1.93

Two-way ANOVA: Lifetime exposure to F: $p<0.001$; Amount of toothpaste: $p>0.05$

Lifetime exposure to fluoride in water until age six	Amount of toothpaste [c]	Deciduous dmfs (SD) at age eight			
		when brushing started [a]		at age five [b]	
		Mean	SD	Mean	SD
0% lifetime	Larger	4.02	4.95	2.77	4.50
	Smaller	4.45	6.61	4.42	5.65
≤50% lifetime	Larger	2.63	4.87	1.71	2.64
	Smaller	1.93	3.06	2.49	4.58
>50% lifetime	Larger	1.46	2.47	2.58	3.09
	Smaller	1.95	2.94	1.49	2.56

Two-way ANOVA

[a] Lifetime exposure to F: $p<0.001$; Amount of toothpaste: $p>0.05$

[b] Lifetime exposure to F: $p>0.05$; Amount of toothpaste: $p>0.05$

[c] Amount of toothpaste used:

when brushing started: Larger: Pea-sized or larger; Smaller: Smear size

at age five: Larger: Full brush head size; Smaller: Pea-sized or less

One of the risk factors for fluorosis in children, an eating and licking toothpaste habit, did not have a clear effect on dental caries experience either at age six or eight (Table 4.73). Children with no or some but up to 50% lifetime exposure to fluoridated water who had this habit when toothbrushing commenced had lower mean caries experience at age six. Children who had this habit had slightly higher mean dmfs scores at age eight. However, the observed differences were not statistically significant. In contrast, the per cent of lifetime exposure to fluoride to age six was strongly and consistently associated with caries experience.

Table 4.73: Deciduous caries experience at age six and eight by lifetime exposure to fluoride and eating, licking toothpaste habit when brushing started and at age five (mean dmfs, SD)

Lifetime exposure to fluoride in water until age six	Eating, licking toothpaste	Deciduous dmfs (SD) at age six			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Yes	2.28	3.68	2.44	3.57
	No	3.17	5.46	2.90	5.28
≤50% lifetime	Yes	0.99	2.44	1.07	2.40
	No	1.33	2.70	1.20	2.70
>50% lifetime	Yes	1.20	2.48	1.27	2.45
	No	0.88	2.14	0.86	2.17

Two-way ANOVA: Lifetime exposure to F: p<0.001; Eating, licking toothpaste: p>0.05

Lifetime exposure to fluoride in water until age six	Eating, licking toothpaste	Deciduous dmfs (SD) at age eight			
		when brushing started		at age five	
		Mean	SD	Mean	SD
0% lifetime	Yes	4.31	5.45	4.49	5.43
	No	3.96	5.63	3.89	5.58
≤50% lifetime	Yes	2.62	5.00	2.29	3.55
	No	2.25	3.74	2.55	5.05
>50% lifetime	Yes	1.69	2.64	1.89	2.78
	No	1.52	2.66	1.47	2.57

Two-way ANOVA: Lifetime exposure to F: p<0.001; Eating, licking toothpaste: p>0.05

4.6.4 Multivariate models of dental caries among South Australian children 8–13 years old in 2002/03

Linear regression models were generated for deciduous dmfs and permanent DMFS scores at the time of the study, and for deciduous dmfs at age six and eight. The results are reported in Table 4.74 through to Table 4.77.

Variables included in the models were: sex; lifetime exposure to fluoride in the water; birth cohorts; brushing frequency when started, at age five and at the time of the study; type of toothpaste when started, at age five and at the time of the study; infant formula; use of fluoride supplement; age toothbrushing started; amount of toothpaste used when started, at age five and at the time of the study; eating and/or licking toothpaste when brushing started and at age five; parental education attainment; daily consumption of fruit, milk, soft drinks, sweetened drinks, sugar and snacking at the time of the study. Several variables which were significant in at least one model were reported in the tables for cross-comparison between the models. Other variables which were not significant in any model were not listed.

The model for deciduous dmfs at the time of the study explained some 16% of variance of dmfs score in the population (Table 4.74). The summaries of residual statistics showed that assumptions for the linear regression model were not violated in this model. The mean of the standardised residual was zero and its standard deviation was close to one.

Sex was not a significant factor for deciduous dmfs at the time of the study. Children who had a higher per cent of lifetime exposure to fluoride in the water had significantly lower mean deciduous caries compared to children who had zero exposure. The mean dmfs score was strongly related to birth cohort, or effectively age. Children who were born in earlier birth cohorts had significantly lower caries experience. This factor had the highest standardised coefficient in the model.

Having soft drink daily significantly increased the chance of having a higher mean deciduous dmfs score. Having sugar daily was not significant in this model.

The age when toothbrushing started and the frequency of brushing did not have a significant effect on caries experience in this model. Socioeconomic status was also not significant in the model.

Table 4.74: Linear regression model for deciduous dmfs at the time of the study

	β (SE) [a]	Beta [b]	95% CI of β	
			Lower	Upper
Sex				
Boys	-0.28 (0.34)	-0.04	-0.94	0.37
Girls	Ref	Ref		
Birth cohort				
Born in 89/90	** -2.41 (0.42)	-0.29	-3.23	-1.59
Born in 91/92	** -1.48 (0.39)	-0.19	-2.45	-0.70
Born in 93/94	Ref	Ref		
Per cent lifetime exposure to F in water	** -0.02 (0.01)	-0.17	-0.03	-0.01
Parental education				
High school	0.47 (0.48)	0.05	-0.47	1.41
Vocational training	0.00 (0.53)	0.00	-1.04	1.04
University education	Ref	Ref		
Age toothbrushing started	0.02 (0.01)	0.08	-.001	0.04
Use of soft drinks daily				
Twice a day or more	* 0.95 (0.46)	0.10	0.06	1.85
Once a day or less	Ref	Ref		
Use of sugar daily				
Twice a day or more	0.27 (0.37)	0.04	-0.47	1.02
Once a day or less	Ref	Ref		
Frequency of toothbrushing when brushing started				
Twice a day or more	-0.26 (0.45)	-0.03	-1.06	0.54
Once a day or less	Ref	Ref		
Frequency of toothbrushing at age 5				
Twice a day or more	-0.01 (0.40)	-0.01	-0.89	0.70
Once a day or less	Ref	Ref		

Adjusted R square=0.16; *: p<0.05; **: p<0.001

Other non-significant variables not listed

[a] Un-standardised coefficients; [b] standardised coefficient

Model summaries

Residuals statistics

	Minimum	Maximum	Mean	SD	N
Predicted value	-2.1689	7.7048	2.3102	1.79556	938
Residual	-7.1606	30.0022	.0000	4.08106	938
Std. predicted value	-2.495	3.004	.000	1.000	938
Std. residual	-1.721	7.209	.000	.981	938

a Dependent variable: deciduous dmfs at the time of the study

Table 4.75 presents the linear regression model for permanent DMFS score at the time of the study. The summaries of residual statistics showed that assumptions for the linear regression model were not violated in this model. The mean of standardised residual was zero and its standard deviation was close to one.

This model explained a lower percentage of the variances of permanent caries experience in South Australian children than was explained for deciduous caries. Boys and girls did not differ in terms of permanent caries.

Exposure to fluoride in the water was of borderline significance in the model. A higher per cent of lifetime exposed to fluoride in the water resulted in lower mean permanent DMFS score.

There was a strong birth cohort effect on permanent caries experience in the model. Children who were born in the 89/90 birth cohort had significantly higher mean DMFS scores at the time of the study.

The age when toothbrushing commenced was not related to mean DMFS score. However, brushing more frequently at age five was significantly associated with caries experience on permanent teeth. Other components of toothbrushing practice were not significant in the model.

Frequent use of sugar daily significantly increased the mean DMFS score in this study sample. Other dietary factors were not statistically significant.

Table 4.75: Linear regression model for permanent DMFS at the time of the study

	β (SE) [a]	Beta [b]	95% CI of β	
			Lower	Upper
Sex				
Boys	-0.15 (0.17)	-0.04	-0.48	0.18
Girls	Ref	Ref		
Per cent lifetime exposure to F in water	* -0.003 (0.002)	-0.06	-0.008	0.00
Birth cohort				
Born in 89/90	** 0.82 (0.21)	0.21	0.41	1.22
Born in 91/92	0.12 (0.20)	0.03	-0.26	0.51
Born in 93/94	Ref	Ref		
Parental education				
High school	0.18 (0.19)	0.05	-0.20	0.55
Vocational training	0.31 (0.22)	0.07	-0.12	0.75
University education	Ref	Ref		
Age toothbrushing started	0.01 (0.01)	-0.08	-.001	0.04
Use of soft drinks daily				
Twice a day or more	0.21 (0.19)	0.06	-0.16	0.58
Once a day or less	Ref	Ref		
Use of sugar daily				
Twice a day or more	* 0.56 (0.19)	0.15	0.19	0.93
Once a day or less	Ref	Ref		
Frequency of toothbrushing when brushing started				
Twice a day or more	0.23 (0.20)	0.06	-0.17	0.62
Once a day or less	Ref	Ref		
Frequency of toothbrushing at age 5				
Twice a day or more	* -0.50 (0.20)	-0.14	-0.89	-0.10
Once a day or less	Ref	Ref		

Adjusted R square=0.07; *: p<0.05; **: p<0.001

Other non-significant variables not listed

[a] Un-standardised coefficients; [b] standardised coefficient

Model summaries

Residuals statistics

	Minimum	Maximum	Mean	Sd	N
Predicted value	-.7018	3.1366	.9883	.65029	938
Residual	-2.9907	17.8634	.0000	1.95865	938
Std. predicted value	-2.599	3.304	.000	1.000	938
Std. residual	-1.497	8.943	.000	.980	938

a Dependent variable: permanent DMFS at the time of the study

A linear regression model was generated for deciduous caries experience at age six (Table 4.76). The model explained some 5% of the variance of deciduous caries at this age in the population. The model summaries of residual statistics showed that assumptions for the linear regression model were not violated in this model. The mean of standardised residual was zero and its standard deviation was close to one (0.954).

The per cent of lifetime exposure to fluoride in the water was significantly associated with deciduous caries experience at this age. There was a negative linear relationship between the per cent of lifetime exposure to fluoridated water and deciduous caries experience at age six.

The type of toothpaste used when toothbrushing commenced or at age five was not significant in the model. The age when toothbrushing with toothpaste commenced was not significantly associated with deciduous caries experience at age six. The birth cohort was not significantly associated with caries experience in the model.

Parental education was the only significant socioeconomic variable in the model for caries experience at age six. Children whose parents attained high school education or lower had significantly higher deciduous caries experience at this age. Drinking milk frequently was not associated with lower deciduous caries experience at age six.

Table 4.76: Linear regression model for deciduous caries experience at age six

	β (SE) [a]	Beta [b]	95% CI of β	
			Lower	Upper
Sex				
Boys	-0.05 (0.33)	-0.01	-0.70	0.59
Girls	Ref	Ref		
Per cent lifetime exposure to F in water	* -0.01 (0.01)	-0.12	-0.02	-0.002
Birth cohort				
Born in 89/90	0.60 (0.49)	0.08	-0.36	1.56
Born in 91/92	-0.05 (0.41)	-1.16	-1.28	0.33
Born in 93/94	Ref	Ref		
Parental education				
High school	* 1.38 (0.44)	0.18	0.52	2.25
Vocational training	0.57 (0.37)	0.09	-0.17	1.30
University education	Ref	Ref		
Age toothbrushing started	0.01 (0.01)	0.01	-0.02	0.03
Drink milk daily				
Twice a day or more	-0.12 (0.37)	-0.02	-0.85	0.61
Once a day or less	Ref	Ref		
Toothpaste used when brushing started				
Low fluoride toothpaste	-0.86 (0.46)	-0.13	-1.77	0.05
Standard toothpaste	Ref	Ref		
Toothpaste used at age 5				
Low fluoride toothpaste	0.59 (0.44)	0.08	-0.28	1.45
Standard toothpaste	Ref	Ref		

Adjusted R square=0.05; *: p<0.05; **: p<0.001

Other non-significant variables not listed

[a] Un-standardised coefficients; [b] Standardised coefficient

Model summaries

Residuals Statistics

	Minimum	Maximum	Mean	SD	N
Predicted value	-2.6025	6.1065	1.4935	1.44562	853
Residual	-6.1065	30.7540	.0000	3.04550	853
Std. predicted value	-2.833	3.191	.000	1.000	853
Std. residual	-1.914	9.638	.000	.954	853

a Dependent variable: dmfs score at age six

A linear regression model was generated for deciduous caries experience at age eight (Table 4.77). The model explained some 9% of the variance of deciduous caries at this age in the population. The model summaries of residual statistics showed that assumptions for the linear regression model were not violated in this model. Mean of standardised residual was zero and its standard deviation was close to one (0.978).

The per cent of lifetime exposure to fluoride in the water was significantly associated with deciduous caries experience at this age. There was a negative linear relationship between the per cent of lifetime exposure to fluoridated water and deciduous caries experience at age eight. There was no significant difference between birth cohorts at age eight in the model.

The type of toothpaste used when toothbrushing commenced or at age five was not significant in the model. There was a linear relationship between the age when toothbrushing with toothpaste commenced and deciduous caries experience at age eight.

Parental education was the only significant socioeconomic variable in the model. Children whose parents attained high school education or lower had significantly higher deciduous caries experience at this age. Drinking milk frequently was associated with lower deciduous caries experience at age eight.

Table 4.77: Linear regression model for deciduous caries experience at age eight

	β (SE) [a]	Beta [b]	95% CI of β	
			Lower	Upper
Sex				
Boys	-0.16 (0.45)	-0.02	-1.05	0.74
Girls	Ref	Ref		
Per cent lifetime exposure to F in water	* -0.02 (0.01)	-0.18	-0.04	-0.01
Birth cohort				
Born in 89/90	0.47 (0.56)	0.05	-0.64	1.57
Born in 91/92	-1.01 (0.53)	-0.11	-2.05	0.03
Born in 93/94	Ref	Ref		
Parental education				
High school	* 1.67 (0.52)	0.19	0.65	2.70
Vocational training	1.06 (0.60)	0.10	-0.11	2.24
University education	Ref	Ref		
Age toothbrushing started	* 0.03 (0.02)	0.14	0.01	0.06
Drink milk daily				
Twice a day or more	* -1.03 (0.50)	-0.11	-2.00	-0.05
Once a day or less	Ref	Ref		
Toothpaste used when brushing started				
Low fluoride toothpaste	1.14 (0.70)	0.15	-0.23	2.50
Standard toothpaste	Ref	Ref		
Toothpaste used at age 5				
Low fluoride toothpaste	-0.73 (0.60)	-0.08	-1.91	0.45
Standard toothpaste	Ref	Ref		

Adjusted R square=0.09; *: p<0.05; **: p<0.001

Other non-significant variables not listed

[a] Un-standardised coefficients; [b] Standardised coefficient

Model summaries

Residuals statistics

	Minimum	Maximum	Mean	SD	N
Predicted value	-1.1973	9.0742	3.1993	1.67363	828
Residual	-7.0283	30.0279	.0000	4.65102	828
Std. predicted value	-2.627	3.510	.000	1.000	828
Std. residual	-1.478	6.314	.000	.978	828

a Dependent variable: dmfs score at age eight

4.7 Perception of dental appearance and oral health of South Australian children

4.7.1 Dental Aesthetic Index scores

Table 4.78 presents the number and percentage of children with readings other than 0 for the ten components of the Dental Aesthetic Index. The ten components of the DAI were common. More than a third of the children had one crowded section and some 17% had two crowded sections. Spacing, diastema and maxillary irregularities were observed in about a third of the children. Mandibular irregularities were more common and were observed in just less than half children. Mandibular overjet and openbite were recorded in a small proportion of children.

Table 4.78: The ten components of the Dental Aesthetic Index

Component	n	w%	Minimum	Maximum
Missing teeth (number of teeth)	121	15.1	1	8
Crowding				
One section	281	37.6	-	-
Two section	112	17.0	-	-
Spacing				
One section	170	27.6	-	-
Two section	29	7.4	-	-
Diastema (mm)	237	34.5	1	4
Maxillary largest irregularities (mm)	217	31.5	1	6
Mandibular largest irregularities (mm)	311	45.3	1	6
Maxillary overjet (mm)	659	98.2	1	12
Mandibular overjet (mm)	32	4.7	1	4
Open bite	57	7.4	1	5
Anterior-posterior molar position				
Position 1	273	40.4	-	-
Position 2	108	13.9	-	-

n and w%: number and weighted per cent of children with components' readings other than 0
minimum: the lowest components' reading of children with readings other than 0

From hereon, the DAI score reported in tables and figures was a weighted estimate that was calculated from the components without the missing teeth component. Table 4.79 presents means and standard deviations of the Dental Aesthetic Index (DAI) scores of 8–13-year-old South Australian children by sex, residential location, and birth cohort. Sex and residential location did not significantly differ in terms of mean DAI scores. However, the early birth cohort had significantly lower DAI scores compared to that of the latest birth cohort.

Table 4.79: Mean DAI scores of 8–13-year-old South Australian children by sex, residency and year of birth (n=673) (mean DAI scores, SD)

	DAI score [a]	
	Mean	SD
Sex		
Boys	27.3	6.5
Girls	26.9	7.0
Residential location		
Adelaide	26.9	6.5
Other areas	27.8	7.3
Birth cohorts		
Born 89/90	* 25.1	6.3
Born 91/92	27.7	6.7
Born 93/94	28.1	6.7

4 subjects were not assessable for DAI

[a] Missing teeth component was not used in calculation of the DAI

* ANOVA, p < 0.05

Figure 4.1 demonstrates the distribution of DAI scores among the sample. Few subjects were at the either end of the range, most aesthetic and least aesthetic. The majority of the sample had their DAI score below the aesthetically unacceptable cut-off point (DAI of 35).

Figure 4.1: Cumulative percentage of DAI scores of 8–13-year-old children

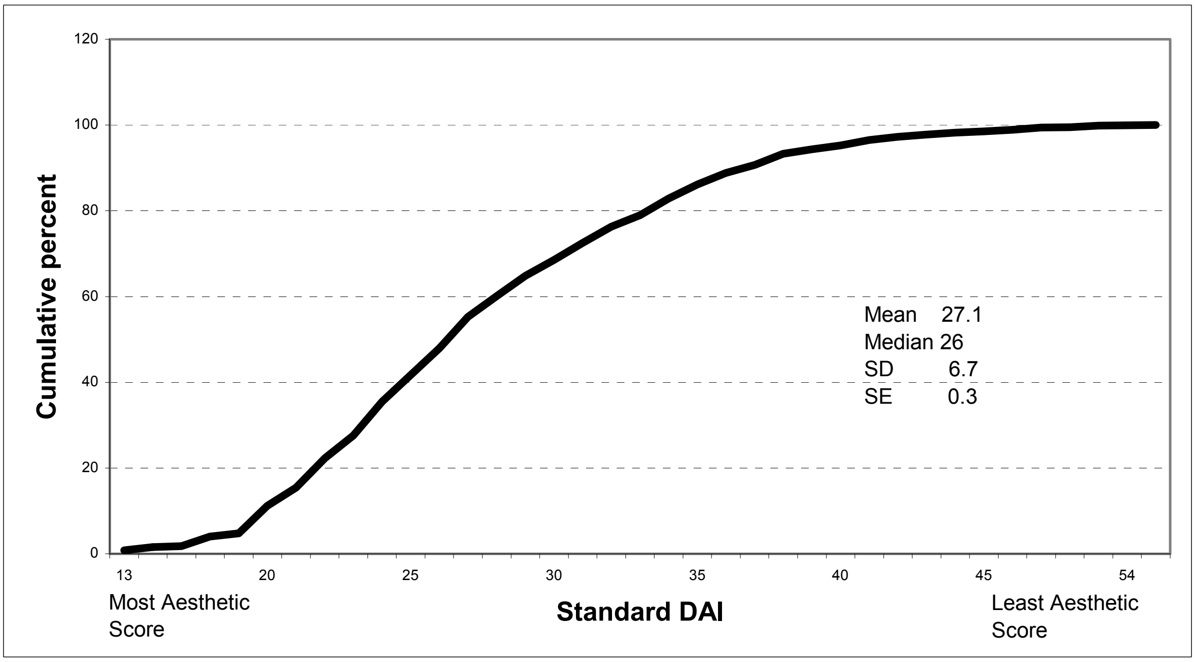


Table 4.80 presents distribution of DAI scores by responses to items in the perception questionnaire that were occlusion-related. Respondents were asked to indicate their perception of their (their children's) shape of front teeth and crookedness of front teeth.

There were significant associations in mean DAI score with ordinal level of responses to those two items. Respondents who perceived their (their children's) occlusion favourably had significantly lower mean DAI scores compared to those who perceived front teeth as unattractive or crooked. Parents who perceived their children's front teeth as very crooked had a mean DAI score that was above the aesthetically acceptable cut-off point (DAI=35).

Table 4.80: Dental Aesthetic Index score by perception of shape and alignment of front teeth (mean DAI score by responses to each item)

	DAI score mean (SD)		DAI score mean (SD)
Shape of teeth is…?		Front teeth are…?	
Parental responses	n=646	**Parental responses**	n=641
Very attractive	** 23.8 (4.5)	Not crooked at all	** 25.2 (5.8)
Attractive	26.0 (5.8)	A little bit crooked	28.2 (6.3)
Just ordinary	28.6 (7.4)	Quite a bit crooked	32.1 (7.2)
Quite unattractive	32.0 (7.4)	Very crooked	36.8 (10.4)
Very unattractive	34.4 (7.7)		
Child 8-10 yo	n=295	**Child 8-10 yo**	n=296
Very attractive	* 25.4 (6.3)	Not crooked at all	** 26.5 (5.9)
Attractive	27.9 (5.7)	A little bit crooked	29.3 (7.0)
Just ordinary	28.4 (7.2)	Quite a bit crooked	32.4 (7.7)
Quite unattractive	30.3 (5.9)	Very crooked	30.8 (7.1)
Very unattractive	33.6 (7.7)		
Child 11-13 yo	n=328	**Child 11-13 yo**	n=329
Very attractive	** 23.7 (5.6)	Not crooked at all	** 24.7 (5.7)
Attractive	24.9 (5.5)	A little bit crooked	27.6 (6.8)
Just ordinary	27.0 (6.5)	Quite a bit crooked	31.1 (6.4)
Quite unattractive	31.3 (9.7)	Very crooked	33.5 (10.1)
Very unattractive	30.5 (7.1)		

ANOVA * $p<0.05$; ** $p<0.001$

4.7.2 Global items of the dental appearance, oral health and oral health impact

The overall satisfaction of the appearance of front teeth, global questions of self-rated oral health, and the impact of oral health on life overall were analysed against sex and residential location. Table 4.81 presents the overall satisfaction of the appearance of front teeth by sex and residential location. Just under a fifth of parents were dissatisfied or very dissatisfied with their child's dental appearance. Slightly fewer children reported dissatisfaction with the appearance of their front teeth. Parents did not differ in satisfaction with the appearance of their child's front teeth irrespective of their child's sex or their residential location. Children who were 8 to 10 years old in 2002/03 were also similarly satisfied with the appearance of their front teeth either by sex or residential location. However, boys and girls who turned 11 to 13 years old in 2002/03 significantly differed in overall satisfaction with their dental appearance. This difference was observed when responses of all children were combined.

Table 4.81: Satisfaction with the appearance of front teeth by sex and residential location

Satisfaction with the appearance of front teeth?	Sex		Residential location	
	Boys	Girls	Adelaide	Other areas
Parental response	w%	w%	w%	w%
Very satisfied	15.5	17.2	15.1	20.0
Satisfied	39.1	41.1	38.8	44.4
Neither	26.0	22.3	25.8	18.8
Dissatisfied	18.8	16.2	18.4	15.0
Very dissatisfied	0.6	3.2	2.1	1.9
Child 8–10 yo response				
Very satisfied	18.6	22.6	20.6	21.0
Satisfied	44.3	38.7	39.7	48.4
Neither	23.6	21.2	24.3	16.1
Dissatisfied	9.3	16.1	12.6	12.9
Very dissatisfied	4.3	1.5	2.8	1.6
Child 11–13 yo response				
Very satisfied	* 17.0	20.8	19.7	16.5
Satisfied	50.5	40.5	46.3	44.3
Neither	18.6	19.6	17.8	22.7
Dissatisfied	9.6	17.9	13.5	13.4
Very dissatisfied	4.3	1.2	2.7	3.1
All children response				
Very satisfied	* 17.6	21.7	20.2	18.2
Satisfied	47.7	39.8	43.2	45.9
Neither	20.7	20.4	20.8	19.5
Dissatisfied	9.7	17.1	13.1	13.8
Very dissatisfied	4.3	1.0	2.7	2.5

* Chi-square, p<0.05

Table 4.82 presents the responses to the global item of oral health by sex and residential location. Sex was significantly associated with self-rated oral health reported by parents of the children and by children who were 11 to 13 years of age in 2002/03. Parents of girls were more likely to perceive their child's oral health as excellent compared to parents of boys. More boys aged 11 to 13 years old in 2002/03 perceived their oral health as good or poor compared to girls of the same age.

Residential location was not significantly associated with self-rated oral health by either children or their parents. Overall, some 10% of parents rated their child's oral health as poor or very poor compared with around 5% of children aged 8 to 10 years old, and around 13% of children who were 11 to 13 years old in 2002/03.

Table 4.82: The global item of oral health by sex and residential location

	Sex		Residential location	
Overall oral health is…?	Boys	Girls	Adelaide	Other areas
	w%	w%	w%	w%
Parental response				
Excellent	* 12.4	19.4	15.5	16.9
Very good	37.2	38.9	38.7	36.3
Good	40.4	29.0	34.6	35.6
Poor	9.1	11.1	10.2	10.0
Very poor	0.9	1.6	1.0	1.3
Child 8–10 yo response				
Very good	15.7	15.4	16.4	11.5
Good	44.3	41.9	41.6	49.2
OK	35.0	38.2	37.9	32.8
Poor	5.0	4.4	4.2	6.6
Child 11–13 yo response				
Excellent	* 10.2	9.6	10.8	8.2
Very good	28.3	44.9	36.3	34.7
Good	46.0	34.7	39.0	43.9
Poor	13.9	9.6	12.7	10.2
Very poor	1.6	1.2	1.2	3.1

* Chi-square, p<0.05

All children responses could not be combined

Responses to the global item of impact of oral health on overall life are presented by sex and residential location in Table 4.83. Over 20% of parents reported some or more impact of their child's oral health on overall life. A similar percentage of children perceived the impact of their oral health on life.

Sex and residential location were not significantly associated with the perception of impact of oral health on overall life. Parents and children did not vary in responding to this global item.

Table 4.83: The global item of impact of oral health by sex and residential location

How much does oral health affect life overall…?	Sex		Residential location	
	Boys	Girls	Adelaide	Other areas
Parental response	w%	w%	w%	w%
Not at all	42.8	38.4	40.2	41.4
Very little	35.4	38.4	37.0	36.4
Some	12.1	15.8	14.0	13.6
Quite a lot	8.6	6.8	8.2	6.8
Very much	1.2	0.6	0.6	1.9
Child 8–10 yo response				
Not at all	38.5	43.7	43.1	34.4
Very little	39.9	43.0	39.4	47.5
Some	16.8	11.9	14.2	14.8
Quite a lot	2.8	1.5	2.3	3.3
Very much	2.1	0.0	0.9	0.0
Child 11–13 yo response				
Not at all	32.1	33.9	32.2	35.1
Very little	42.8	41.7	43.0	40.2
Some	15.0	14.9	14.0	17.5
Quite a lot	7.0	7.1	7.8	6.2
Very much	3.2	2.4	3.1	1.0
All children response				
Not at all	34.7	38.2	37.3	34.8
Very little	41.4	42.1	41.5	42.4
Some	15.7	13.5	14.1	16.5
Quite a lot	5.4	4.9	5.1	5.1
Very much	2.7	1.3	2.1	1.3

Chi-square, p>0.05

4.7.3 Construct validity of the perception questionnaires

The four domains of the perception oral health-related quality of life were tested for their correlation with the two global items of oral health and of impact of oral health on quality of life. The results are reported in the two following tables.

There were statistically significant correlations between the four domains scores and the global rating of oral health (Table 4.84). These correlations ranged from 0.13 (Social wellbeing by 8–10-year-old children) to 0.40 (Emotional wellbeing scale by 10–13-year-old children). The domains scores calculated from the 11–13-year-old children's responses had the highest correlation coefficients with this global item.

The Oral symptoms scale scores reported by children had a stronger correlation with their perception of oral health-related quality of life than that reported by their parents.

Table 4.84: Spearman rank correlation of the four domains scales scores with the global rating of oral health

Domains	8–10-yo responses	11–13-yo responses	Parental responses
Oral symptoms	0.37	0.38	0.32
Functional limitations	0.28	0.33	0.30
Emotional wellbeing	0.33	0.40	0.28
Social wellbeing	0.13	0.29	0.28

All correlations: $p<0.05$

Table 4.85 presents correlation coefficients of the four domains scores with the global rating of impact of oral health on quality of life. These correlation coefficients were significant and moderately strong. The Oral symptoms scale had a higher correlation with impact on life for younger children. The Emotional wellbeing scale scores were most strongly correlated with impact of oral health on quality of life. The Social wellbeing scale score reported by the younger group of children had the lowest correlation coefficient with the global item of impact on quality of life.

Table 4.85: Spearman rank correlation of the four domains scales scores with the global rating of impact of oral health on quality of life

Domains	8–10-yo responses	11–13-yo responses	Parental responses
Oral symptoms	0.38	0.32	0.30
Functional limitations	0.36	0.31	0.30
Emotional wellbeing	0.39	0.41	0.38
Social wellbeing	0.24	0.30	0.32

All correlations: $p<0.01$

The internal consistency of items included in the four domains was evaluated by calculating Cronbach's alpha scores (Table 4.86). The estimates were generally high to very high, ranging from 0.56 to 0.93. Internal consistency of the first domain, oral symptoms, was relatively lower in the three groups. Parents were less consistent in reporting their children's oral symptoms. The older child group was the most consistent in responding to items in the domains.

Table 4.86: Internal consistency of items included in domains by parent and children (Cronbach's alpha)

Domains	8–10-yo responses		11–13-yo responses		Parental responses	
	N of items	Cronbach's Alpha	N of items	Cronbach's Alpha	N of items	Cronbach's Alpha
Oral symptoms	5	0.65	6	0.69	6	0.56
Functional limitations	5	0.72	9	0.79	7	0.74
Emotional wellbeing	5	0.86	9	0.93	8	0.88
Social wellbeing	10	0.70	13	0.90	10	0.87

All domains: $p<0.01$

4.7.4 Perception of dental appearance by fluorosis status

The perception of the colour of the front teeth was tabulated by fluorosis status on the upper central incisors (Table 4.87). Around 40% of parents perceived their children's front teeth as attractive or very attractive, whereas this percentage was much lower in the two groups of children. Slightly more parents of those children who had a TF score 1 on their central incisors perceived teeth colour as attractive or very attractive, followed by the group without fluorosis. A similar pattern was observed with 8–10-year-old children in 2002/03. However, only 22% of 11–13-year-old children who were without fluorosis perceived it favourably compared to 43% of children with TF score 1.

There was no clear pattern among parents who perceived their child's front teeth as unattractive or worse. This percentage was high among young children with TF score 1. There was a significantly higher percentage of older children with a TF score 2+ on the upper central incisors who perceived the teeth as unattractive or very unattractive, compared to 6% of children of the same age with fluorosis score 1 or 0.

Table 4.87: Perception of front teeth colour by fluorosis status on upper central incisors

Teeth colour is…?	TF scores on upper central incisors					
	TF=0		TF=1		TF=2+	
Parental response	n	w%	n	w%	n	w%
Attractive or very attractive	205	41.4	37	44.2	18	35.1
Neither	255	54.0	44	49.5	34	60.8
Unattractive or very unattractive	22	4.6	5	6.3	3	4.1
Child 8–10 yo response						
Attractive or very attractive	73	30.5	11	27.7	5	24.0
Neither	138	62.5	26	59.6	17	76.0
Unattractive or very unattractive	20	7.0	4	12.8	0	0.0
Child 11–13 yo response *						
Attractive or very attractive	56	22.4	20	42.6	8	28.6
Neither	167	72.2	21	51.1	19	57.1
Unattractive or very unattractive	15	5.4	3	6.4	4	14.3
All children response *						
Attractive or very attractive	129	26.2	31	35.1	13	27.0
Neither	305	67.6	47	55.3	36	63.5
Unattractive or very unattractive	35	6.1	7	9.6	4	9.5

* Chi-square, p<0.05

The perception of tooth staining by parents and older children was significantly related to fluorosis status on the upper central incisors (Table 4.88). However, there was no clear variation in the perception of tooth staining by young children. Forty per cent of parents of children with TF score of 0 or 1 did not perceive staining on front teeth compared to thirty per cent of parent whose children had TF score of 2+. Four per cent of parents whose children were fluorosis-free perceived their children's teeth as badly or very badly stained, whereas ten per cent of parents of children with fluorosis did so.

There was no significant association between TF scores and the perception of tooth staining by 8–10-year-old children. More than a third of the children perceived their teeth as not stained at all. Two-thirds of children who had a TF score of 2 or higher perceived their teeth as slightly stained. Some children who had no fluorosis or a TF score of 1 perceived their front teeth as badly or very badly stained.

A high proportion of 11–13-year-old children who had a TF score of 1 did not perceive staining on their teeth. Sixteen per cent of children of this age who had a TF score of 2 or higher perceived it as badly or very badly stained compared to a lower proportion of children with lower fluorosis scores. When all children were combined, there was a significantly higher number of children with a TF score of 2 or higher who perceived their teeth as badly or very badly stained compared to children who had a TF score of 0 or 1.

Table 4.88: Perception of staining of front teeth by fluorosis status on upper incisors

	TF scores on upper central incisors					
Front teeth are…?	TF=0		TF=1		TF=2+	
Parental response *	n	w%	n	w%	n	w%
Not at all stained	200	44.5	38	39.2	23	30.3
Just slightly stained	234	52.1	49	50.5	45	59.2
Badly or very badly stained	15	3.3	10	10.3	8	10.5
Child 8–10 yo response						
Not at all stained	71	35.3	18	37.5	8	33.3
Just slightly stained	116	57.7	25	52.1	16	66.7
Badly or very badly stained	14	7.0	5	10.4	0	0.0
Child 11–13 yo response *						
Not at all stained	71	29.5	24	51.1	11	22.9
Just slightly stained	154	63.9	22	46.8	29	60.4
Badly or very badly stained	16	6.6	1	2.1	8	16.7
All children response *						
Not at all stained	141	32.0	43	45.3	19	26.0
Just slightly stained	270	61.2	46	48.4	45	61.6
Badly or very badly stained	30	6.8	6	6.3	8	12.3

* Chi-square, $p<0.05$

Table 4.89 presents responses by the children and their parents to the question "If it were possible, would you like to change the colour of your teeth?" Fluorosis status was not significantly associated with perception of need for treatment reported by the parents. Some 33% of parents of fluorosis-free children perceived a need for treatment to change the colour of their child's teeth compared with 26% and 40% of parents of children with a TF score of 1 and 2+ respectively. Slightly more parents of children who had fluorosis perceived that treatment to change the colour of their child's teeth was not necessary, compared to parents of fluorosis-free children.

Children 8–10 years old at the time of the study did not significantly differ in their perception of the need for treatment to change the colour of their teeth. There were similar proportions of children with or without fluorosis perceived a need for treatment for their teeth.

Children 11–13 years old at the time of the study who were with or without fluorosis differed significantly in perception of the need for treatment to change the colour of their teeth. Some 40% of children who had a TF score of 1 perceived the need for a change of the colour of their teeth compared to 62% and 65% of children who were fluorosis-free or who had a TF score of 2+ respectively. There were 17% of children with a TF score of 1 who responded as "Definitely not" to this question, compared to 8% and 2% of children in the other two groups. All the children combined were also significantly different in their perception of the need for treatment to change the colour of their teeth; the perception of the need for treatment was lower in the group who had a TF score of 1 on their central incisors.

Table 4.89: Perception of need for treatment to change colour of teeth by fluorosis status

Do you want treatment to change colour of your (your child's) teeth…?	TF scores on upper central incisors					
	TF=0		TF=1		TF=2+	
Parental response	n	w%	n	w%	n	w%
Definitely not	73	15.0	17	14.6	6	10.7
Probably not	137	26.8	23	32.3	19	36.0
Neither	134	25.0	23	27.1	9	13.3
Probably yes	106	25.7	17	15.6	17	32.0
Definitely yes	31	7.5	7	10.4	5	8.0
Child 8–10 yo response						
Definitely not	43	18.4	11	25.0	3	7.7
Probably not	77	33.3	15	35.4	10	46.2
Neither	33	15.4	6	12.5	3	11.5
Probably yes	38	15.9	2	4.2	2	11.5
Definitely yes	40	16.9	8	22.9	4	23.1
Child 11–13 yo response *						
Definitely not	19	8.0	8	17.4	2	2.0
Probably not	39	16.0	9	23.9	6	18.4
Neither	31	13.5	7	17.4	4	14.3
Probably yes	110	46.4	11	23.9	11	34.7
Definitely yes	38	16.0	9	17.4	8	30.6
All children response *						
Definitely not	62	12.6	19	21.1	5	4.1
Probably not	116	24.0	24	29.5	16	28.4
Neither	64	14.6	13	15.8	7	13.5
Probably yes	148	32.4	13	13.7	13	25.7
Definitely yes	78	16.4	17	20.0	12	28.4

* Chi-square, $p<0.05$

There were some variations in satisfaction with dental appearance by fluorosis status on the upper incisors (Table 4.90). Among parents and younger children there was no statistically significant association of level of satisfaction with dental appearance with fluorosis status. Slightly more parents whose children had some fluorosis were satisfied or very satisfied with their children's dental appearance. A similar pattern was observed among younger children.

Significantly more 11–13-year-old children who had some fluorosis were satisfied or very satisfied with their dental appearance. However, more children who had fluorosis were very dissatisfied with the appearance of their teeth compared to fluorosis-free children. A higher proportion of fluorosis-free children was neither satisfied nor dissatisfied with their dental appearance compared to children with fluorotic teeth.

Table 4.90: Satisfaction with dental appearance by fluorosis status of upper incisors

Satisfied with appearance of front teeth . . .?	TF scores on upper incisors					
	TF=0		TF=1		TF=2+	
Parental response	n	w%	n	w%	n	w%
Very satisfied	81	14.0	21	21.2	9	20.3
Satisfied	205	40.5	39	38.5	25	41.8
Neither	101	23.6	23	26.0	15	22.8
Dissatisfied	75	19.8	11	12.5	8	12.7
Very dissatisfied	9	2.0	2	1.9	2	2.5
Child 8–10 yo response						
Very satisfied	44	18.7	14	25.5	5	29.2
Satisfied	98	40.9	20	43.1	11	41.7
Neither	51	25.8	7	17.6	2	8.3
Dissatisfied	31	12.6	4	9.8	3	16.7
Very dissatisfied	5	2.0	2	3.9	1	4.2
Child 11–13 yo response *						
Very satisfied	41	15.8	8	15.4	10	34.0
Satisfied	100	43.8	28	61.5	12	38.0
Neither	50	22.1	8	11.5	5	14.0
Dissatisfied	37	15.8	2	5.8	5	12.0
Very dissatisfied	7	2.5	2	5.8	1	2.0
All children response *						
Very satisfied	88	17.2	20	22.1	14	30.1
Satisfied	197	41.6	45	54.7	23	39.7
Neither	105	24.4	11	11.6	6	12.3
Dissatisfied	68	14.9	6	6.3	7	13.7
Very dissatisfied	10	1.8	4	5.3	2	4.1

* Chi-square, $p<0.05$

Table 4.91 presents the perception of dental appearance reported by all children and their parents from different birth cohorts. Birth cohort was not significantly associated with perception of colour of front teeth, staining of front teeth, or overall satisfaction with the appearance of front teeth reported by the children. However, the parents of children from different birth cohorts significantly differed in satisfaction with the appearance of their child's front teeth. There was a higher percentage of parents of children in the earliest birth cohort who were satisfied with their child's dental appearance.

Table 4.91: Perception of dental appearance by birth cohort

	Birth cohort					
	Born 89/90		Born 91/92		Born 93/94	
Colour of front teeth . . .?	n	w%	n	w%	n	w%
Parental responses						
Attractive or very attractive	76	43.3	90	40.8	107	39.5
Neither	85	52.6	113	54.7	148	54.5
Unattractive or very unattractive	8	4.1	12	4.5	13	6.0
All children responses						
Attractive or very attractive	46	25.4	61	30.5	77	28.1
Neither	110	67.9	132	64.3	160	62.7
Unattractive or very unattractive	12	6.7	13	5.2	24	9.2
Front teeth are…?						
Parental responses						
Not at all stained	81	42.8	108	47.7	108	37.2
Just slightly stained	80	51.5	92	46.8	145	57.1
Badly or very badly stained	8	5.7	12	5.4	12	5.6
All children responses						
Not at all stained	51	26.2	79	38.5	101	35.1
Just slightly stained	100	67.0	110	54.0	143	57.5
Badly or very badly stained	14	6.8	17	7.5	18	7.5
Satisfaction with appearance of front teeth…?						
Parental responses *						
Satisfied or very satisfied	113	64.9	121	51.4	158	54.1
Neither	30	19.9	46	24.1	67	27.5
Dissatisfied or very dissatisfied	25	15.2	46	24.5	41	18.5
All children responses						
Satisfied or very satisfied	107	62.2	134	69.3	166	59.4
Neither	31	18.7	38	17.0	56	25.3
Dissatisfied or very dissatisfied	28	19.2	34	13.7	40	15.3

* Chi-square, $p<0.05$

4.7.5 Perception of oral health-related quality of life

4.7.5.1 Perception of oral health-related quality of life by birth cohort

Table 4.92 presents the four domain scores by parents and children by birth cohort. Mean domain scores and their standard deviations were presented. Higher mean domain scores indicated worse perception of oral health and more impact on quality of life.

The parents of children of the earliest birth cohort reported a significantly better perception of oral symptoms compared to the parents of children of the latest birth cohort. Birth cohort was not significantly associated with the other three domains. However, there was a trend that the parents of children in the earliest birth cohort reported a worse perception of emotional wellbeing and social wellbeing compared to the parents of children in the later birth cohorts.

Children who were born in 1993/94 reported a significantly higher perception score for the Oral symptom scale compared to children of the earliest birth cohort. Birth cohort was not significantly associated with the other three domains of perception of oral health reported by the children.

Table 4.92: The perception of oral health-related quality of life by birth cohort

	Birth cohort		
	Born 89/90	Born 91/92	Born 93/94
	Mean (SD)	**Mean (SD)**	**Mean (SD)**
Parental response			
Oral symptoms	† 0.73 (0.52)	0.82 (0.50)	† 0.85 (0.52)
Functional limitation	0.40 (0.59)	0.41 (0.53)	0.40 (0.56)
Emotional well being	0.33 (0.60)	0.30 (0.51)	0.28 (0.45)
Social well being	0.20 (0.41)	0.17 (0.35)	0.15 (0.33)
All children response			
Oral symptoms	† 0.85 (0.55)	0.93 (0.54)	† 1.06 (0.63)
Functional limitation	0.38 (0.51)	0.45 (0.54)	0.37 (0.48)
Emotional well being	0.37 (0.59)	0.32 (0.52)	0.42 (0.66)
Social well being	0.20 (0.39)	0.15 (0.28)	0.15 (0.27)

† One-way ANOVA, Tukey posthoc test, statistically significant by pair

4.7.5.2 *The perception of oral health-related quality of life by fluorosis status*

The parents' and children's responses to the global item of oral health were tabulated with the fluorosis status (Table 4.93). More parents of children who had a TF score 2+ on their upper incisors perceived their children's oral health as excellent or very good. Only a few parents of those children perceived their children's oral health as poor compared to 10% of parents whose children had a lower fluorosis score.

There were inconsistent variations in 8–10-year-old children's responses to this global item by fluorosis status. Still, a slightly higher proportion of children with a TF score 2+ perceived their oral health favourably.

Older children with different degrees of fluorosis significantly varied in response to the global item. Around 40% of fluorosis-free children perceived their oral health as excellent or very good, whereas over 60% of children with fluorotic teeth did so. Slightly more children in the fluorosis-free group thought their oral health was poor or very poor.

Table 4.93: Responses to the global item of oral health by fluorosis status on upper incisors (weighted column %)

	TF scores on upper incisors					
	TF=0		TF=1		TF=2+	
Parental response	n	w%	n	w%	n	w%
Excellent	72	14.6	16	15.2	11	22.1
Very good	178	36.6	36	40.0	26	42.9
Good	173	37.3	31	31.4	19	31.2
Poor	48	10.4	12	10.5	2	3.9
Very poor	8	1.1	1	2.9	0	0.0
Child 8–10 yo response						
Very good	31	13.7	9	21.6	3	16.0
Good	103	43.7	18	37.3	13	52.0
OK	79	37.1	19	41.2	5	28.0
Poor	15	5.6	0	0.0	1	4.0
Child 11–13 yo response *						
Excellent	16	5.9	8	13.5	9	23.1
Very good	75	33.5	21	44.2	13	38.5
Good	109	45.3	14	34.6	10	28.8
Poor	26	13.1	4	7.7	3	9.6
Very poor	7	2.1	1	0.1	0	0.0

* Chi-square, $p<0.05$

Parents and children did not significantly differ in response to the second global item: impact of oral health on quality of life (Table 4.94). There was a trend that fluorosis-free children and their parents were more likely to report a greater impact of oral health on quality of life. More than 80% of older children who had fluorosis reported no or very little impact on life. However, around 5% of all children reported that their oral health impacted on their life "quite a lot" or "very much". This percentage was similar between groups by fluorosis.

Table 4.94: Responses to the global item of the impact of oral health by fluorosis status of upper central incisors (weighted column %)

	TF scores on upper central incisors					
	TF=0		TF=1		TF=2+	
Parental response	n	w%	n	w%	n	w%
Not at all	192	39.2	38	36.5	31	53.8
Very little	176	37.2	42	46.2	15	25.6
Some	68	14.5	9	10.6	8	12.8
Quite a lot	34	8.0	6	6.7	3	7.7
Very much	7	1.1	1	0.1	0	0.0
Child 8–10 yo response						
Not at all	82	38.0	21	49.0	9	48.0
Very little	104	43.5	18	34.7	11	40.0
Some	34	14.0	6	16.3	2	12.0
Quite a lot	8	3.0	1	0.0	0	0.0
Very much	2	1.5	0	0.0	0	0.0
Child 11–13 yo response						
Not at all	77	33.2	17	30.8	14	42.3
Very little	93	40.8	22	50.0	14	40.4
Some	44	16.8	6	13.5	3	9.6
Quite a lot	16	6.3	3	5.8	1	1.9
Very much	5	2.9	0	0.0	3	5.8
All children response						
Not at all	162	35.5	35	41.5	22	43.2
Very little	201	42.5	34	38.3	23	40.5
Some	76	15.4	12	16.0	5	10.8
Quite a lot	24	4.8	4	4.3	1	1.4
Very much	6	1.8	0	0.0	3	4.1

Chi-square, $p>0.05$

Means of oral health perception scale scores are presented by fluorosis status (Table 4.95). There were significant associations between fluorosis status and the perception of oral health-related quality of life reported by the children and their parents.

Parents of fluorosis-free children reported significantly higher mean of all domains (perception of poorer oral health) compared to parents whose children had fluorosis on their central incisors. Parents of children with a TF score 2 or higher had domains' mean scores lower or equal to those parents whose children had a TF score 1.

There were no significant differences in mean scale scores reported by younger children. No clear trend of variation related to fluorosis status was observed. Children in the older age group with different fluorosis status significantly varied in their perception of oral health-related quality of life. Children without fluorosis reported significantly higher mean of the domain scores on all scales. Observed differences in the Oral symptom and Functional limitation scales between fluorosis-free children and those with a TF score 2+ were relatively large. These two scales were also significant when all children's scales scores were combined. Children who had a TF score of 2 or more reported a better perception of oral health-related quality of life in the first two domains, Oral symptoms and Functional limitations, compared to children who had no fluorosis.

Table 4.95: Perception of oral health domains by fluorosis score on upper central incisors

	TF scores on upper central incisors		
	TF=0	TF=1	TF=2+
	Mean (SD)	Mean (SD)	Mean (SD)
Parental response			
Oral symptoms	† 0.86 (0.54)	‡ 0.74 (0.44)	† ‡ 0.57 (0.41)
Functional limitation	† 0.46 (0.59)	0.36 (0.51)	† 0.24 (0.37)
Emotional wellbeing	† ‡ 0.36 (0.56)	‡ 0.20 (0.40)	† 0.20 (0.34)
Social wellbeing	† 0.20 (0.42)	0.10 (0.23)	† 0.08 (0.20)
Child 8-10 yo response			
Oral symptoms	1.05 (0.65)	1.10 (0.53)	0.93 (0.65)
Functional limitation	0.39 (0.51)	0.35 (0.56)	0.34 (0.47)
Emotional wellbeing	0.41 (0.63)	0.43 (0.72)	0.50 (0.60)
Social wellbeing	0.13 (0.24)	0.15 (0.29)	0.19 (0.24)
Child 11-13 yo response			
Oral symptoms	† ‡ 0.98 (0.59)	‡ 0.72 (0.52)	† 0.58 (0.41)
Functional limitation	† 0.52 (0.59)	0.31 (0.44)	† 0.24 (0.34)
Emotional wellbeing	† 0.41 (0.64)	† 0.19 (0.36)	0.21 (0.35)
Social wellbeing	† 0.22 (0.42)	0.12 (0.17)	† 0.07 (0.14)
All children response			
Oral symptoms	† 1.02 (0.62)	0.91 (0.56)	† 0.69 (0.52)
Functional limitation	† 0.46 (0.56)	0.33 (0.50)	† 0.27 (0.38)
Emotional wellbeing	0.41 (0.64)	0.31 (0.58)	0.30 (0.47)
Social wellbeing	0.18 (0.35)	0.13 (0.24)	0.11 (0.19)

† ‡ One-way ANOVA, Tukey posthoc test, statistically significant by pairs

4.7.5.3 *The perception of oral health-related quality of life by caries status*

Responses to the global item of oral health by the children and their parents in relation to dental caries status are presented in Table 4.96. Parental perception of their children's oral health was significantly related to the children's dental caries status. Over 60% of parents whose children had no deciduous caries perceived their children's oral health as "Excellent" or "Very good" compared to over 40% of those whose children had deciduous decay. Likewise, similar proportions were observed when permanent caries was considered. Relatively more parents whose children had either deciduous or permanent decay perceived their children' oral health as "Poor" or "Very poor" compared to parents of caries-free children.

There were no statistically significant differences in the children's responses to the global item of oral health by caries status. However, there was a trend that children with deciduous or permanent caries were less likely to favourably perceive their oral health and were more likely to perceive it as "Poor".

Table 4.96: Responses to the global item of oral health by the prevalence of dental caries (weighted column %)

	Deciduous caries		Permanent caries	
	dmfs=0	dmfs>0	DMFS=0	DMFS>0
Parental response				
Excellent	* 20.9	8.9	* 18.6	11.1
Very good	41.8	34.0	39.9	36.2
Good	28.8	41.3	32.7	36.2
Poor	7.1	14.2	8.2	13.5
Very poor	1.4	1.6	0.7	2.9
Child 8–10 yo response				
Very good	14.5	16.6	16.7	13.1
Good	49.2	41.7	45.3	44.0
OK	30.6	36.8	34.0	34.5
Poor	5.6	4.9	3.9	8.3
Child 11–14 yo response				
Excellent	12.1	6.6	13.4	6.7
Very good	39.0	28.9	38.0	34.2
Good	38.5	44.7	36.9	45.0
Poor	7.8	17.1	9.6	10.8
Very poor	2.6	2.6	2.1	3.3

* Chi-square, $p<0.05$

There were no significant differences in parents' and children's responses to the global item of impact of oral health on quality of life by caries status (Table 4.97). There was a trend that more parents of caries-free children reported that their children's oral health had no impact on quality of life compared to those whose children had some decay. The trend among children was not clear.

Table 4.97: Responses to the global item of impact of oral health by the prevalence of dental caries (weighted column %)

	Deciduous caries		Permanent caries	
	dmfs=0	dmfs>0	DMFS=0	DMFS>0
Parental response				
Not at all	46.4	35.1	43.8	38.0
Very little	33.2	42.4	37.4	36.1
Some	11.8	15.9	11.4	17.6
Quite a lot	7.7	5.7	6.7	7.3
Very much	0.8	0.8	0.7	1.0
Child 8–10 yo response				
Not at all	33.9	42.1	38.4	38.8
Very little	48.4	40.2	43.3	44.7
Some	16.1	12.8	14.3	14.1
Quite a lot	1.6	3.7	3.0	2.4
Very much	0.0	1.2	1.0	0.0
Child 11–13 yo response				
Not at all	33.3	30.3	34.8	29.2
Very little	40.3	43.4	40.6	41.7
Some	16.0	19.7	15.5	19.2
Quite a lot	6.9	6.6	5.9	8.3
Very much	3.5	0.0	3.2	1.7
All children response				
Not at all	34.3	40.4	35.9	37.4
Very little	43.3	38.5	42.9	39.3
Some	13.9	15.9	14.4	15.4
Quite a lot	5.9	3.8	4.2	7.0
Very much	2.6	1.4	2.6	0.9

* Chi-square, p<0.05

There were statistically significant differences in parents' and children's means of the scales' scores by caries status (Table 4.98). Parents whose children did not have deciduous caries had a significantly lower mean of the Oral symptom scale compared to those whose children had deciduous caries. Those two groups did not differ in terms of the other three domains scores. The presence or absence of permanent dental caries had a significant impact on parental perception on three scales: Functional limitation, Emotional wellbeing and Social wellbeing.

The group of younger children did not statistically significantly differ in their perception of oral health-related quality of life by caries status. The older group of children without deciduous caries had lower means of the Oral symptom and Functional limitation scales, but the differences were not statistically significant. The presence of permanent caries significantly worsened the perception of oral health among those older children in the three scales apart from the Oral symptom scale. All children combined significantly differed in the Functional limitation and Social wellbeing scales when permanent caries was considered.

Table 4.98: Perception of oral health domains by the prevalence of deciduous and permanent dental caries

	Deciduous caries		Permanent caries	
	dmfs=0	dmfs >0	DMFS=0	DMFS >0
Parental response				
Oral symptoms	* 0.75 (0.51)	0.88 (0.52)	0.77 (0.50)	0.86 (0.56)
Functional limitation	0.41 (0.58)	0.39 (0.50)	* 0.36 (0.50)	0.49 (0.62)
Emotional wellbeing	0.30 (0.55)	0.29 (0.46)	* 0.26 (0.48)	0.38 (0.58)
Social wellbeing	0.16 (0.35)	0.17 (0.37)	* 0.13 (0.30)	0.25 (0.45)
Child 8-10 yo response				
Oral symptoms	1.09 (0.63)	1.04 (0.61)	1.07 (0.63)	1.03 (0.60)
Functional limitation	0.36 (0.45)	0.35 (0.51)	0.36 (0.49)	0.36 (0.47)
Emotional wellbeing	0.43 (0.67)	0.38 (0.61)	0.40 (0.67)	0.41 (0.54)
Social well being	0.13 (0.19)	0.16 (0.31)	0.13 (0.24)	0.19 (0.32)
Child 11-14 yo response				
Oral symptoms	0.85 (0.55)	0.97 (0.60)	0.84 (0.54)	0.93 (0.59)
Functional limitation	0.41 (0.53)	0.54 (0.56)	* 0.37 (0.48)	0.55 (0.61)
Emotional wellbeing	0.35 (0.59)	0.32 (0.49)	* 0.28 (0.49)	0.44 (0.66)
Social wellbeing	0.19 (0.38)	0.17 (0.22)	* 0.14 (0.29)	0.26 (0.41)
All children response				
Oral symptoms	0.93 (0.59)	1.02 (0.61)	0.96 (0.60)	0.98 (0.60)
Functional limitation	0.39 (0.50)	0.41 (0.53)	* 0.36 (0.49)	0.47 (0.56)
Emotional wellbeing	0.38 (0.62)	0.36 (0.58)	0.34 (0.60)	0.43 (0.61)
Social wellbeing	0.17 (0.33)	0.17 (0.28)	* 0.13 (0.26)	0.23 (0.38)

* ANOVA (dmfs=0 vs dmfs>0 and DMFS=0 vs DMFS>0), p<0.05

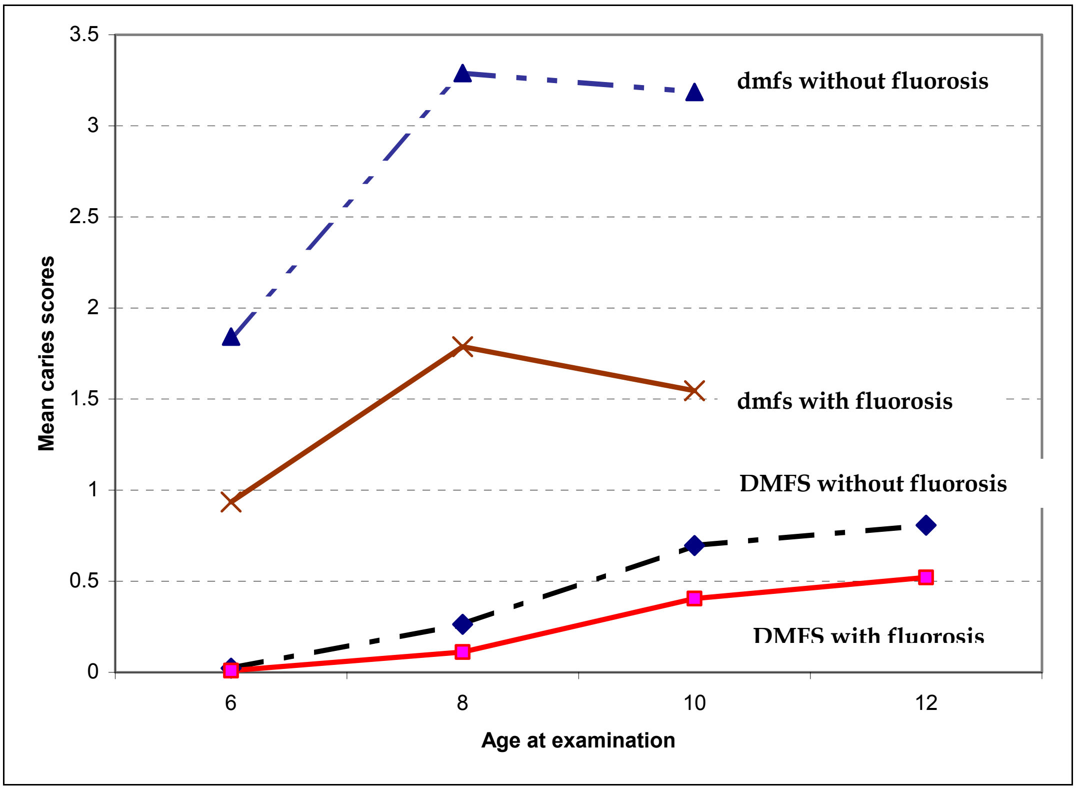
4.8 Fluoride exposure, dental fluorosis, caries and oral health-related quality of life

4.8.1 The association between fluorosis and caries in relation to exposures to fluoride

There was an association between the presence of fluorosis and caries in this study population (Figure 4.2). Children with fluorosis on one of their upper central incisors had a lower mean deciduous dmfs at age six. There was an increase in deciduous caries experience to age eight and a decrease after this age in the groups with and without fluorosis. However, children who were without fluorosis had a sharper increase in mean dmfs from age six to age eight and a slower decrease after age eight compared to the other group.

Permanent caries experience was negligible when the children were at age six. Once again, children who were fluorosis-free had a faster increase in their mean permanent DMFS score compared to children with fluorosis. The difference in mean DMFS between these groups was larger at subsequent ages.

Figure 4.2: Trend of deciduous and permanent caries by experience of fluorosis defined as having TF score 1+ on upper central incisors



Exposure to different sources of fluoride were compared in terms of the prevalence of dental fluorosis, defined as having a TF score of 1+ and 2+ on the upper central incisors, and of deciduous caries experience defined as mean dmfs scores at age six and eight. The differences between groups were tested for statistical significance using Chi-square for fluorosis and one-way ANOVA for caries. The Tukey posthoc test was used when independent variables had three groups or more to test difference between each pair of the groups in each variable. The results are presented in Table 4.99 through to Table 4.102.

Children who were exposed to fluoride in the water had a significantly higher prevalence of dental fluorosis on their upper teeth defined by the TF index (Table 4.99). The difference in risk for having fluorosis was 10% between groups with zero exposure and group with more than 50% lifetime exposure. Having some but less than or equal to 50% of lifetime exposure had a lower prevalence by one per cent compared to those who had more than 50% lifetime exposure. Exposure to fluoride was also significantly associated with caries experience at different ages. Mean deciduous decayed, missing and filled surfaces were significantly lower among children with at least some exposure to fluoride. Exposure to fluoride in the water for more than 50% of lifetime was associated with 1.25 and 1.88 fewer carious surfaces at age six and age eight respectively. Children who had some, but less than or equal to 50% of their lifetime exposed to fluoride in water had intermediate caries experience compared to the other two groups. However, these children experienced significantly higher caries at ages six and eight compared with children who had more than 50% lifetime exposure to fluoride in the water.

Table 4.99: Dental caries and fluorosis experience of children with different levels of lifetime exposure to fluoride in water

	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
Exposure to fluoride in water	TF score 1+	TF score 2+	At age six	At age eight
0% lifetime	* 14.6	* 3.4	† 2.19 (4.06)	† 3.53 (5.09)
>0 & <50% lifetime	26.8	10.9	# 1.71 (3.43)	# 3.00 (5.18)
>50%lifetime	33.7	14.0	† # 0.94 (2.34)	† # 1.65 (3.16)

[a] Defined as having one or more upper central incisors with a TF score 1+ or 2+;

* Chi-square, p<0.01

[b] Mean deciduous dmfs at different ages, (SD in bracket)

† # One-way ANOVA, Tukey's posthoc test: statistically significant by pair

The association of the age when toothbrushing commenced with the prevalence of fluorosis and caries experience at ages six and eight was explored (Table 4.100). Commencing toothbrushing with toothpaste before 18 months of age or from 19 to 30 months was related to a significantly higher prevalence of fluorosis defined as having a TF score of 2 or more compared to commencing it after 30 months. Commencing toothbrushing with toothpaste between 19 months and 30 months resulted in a reduction of 6% and 1% in the prevalence of fluorosis defined as having a TF score of 1+ or a TF score of 2+ respectively. However, starting toothbrushing during the period 19 to 30 months of age did not result in significantly increased caries experience. Children who started brushing during this period still had significantly lower caries experience at age six compared to children who commenced toothbrushing after 30 months of age. Children who started brushing after 30 months of age had significantly higher mean dmfs scores at ages six and eight compared to children who commenced toothbrushing before 18 months. The difference was more than one deciduous surface affected by caries.

Table 4.100: Dental caries and fluorosis experience of children with age started toothbrushing

	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
Age started toothbrushing	**TF score 1+**	**TF score 2+**	**At age six**	**At age eight**
≤18 months	* 31.8	* 13.2	† 1.03 (2.48)	† 1.85 (3.58)
From 19 to 30 months	25.8	12.2	# 1.13 (2.60)	2.32 (3.79)
After 30th months	22.5	7.8	† # 2.04 (4.00)	† 3.20 (5.82)

[a] Defined as having one or more upper central incisors with a TF score 1+ or 2+;

* Chi-square, p<0.05

[b] Mean deciduous dmfs at different ages, (SD in bracket)

† # One-way ANOVA, Tukey posthoc test: statistically significant by pair

The relationship of the components of toothbrushing practice was evaluated with the prevalence of dental fluorosis and caries experience at age six and eight (Table 4.101). Using children's low concentration fluoride toothpaste when brushing started was associated with a lower prevalence of fluorosis defined as having a TF score of 1+ or 2+ compared to using standard toothpaste. There was no significant difference in mean deciduous dmfs score between standard toothpaste users and low fluoride toothpaste users at age six and eight.

Brushing teeth more frequently when toothbrushing commenced was not significantly associated with an increase in the prevalence of fluorosis defined as having a TF score of 1+ or 2+ on the central incisors compared with brushing once a day or less. However, brushing more frequently was significantly associated with a reduced mean caries experience at age six. Those children who brushed more frequently had lower mean dmfs at age eight; however, the difference was not significant.

Swallowing slurry after toothbrushing when toothbrushing commenced in childhood was not significantly associated with a change in fluorosis and caries. However, swallowing slurry was associated with a higher prevalence of fluorosis, defined as having a TF score of 1+ or 2+, and with lower caries experience at age six and eight compared with children who rinsed and spat out after brushing. The differences were not statistically significant.

Having more than a pea-sized amount of toothpaste when brushing started was not significantly associated with the prevalence of fluorosis defined as having a TF score of 1+ or 2+. Using a smaller, smear amount of toothpaste when toothbrushing started was associated with higher mean dmfs scores at ages six and eight. However, the differences were not statistically significant.

Table 4.101: Dental caries and fluorosis experience of children with components of toothbrushing practice when toothbrushing started

Type of toothpaste used when brushing started	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
	TF score 1+	TF score 2+	At age six	At age eight
Standard F toothpaste	* 31.8	* 16.2	1.05 (2.82)	2.52 (5.52)
Children low F toothpaste	23.4	6.4	1.47 (3.08)	2.35 (3.93)

Brushing frequency when brushing started	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
	TF score 1+	TF score 2+	At age six	At age eight
Twice a day or more	28.9	11.0	† 1.11 (2.81)	2.33 (4.68)
Once a day or less	24.7	11.1	1.53 (3.15)	2.44 (4.14)

After-brushing routine when brushing started	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
	TF score 1+	TF score 2+	At age six	At age eight
Swallowed	29.1	13.0	1.28 (2.88)	2.52 (4.41)
Rinsed and spat out	26.6	10.3	1.78 (3.67)	2.84 (4.08)

Toothpaste amount when brushing started	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
	TF score 1+	TF score 2+	At age six	At age eight
Pea size or larger	* 34.2	10.6	1.39 (2.87)	2.64 (4.06)
Smear amount	24.5	13.4	1.78 (3.96)	3.01 (5.64)

[a] Defined as having one or more upper central incisors with a TF score 1+ or 2+;

* Chi-square, p<0.05

[b] Mean deciduous dmfs at different ages, (SD in bracket)

† ANOVA, p<0.05

Children who were reported as having an eating and/or licking toothpaste habit when they started toothbrushing had a significantly higher prevalence of fluorosis, defined as having a TF score of 1+ or 2+ on their upper central incisors (Table 4.102). However, there was no difference in dental caries experience at age six and eight between the groups who did and who did not have this habit. The mean deciduous caries at ages six and eight were strikingly similar between the groups, despite the difference in the prevalence of fluorosis.

Table 4.102: Dental caries and fluorosis experience of children with an eating and/or licking toothpaste habit when toothbrushing started

Eating and/or licking toothpaste habit when brushing started	Prevalence of fluorosis [a]		Deciduous caries experience [b]	
	TF score 1+	TF score 2+	At age six	At age eight
Yes	* 33.3	* 14.5	1.36 (2.95)	2.39 (4.01)
No	22.5	8.7	1.35 (3.08)	2.37 (4.63)

[a] Defined as having one or more upper central incisors with TF score 1+ or 2+;

* Chi-square, p<0.05

[b] Mean deciduous dmfs at different ages, (SD in bracket)

ANOVA, p>0.05

4.8.2 Determinants of the perception of oral health-related quality of life

Multivariate models for the perception of oral health domains were generated for children's and parental scales scores (Table 4.103 and Table 4.104). Models were run for each domain score reported by all children and their parents with caries and fluorosis status, controlled for age, sex, residential location and occlusal traits measured by the DAI score.

Having fluorosis on the central incisors was the only significant contributor in the model for the oral symptom scale of children (Table 4.103). The presence of fluorosis significantly reduced the perception of oral symptoms among children, i.e. fewer oral symptoms in the reference period. Caries experience was of borderline significance in the model for this scale. Other factors were not significant in this model.

Caries experience, fluorosis status and DAI score were significant contributors in the model for the functional limitation scale. Having higher caries experience and higher DAI score significantly increased the mean domain score, whereas having fluorosis on teeth reduced the perception of functional limitation.

Occlusal traits measured by the DAI score were significant in the model for the emotional wellbeing scale of children. Having higher DAI score (a less socially acceptable dental appearance) significantly worsened the perception of the emotional wellbeing of children. Other factors were not significant in this model.

The presence of fluorosis on teeth and having less acceptable occlusal traits were significant factors in the model for the social wellbeing scale. Having fluorosis marginally improved the Social wellbeing scale score whereas having less acceptable occlusal traits worsened this perception in the presence of other variables in the model.

Table 4.103: Linear regression models for oral health perception domains scores reported by children

Domain	Variables	Un-std β	Std Beta	95% CI of β	
				Lower	Upper
Oral symptoms	Age	0.003	0.026	-0.006	0.011
	Boys vs girls	-0.009	-0.009	-0.113	0.090
	Urban vs rural	-0.020	-0.012	-0.137	0.103
	TF scores on incisors	* -0.127	-0.155	-0.196	-0.059
	Caries experience	0.005	0.069	-0.001	0.023
	DAI scores	0.003	0.055	-0.003	0.013
Functional limitations	Age	0.004	0.042	-0.003	0.011
	Boys vs girls	0.006	0.008	-0.080	0.097
	Urban vs rural	-0.006	-0.035	-0.149	0.060
	TF scores on incisors	* -0.070	-0.111	-0.139	-0.021
	Caries experience	* 0.009	0.083	0.000	0.022
	DAI scores	** 0.012	0.170	0.008	0.021
Emotional wellbeing	Age	-0.002	-0.033	-0.011	0.005
	Boys vs girls	0.045	0.044	-0.047	0.154
	Urban vs rural	-0.068	-0.046	-0.184	0.053
	TF scores on incisors	-0.006	-0.060	-0.116	0.019
	Caries experience	0.001	0.034	-0.008	0.018
	DAI scores	** 0.010	0.139	0.005	0.021
Social wellbeing	Age	0.002	0.023	- 0.003	0.005
	Boys vs girls	-0.021	-0.031	- 0.073	0.033
	Urban vs rural	-0.028	-0.052	-0.101	0.023
	TF scores on incisors	* -0.036	-0.083	-0.071	-0.002
	Caries experience	0.003	0.032	-0.004	0.009
	DAI scores	* 0.004	0.155	0.000	0.007

Caries experience is sums of deciduous dmfs and permanent DMFS at the time of the study

* p<0.05; ** p<0.01

Models for parental domains scores are presented in Table 4.104. The presence of fluorosis and caries were significant in the model for the oral symptoms scale. These factors were the only significant variables controlling for other factors. Having fluorosis reduced the perception of oral symptoms, whereas higher caries experience significantly increased the domain score reported by parents.

Dental aesthetic was the strongest determinant of parental perception of their children's functional limitations. Having less socially acceptable occlusal traits significantly increased the perception score for this domain. Having fluorosis was also significant. However, this factor significantly improved parental perception of this aspect of their children's oral health.

The emotional wellbeing of children perceived by their parents was associated with the child's age at the time of the study, occlusal traits and the presence or absence of fluorosis in their mouth. The age of the children was the most important factor in the perception of the child's emotional wellbeing by their parents. Having a higher DAI score significantly worsened the emotional wellbeing of children whereas having fluorosis improved it.

A number of variables were significant in the model for the Social wellbeing scale as perceived by parents of children in the study. Having less socially acceptable occlusal traits and having higher mean of decayed teeth significantly worsened the perception of social wellbeing, whereas being boy and having fluorosis significantly improved this perception.

Table 4.104: Linear regression models for oral health perception domains scores reported by parents

Domain	Variables	Un-std β	Std Beta	95% CI of β	
				Lower	Upper
Oral symptoms	Age	0.004	0.040	-0.003	0.010
	Boys vs girls	-0.020	-0.020	-0.106	0.063
	Urban vs rural	-0.007	-0.007	-0.109	0.092
	TF scores on incisors	* -0.107	-0.177	-0.180	-0.067
	Caries experience	* 0.012	0.113	0.004	0.024
	DAI scores	0.003	0.055	-0.002	0.011
Functional limitations	Age	0.001	0.018	-0.006	0.009
	Boys vs girls	-0.049	-0.049	-0.143	0.035
	Urban vs rural	-0.054	-0.054	-0.176	0.036
	TF scores on incisors	* -0.116	-0.116	-0.145	-0.025
	Caries experience	0.005	0.045	-0.005	0.016
	DAI scores	** 0.017	0.173	0.008	0.022
Emotional wellbeing	Age	** -0.016	-0.169	-0.021	-0.008
	Boys vs girls	-0.049	-0.012	-0.135	0.035
	Urban vs rural	-0.081	-0.057	-0.249	0.087
	TF scores on incisors	* -0.092	-0.100	-0.146	-0.037
	Caries experience	0.001	0.025	-0.007	0.013
	DAI scores	* 0.010	0.125	0.004	0.017
Social wellbeing	Age	-0.000	-0.010	- 0.005	0.004
	Boys vs girls	* -0.084	-0.080	- 0.144	-0.024
	Urban vs rural	-0.042	-0.034	-0.161	0.076
	TF scores on incisors	* -0.064	-0.097	-0.103	-0.026
	Caries experience	* 0.007	0.078	0.000	0.014
	DAI scores	* 0.005	0.108	0.002	0.011

Caries experience is sums of deciduous dmfs and permanent DMFS at the time of the study

* $p<0.05$;   ** $p<0.01$

5. Discussion

5.1 Overview – strengths and limitations

This study was designed as a population-based historical cohort study with complex data collection process. The design complied with the aims of the study to evaluate the relationship between exposures to fluoride in childhood with dental fluorosis and caries among South Australian children. The multistage, stratified random sample selection used in the study aimed to achieve variability in fluoride exposure that was essential for the study. Known probabilities of selection were important so as to be able to weight the results to obtain the best possible population estimates, since the findings of the study were to be related back to the population of interest. The selection and recruitment of study participants was complex but achievable; however, it was time-consuming and labour intensive. These characteristics of the study design were preserved and further improved from its predecessor – the Child Fluoride Study 1991/1992 (Slade et al., 1995a; 1996a; 1996b), which was cited as one of a few pivotal studies in child dental health research (NHMRC, 1999).

This study employed complex data collection procedures. Retrospective and concurrent data were collected on a number of inter-related aspects of oral health and contributory factors. A detailed questionnaire that was used in the COHS retrospectively collected fluoride exposure history at different time points. These data facilitated fluoride exposure measurements that could be related to fluorosis, caries and their consequences for child oral health-related quality of life. Dental caries data were retrospectively and concurrently collected, which enabled the examination of caries status at different anchor ages. The caries status of different birth cohorts was therefore directly comparable. Dental fluorosis status was evaluated only concurrently for all cohorts, assuming the post-eruptive time period would have minimal effect on the prevalence and severity of fluorosis. Dental appearance and oral health perception information were collected only concurrently to be related to the oral health status of the children at the time of the study.

Data weighting was another feature of the study. Owing to the complexity of the study design, a weighting procedure of the final study sample was required. This procedure aimed to correct for differences in selection ratios and in response rates at different stages of the selection of the children and conduct of the study. This procedure was necessary to assure unbiased population estimates and generalisability of the findings. The findings of the study were considered applicable to the population of South Australian children attending the

School Dental Service, which is approximately 80% of children, ages 5 to 13 years old in South Australia.

The study had achieved the required sample size (see 3.1.2.2). However, a number of sampling and response issues occurred, such as that the earliest birth cohort had a lower response rate and, hence, had a lower number of subjects in the study. Therefore, the power of the study was re-calculated with the actual number of subjects and disease estimates using a similar approach to that described in the planning of the study. The calculated power for the working hypotheses was above 80% when an un-weighted number of subjects was used. The actually power of the analyses might have been higher because the re-weighting procedure corrected for differences in response rates.

The associated questionnaires collected detailed retrospective information of fluoride history and concurrent perceptions of oral health and dental appearance. The Child Oral Health Study (COHS) questionnaire provided valuable information for fluoride exposure measurements and other important factors such as socioeconomic status and dietary factors. Most factors that have been identified in the literature as related to dental fluorosis and caries in children were the subject of detailed questions. These fluoride exposure data were deemed essential for the better understanding of the nature of these two inter-related conditions, dental fluorosis and caries.

Questions are frequently raised about recall bias associated with retrospective data collection. There was a likelihood of some recall bias in fluoride exposure history data, depending on the complexity of the data concerned. However, this mode of data collection mirrors much of the information collected in dental research in particular and medical research in general, owing to its time and cost effectiveness. The questionnaire used in this study was designed so as to minimise the possibility of recall bias. The data management process also helped to identify and correct for those biases. For example, if a child who was born in 1989 reported using low fluoride toothpaste before the first birthday, this response might be deemed as biased, as low fluoride toothpaste was not available in Australia until 1991.

The dental perception questionnaire employed in the study used previously tested instruments to measure perception of dental appearance and oral health. The instrument was designed so as to effectively gather information from children. The parallel collection of information from both a parent and a child was informative. The dental appearance items were adopted from the well-developed Dental Aesthetic Index questionnaire (Cons, Jenny and Kohout, 1986) and it was effectively used in the previous fluorosis study of South Australian children (Hoskin and Spencer, 1993). The oral health perception items in the CPQ and PPQ and their calculated domains were successfully tested in a number of studies (Jokovic et al., 2002; 2003; Jokovic, Locker and Guyatt, 2004). However, those studies used the CPQ and PPQ in convenience samples of children with specific oral conditions. To the knowledge of the author, this study was one of the first studies that used the perception questionnaires in a sample of the general child population who might or might not have dental or oral conditions. The construct validity and internal consistency of the questionnaires tested in this study indicated useability of these questionnaires in the general child population and with their parents.

The fluorosis examination was carried out by one specially trained examiner. This fact significantly improved the reliability of the collected information since there was no inter-examiner variation. The examination procedures were to encourage the examiner's and study participants' comfort and, hence, reliability of the collected data. The examinations, however, were very time-consuming and labour and cost intensive. Nevertheless, the quality of collected data outweighed the expense of the fieldwork.

The fact that one examiner conducted two fluorosis indices might raise some issues. Some may argue that there might be a carry-over effect in scoring the two indices. This might have been true given two indices with similar examination requirements. But the FRI and the TF Index used in this study differ substantially in criteria and examination requirements. This was a strong reason for their selection for this study. The FRI evaluates each one-fourth of buccal surface of a tooth when the tooth is "wet". On the other hand, the TF Index scores the whole buccal surface of a tooth when the tooth is dry. Therefore, using these two indices together would have little, if any, carry-over effect. For example, in the case of a "snow capping" of a tooth, the occlusal/incisal edge of that tooth might be scored as FRI 2 whereas the tooth might have a TF score of even 0 if the whole buccal/labial surface was not affected.

Intra-examiner reliability, which was satisfactorily high, was another credit to the study. The kappa scores were similar to those of other studies in the area using the same index (Riordan and Banks, 1991; Ellwood, Cortea and O'Mullane, 1996). The observed reliability scores represented "substantial" strength of agreement between the original and replicated examinations, according to the classification by Landis and Koch (1977).

There might be criticism that the examiner was not "blind" towards the children's residential status. It would be ideal to examine children at a neutral site. However, locations of study sites in this study made it logistically impossible to do so. Nevertheless, this fact did not affect the quality of the data collected for several reasons. First, the examiner did not have access to fluoride exposure history data collected via the parent's COHS questionnaire during the fieldwork. The examiner was, therefore, "blind" towards exposure history, which was one of the main factors of interest in this study. Second, residence was not used as an explanatory factor for fluorosis because residential status at the time of the study might not reflect exposure to fluoridated water at the time of tooth development.

There may be some criticism that the dental caries data were collected by a large number of un-calibrated examiners (dentists and dental therapists at School Dental Service and therefore inter-examiner variation might have affected the data. However, those examiners were similarly trained and had centrally regulated practice guidelines. In addition, inter-examiner variation would have equally affected groups by exposure to fluoride. Therefore, systematic biases were unlikely. Also, a similar approach in caries data collection was used in the Child Fluoride Study 1991/1992 (Slade et al., 1995a; 1996a; 1996b), which had been considered as a pivotal study in children oral health (NHMRC, 1999). The methodologies used in this COHS were similar to those of the Child fluoride Study, with some modifications aimed at improving the reliability of the data.

There is a common problem of dental caries data in children that data are often highly skewed. Caries is confined to a minority of children who bear most of the burden of the disease. This might create some problems for statistical analysis. However, most of parametric statistical analyses are reasonably robust and are not substantially affected when the assumption of data being normally distributed is slightly violated (Munro, 1994). Further, the sample size of the study was large enough to increase the normality of the distribution of means, according to the central limit theorem (Munro, 1994). The model summaries of the linear regression models reported in the study showed that residuals were normally distributed; hence, those models were applicable to test the study hypothesis.

The time factor was important in examining the outcome of the population measures in reducing fluorosis that have been implemented for the last ten years. The study was considered as particularly timely for this purpose for several reasons. First, retrospective data would be better collected as soon as possible. The quality and reliability of those data may be reduced over time. Second, fluorosed enamel may be affected by some external factors after eruption, such as wear or dental treatment, although this change would be minimal with mild fluorosis across a limited number of years. Children up to adolescent years would be less likely to have aesthetic dental treatment. Third, the expected outcome of the population initiatives (fluorosis status on permanent teeth) must be present at a recordable level. Children who were expected to be affected by the policy initiatives (born at or after the changes) would be 8 to 9 years old in 2002/03. This age group would have enough permanent teeth present for clinical examination of fluorosis to take place.

To summarise, the study can be considered as appropriately designed to pursue the specific aims of examining the outcome of policy initiatives introduced in Australia to control fluoride exposure so as to reduce the prevalence and severity of fluorosis.

5.2 Exposure to fluoride among South Australian children

5.2.1 Overview of exposure measurement

Exposure measurement has a special place in modern epidemiology. It is important in establishing a causal relationship for any disease and condition. By having identified a person as exposed or not exposed to a factor of interest, epidemiologists can evaluate the relative importance of that factor in the causal chain of a condition. In modern epidemiology, exposure measurement has moved far beyond the qualitative assessment (presence or absence of a factor) of a cause-effect relationship. Medical research attempts to quantify levels of exposure to establish dose-response effects in a causal relationship.

Exposure to fluoride has been frequently investigated in the oral epidemiology. There is general agreement that exposure to fluoride has a caries protective effect. At the same time, that exposure can pose a level of risk for dental fluorosis. For a long time, the exposure to fluoride has been approached as a dichotomy – presence or absence of a factor. That approach has been at the core of research that evaluates effectiveness of any fluoride source. However, that approach may not be useful in evaluating the dose response effect of fluoride exposure, when the causal relationship is of interest.

The use of water fluoridation status as a factor in oral epidemiological research is an example of that approach. The vast majority of studies of dental fluorosis used residence in either fluoridated or non-fluoridated areas as an explanatory variable. This was based on an assumption that any individual living in a certain area would have the same use of water, i.e. have the same level of exposure. This assumption may be more or less true for non-fluoridated areas during a particular short period of time, when every individual has the same low level of fluoride intake whether or not they drink public water or other waters. However, if lifetime exposure is of concern, people may have different levels of exposure depending on the times and places they have lived. There can be substantial variation in exposure to fluoride between individuals who live in a fluoridated area either at a time point or for a period of life. Individuals vary in exposure to fluoride in water depending on the water sources used, and amount of fluid intake. A person who lives in a fluoridated area but does not use public water may be similar in terms of exposure to fluoride in the water to another person who lives in a non-fluoridated area. This present study identified that some 17% of children who lived in fluoridated Adelaide did not use public water at all. Therefore, dichotomising people by water fluoridation status of their residential location may limit the ability to establish a causal relationship between fluoride from water and dental caries and fluorosis. Calculated lifetime exposure to fluoride in the water can be a better alternative. The calculation must depend on the lifetime period spent at any location, the fluoride level at that location, and the level of use of that water.

The per cent of lifetime exposure to fluoride in water has found its applications in numerous research studies of dental caries (Slade et al., 1995a; Singh, Spencer and Armfield, 2003; Armfield and Spencer, 2004). The use of per cent lifetime exposure to water fluoridation in caries research is particularly interesting because it is a continuous variable. A linear relationship between per cent lifetime exposure and mean caries scores can be established. That relationship was found to be significant in this study in a number of linear regression models for dental caries.

Despite its applicability, the variable has yet to be used in the research of dental fluorosis. Exposure to fluoridated water has often been measured as a dichotomy, for example, as place of residence (Riordan and Banks, 1991; Selwitz et al., 1998; Tabari et al., 2000; Riordan, 2002). Water fluoridation in general was considered a risk factor for fluorosis. However, recent studies have not moved to a dose response approach in risk assessment for fluorosis.

The use of per cent lifetime exposure to fluoride in water in this study to explore the relationship between water fluoridation and dental fluorosis has indicated its applicability in risk assessment for fluorosis. The variable has captured the dose response effect of exposure to fluoridated water on the development of fluorosis. Children having been exposed to fluoridated water for different proportions of their lifetime during the tooth development period had varying degrees of risk for fluorosis (see Section 4.5.6.1).

The method of calculating per cent lifetime exposure to fluoridated water in this study was slightly different to that in the other studies (Slade et al., 1995a; Singh, Spencer and Armfield, 2003; Armfield and Spencer, 2004), which were based on data collected in the Child Fluoride Study 1991/92. This earlier study did not specifically collect information on public water consumption, whereas it was detailed in the current COHS questionnaire. Therefore, it was possible to adjust the lifetime spent in a fluoridated area with the proportion of public water consumption to get a more accurate estimate of exposure to fluoridated water.

Patterns of toothbrushing practice were collected to reflect two main aspects: mechanical cleaning of teeth and exposure to fluoride from toothpaste. The age of toothbrushing commencement, frequency of brushing per day, amount of toothpaste used, type of toothpaste used, and after-brushing routine at different time points were useful variables in evaluating dental fluorosis and caries in this study population. Another toothpaste-related variable, an eating and/or licking toothpaste habit, was found interesting because this behaviour might considerably affect fluoride intake without mechanical cleaning of teeth.

Exposure patterns to other discretionary fluoride sources such as fluoride supplements and infant formula were collected. Those variables were used in the analysis of the relationship with fluorosis and caries. However, they were found to explain little variance of those outcomes. These findings will be commented on later in the risk assessment section (see Section 4.5.7).

5.2.2 Exposure to fluoride among South Australian children

5.2.2.1 Exposure to fluoride in water

The per cent of lifetime exposure to fluoridated water was calculated and used as a measurement of exposure to fluoride in drinking water. This continuous variable had advantages of reflecting the time factor, level of fluoride in drinking water at a location, and individual water usage. This variable was found to effectively measure the children's exposure to fluoride in water as a continuous variable that is postulated to be closely related to their exposure to fluoride in water. The calculation of lifetime exposure to fluoride in water for a life period, such as from birth to age six, was successful in identifying the level of exposure during a risk period for fluorosis on early erupting teeth.

A comparison of lifetime exposure to fluoridated water between fluoridated and non-fluoridated areas revealed that this exposure measurement has several advantages over a simple grouping by residence (see Table 4.16). If current residential location were used to dichotomise children into exposed or not exposed to water fluoridation, a proportion of children would have been misclassified. A quarter of the children currently residing in non-fluoridated areas were exposed to fluoridated water from birth to age six, and some 10% of children from fluoridated areas had no exposure to fluoride from water. If only children who spent their whole life in either area were included in the analysis, there would be considerable loss of data, and bias might occur if families who were often on the move differed in some characteristics from ones who never changed their residential location.

Findings on the proportion of public water consumption among children presented interest. Some 20% of the children never consumed public water. Another 40% had less than or equal to half of their total fluid intake as public water. There was no available historical data of water consumption in Australia for comparison. A study in the UK reported a significant decline in the consumption of public water in the year 2000 compared with available data 20 years ago (Zohouri et al., 2004). A significant increase in the consumption of soft drinks was reported. If Australian children followed a similar trend, a significant decline in public water consumption would be expected.

There was a trend that children from the later birth cohort had reduced exposure to fluoride in water. This same cohort was more likely to have some but less than or equal to 50% of their lifetime exposed to fluoridated water. Although the difference was not statistically significant, this trend might indicate a change in people's behaviour toward water consumption, or it might indicate an increasing use of technologies such as water filters or the conservation of water in water tanks in everyday life. This speculation is supported by the fact that children from high-income households tended to have some but less than 50% of their lifetime exposed to fluoridated water (see Table 4.16). This trend may have impacted on dental caries experience in this study population. While the present study has documented the trend, the reasons behind it remain unknown.

5.2.2.2 Exposure to fluoride toothpaste

The children in this study generally started toothbrushing relatively early. Just less than two-thirds of the sample commenced their toothbrushing with toothpaste before the second birthday. This was not consistent with today's professional advice of delaying toothbrushing until the second birthday. However, the early toothbrushing practice of children in this study was probably affected by advice available in the late 1980s and early 1990s, which tended to encourage earlier and more extensive use of toothpaste. This means that those children might have ingested increased amounts of toothpaste in their early years of life and hence had increased risk of fluorosis (Mascarenhas and Burt, 1998).

There was a tendency that girls were likely to practise toothbrushing more extensively compared with boys. Girls started toothbrushing earlier, were significantly more likely to used standard fluoride toothpaste, and used larger amounts of toothpaste per brushing. This difference might be linked with relatively earlier physical growth among girls. However, more research may be needed to explore this difference.

Just less than 65% of children used low concentration fluoride toothpaste when they commenced toothbrushing. This figure was significantly higher compared to an early study conducted by Riordan in Western Australia (Riordan, 2002), where a quarter of the sample used low concentration fluoride toothpaste. However, only 28% of the earliest birth cohort reported using low concentration fluoride toothpaste. This birth cohort was assumed to be born at the same time as the sample in the Western Australian study (Riordan, 2002). Therefore, the two studies were consistent in reporting the level of use of low concentration fluoride toothpaste in Australia. The finding that the type of toothpaste used in childhood was a risk factor for dental fluorosis in bivariate and multivariate analyses in this study, as would be theoretically predicted, indicated the reasonableness of the parents' responses on this aspect of toothbrushing. The type of toothpaste used was strongly related to birth cohort because of its availability in the oral care product market. The use of low concentration fluoride toothpaste was found to be a contributory factor in the decline in the prevalence of fluorosis across birth cohorts (see Table 4.53). The trend of using low concentration fluoride toothpaste increased sharply across birth cohorts. This trend was an indication that the population initiatives introduced in the early 1990s to control fluoride exposure in children were widely implemented in children who were born after the introduction of the measures.

Another target of the population initiatives taken in the 1990s was the amount of toothpaste used per brushing for young children. The fact that almost all children used a pea-sized or lesser amount of toothpaste when toothbrushing commenced indicates that the message was received by the public. The increase in the number of children using recommended amount of toothpaste across birth cohorts indicated the time lines in the diffusion and adoption of a new practice.

Stratified analyses of toothbrushing practice revealed no significant difference between groups by water fluoridation status (see Table 4.18 through to Table 4.22) and by lifetime exposure to fluoridated water (see Table 4.23). Children who benefited from exposure to fluoridated water were also exposed to other fluoride available from multiple sources including fluoride toothpaste, whereas children from non-fluoridated areas were only exposed to some other fluoride sources, possibly leaving them with lower than necessary exposure to effectively prevent caries. Increased exposure to fluoride may not be beneficial, given the well-known curve-linear relationship between fluoride and caries, and the linear relationship between fluoride and fluorosis, which means that increasing fluoride exposure beyond accepted levels can significantly increase fluorosis but may not have an effect on caries. On the other hand, if children in non-fluoridated areas followed the advice to reduce exposure to fluoride from toothpaste when not being protected by fluoridated water, they would have an increased risk of having dental caries. Differentiation between fluoridated and non-fluoridated areas might be taken into consideration in recommending toothbrushing practice for children.

5.2.3 Exposure to other discretionary fluoride sources

There were few children in this study who used fluoride supplements in their first years of life. The proportion of children who used fluoride supplements was lower than that in the earlier South Australian fluorosis study in 1992 (Puzio, Spencer and Brennan, 1993). Since a reduction in fluoride supplement use was recommended as part of the population initiatives taken in the early 1990s, this trend could be considered as an indication of the success of the policy measures. A similar finding was observed in the study of Western Australian children (Riordan, 2002). The inter-cohort trend further indicated the reduction in the use of fluoride supplements. The patterns of fluoride supplements use in this study, namely age started using and dosage did not show significant discrepancy from the recommended schedule. However, the low number of children who reported using supplements necessitates caution in the analysis presented.

Although half of the sample used infant formula in childhood, this variable was not found to be related to experience of fluorosis or caries in this study. Infant formula use was a risk factor for fluorosis in the previous fluorosis studies conducted in South Australia (Puzio, Spencer and Brennan, 1993) and Western Australia (Riordan, 1993a). However, the recent study in Western Australia did not repeat that finding (Riordan, 2002). Previous studies captured formula use at times when infant formula powders had high levels of fluoride. However, manufacturers' changes in the early 1990s reduced the level of fluoride in infant formula powder. Children who were born in early birth cohort in this study might still have had access to infant formula powders that were high in fluoride (Silva and Reynolds, 1996). However, the impact of infant formula used by that cohort on fluorosis and caries was also not significant.

5.2.4 Summaries of exposure to fluoride

Several findings could be drawn from this study in regard to exposure to fluoride among the study population. These findings can be used to explain time trends of fluorosis across the birth cohorts. Also, they may have implications in developing recommendations to more effectively control fluoride exposure.

First, there was a decline in exposure to discretionary fluoride in this study population. The decline was in accordance with policy initiatives introduced in the early 1990s. Those initiatives aimed at decreasing the systemic intake of fluoride by young children from discretionary sources of fluoride.

Second, there was an indication, though the analysis not significant, that exposure to fluoridated water was also decreasing. Increasing use of bottle water and water filtering systems that may remove fluoride could reduce the per cent of lifetime exposure to fluoridated water. Further research is required to confirm that speculation.

Third, the findings indicated that children from fluoridated and non-fluoridated areas had similar patterns of fluoride toothpaste use. There was no differentiation in toothbrushing practice between young children living in fluoridated areas and young children living in non-fluoridated areas. Guidelines for the use of fluoride toothpaste that differentiate between levels of fluoride in water could result in a more appropriate exposure to fluoride in children under six years of age in order to prevent fluorosis without reducing the anti-caries effect of fluoride.

5.3 Dental fluorosis among South Australian children

5.3.1 Dental fluorosis measurement in the study population

Dental fluorosis experience in this study population was measured by the two well-established indices for fluorosis, the TF Index and the FRI. These indices have been used in numerous studies in different populations for varying purposes. The TF Index has been one of the most widely used indices for fluorosis owing to its ability to relate the clinical appearance of a fluorotic lesion with its histological features, and its capability to classify different levels of fluorosis severity. The FRI is a more complex index, which is characterised by its capability to relate fluoride exposure at different time periods with the clinical expression of fluorosis. The two indices suited the specific objectives of this study.

The use of the two indices by one examiner in this study is unlikely to be associated with a "carry-over" effect. The indices differ markedly by the sites of examination and examination requirements, such as the drying requirement in the TF Index, which reduces the effect of the scoring on the first index on the scoring of the second. Both indices require a diagnosis of fluorosis to be made. However, the clinical appearance of fluorosis in different areas of a tooth surface determines scores for each index. This was demonstrated in the differences in reporting the prevalence of fluorosis by the two indices (see Table 4.35).

The examination for fluorosis in this study was affected by the children's mixed dentition status. There was a difference in the number of permanent teeth that were present for examination. Fluorosis status that was defined by TF scores of the central incisors and the FRI Classification I case definition were not affected by this variation in permanent teeth. These case definitions were used, therefore, when the inter-cohort comparison was of interest.

The use of the FRI in young children in this study was limited to some extent. The index is designed for use in children with a more complete permanent dentition, whereas the large proportion of this study sample had mixed dentition. The FRI Classification I case definition was not generally affected by that fact. However, the FRI Classification II case definition was birth cohort related. Therefore, some analytical characteristics of the index could not be fully utilised in this study. That potential problem was expected in the planning stage of the study. Nevertheless, the FRI was still preferred as the index to be used with the TF in order to reduce the possibility of a "carry over" effect when one examiner conducts two fluorosis indices at a time. Also, the FRI was expected to contribute to the risk assessment of fluorosis in this study.

5.3.2 Dental fluorosis experience in the study population

This study was undertaken to describe the dental fluorosis experience in the South Australian child population. Several case definitions were used to report the prevalence of the condition to enable comparison with other studies. Since the TF Index is one of the most widely used indices of fluorosis in recent studies, case definitions using the TF Index were of greater interest.

The observed dental fluorosis in the study population was mainly mild to very mild, i.e. TF score 1 and 2. More than half the cases with fluorosis on the central incisors had a worse TF score of 1. A similar level of fluorosis severity has been reported in most of studies in western populations. The recent study in Western Australian children reported a similar per cent of children in fluoridated Perth and non-fluoridated Bunbury who had a TF score of 1 on their central incisors, and a slightly lower prevalence of TF score 2 and 3 (Riordan, 2002). This distribution of scores is probably a characteristic of the clinical expression of fluorosis in populations which have a close to optimal exposure to fluoride. Data from a population living in areas with a high to very high level of fluoride naturally occurring in water showed that a significant proportion of fluorosis cases had a higher TF score (Manji et al., 1986).

Girls were more likely to have fluorosis on their upper central incisors. The factors that may explain the difference between sexes were not known. Evidence from the literature was conflicting, with some studies reporting higher fluorosis in boys (Clark et al., 1994; Skotowski, Hunt and Levy, 1995) while others reporting the opposite trend (Brothwell and Limeback, 1999; Maupome et al., 2003). A possible reason for the sex difference in the fluorosis experience in this study might be found in variations in the use of fluoride toothpaste. Girls in this study reported significantly more extensive toothpaste use, which was found to be a strong risk factor for fluorosis in this study population.

Just over a quarter of children in this study population presented with dental fluorosis on their upper central incisors. This proportion was reduced by more than a half when only TF scores of 2 or higher were considered. Very few children had a TF score of 3. This level of severity was also at very low prevalence on other examined teeth. This result is similar to findings from other studies conducted in western countries where fluoride exposure is a subject of public policy and behavioural guidelines. The recent study in Western Australian children reported a slightly lower percentage of children with a TF score of 2 or 3 on their upper central incisor (Riordan, 2002). Other studies that investigated fluorosis in comparable countries reported similar findings (Holloway and Ellwood, 1997; Rozier, 1999; Whelton et al., 2004).

5.3.3 Trend of dental fluorosis in South Australian children

The trend of fluorosis in South Australian children was evaluated by an inter-cohort comparison between three successive two-year-wide birth cohorts in the prevalence and severity of fluorosis. Since children of different ages differed in their permanent dentition status, only the fluorosis status of the central incisors was compared. This comparison was expected to address the research question of whether any change over time in the fluorosis experience actually occurred.

There was a clear trend of decreasing prevalence of fluorosis defined as having a TF score of 1+ or 2+ on the upper central incisors. The prevalence of fluorosis defined as having any TF score among children who were in the 89/90 birth cohort was 12% higher than that of children of the youngest cohort group. The difference was more than twice as high when only a TF score of 2+ was considered. The 91/92 birth cohort was intermediate to the other two groups. This trend was strong and indicative of actual change in the fluorosis experience in the population.

The inter-cohort change was characterised by a significant decrease in the proportion of children of the latest birth cohort who had a TF score of 2 on their upper central teeth. Since this severity level of fluorosis may be considered as the upper limit of aesthetical acceptability, this change was significant in terms of the dental public health aspect of fluorosis.

In the search for factors that might be responsible for the inter-cohort change in the prevalence of fluorosis, the type of toothpaste used in childhood emerged as the most probable factor. This exposure to fluoride was highly cohort-related, with more than two-thirds of the latest birth cohort reporting use of low fluoride toothpaste as compared to a quarter of the earliest birth cohort. The use of standard concentration fluoride toothpaste was linked to a significantly higher proportion of children with a TF score of 2 in bivariate analysis. Most interestingly, the type of toothpaste used when toothbrushing commenced was found to change the effect of the birth cohort in logistic regression models for the prevalence of fluorosis defined by the TF Index. Other fluoride exposures were not found to have a similar effect. This was highly indicative that change in the type of fluoride toothpaste used in childhood was responsible for the trend of fluorosis in this study population.

There might be a question about a possibility of examiner bias, since the children's age could be identified by their physical size and dentition status. Studies of the time trend in dental fluorosis have been affected by this factor (Evans, 1989; Burt, Keels and Heller, 2000; 2003). Burt and co-workers examined children in three consecutive years in an attempt to "match" subjects' age at the clinical examination (Burt, Keels and Heller, 2000). However, that approach did not solve the problem since children of later birth cohorts would be scheduled for examination in later years in order to match children's age at the examination. Also "diagnostic drift" was possible if the fieldwork took a long period of time, as discussed by Burt, Keels and Heller (2000). The only approach could be examining cropped photographs of two upper central incisors, without showing other teeth present. However, that approach could be technically cumbersome. Photographs were taken from children in this study to be used later for intra-examiner reliability. This approach was used to control for the possibility of this examiner bias.

The fluorosis study of South Australian children in 1993 using a similar case definition reported a much higher percentage of the sample with fluorosis. Some 40.5% and 3.3% of children had a TF score of 1 or 2+, respectively. Although the two studies might not be directly comparable, it was clear that the proportion of South Australian children with any fluorosis in 2002/03 was lower than that observed in 1992/03. However, the prevalence of fluorosis defined as having a TF score of 2 or 3 was higher in 2002/03 than that of the 1993 fluorosis study sample (11.8% versus 3.3%). It is not known whether that was a true difference between the two study samples or if it was affected by differences in representativeness of the samples. The sample of the fluorosis study of 1993 was not weighted, whereas children in this present study were weighted by age and sex distribution to represent the South Australian child population. Children from non-fluoridated areas who comprised more than half of the sample of the previous fluorosis study were much less likely to have a TF score of 2 or higher. Therefore, the averaged percentage of the prevalence of fluorosis in that study was likely to be heavily affected, i.e. scaled down, by the low prevalence of fluorosis defined as a TF score of 2 or higher in those children.

To conclude, there was strong evidence that the prevalence and severity of dental fluorosis declined across several successive birth cohorts of South Australian children. This decline was most likely the result of reduced exposure to discretionary fluoride sources.

5.4 Risk factors for dental fluorosis among South Australian children

5.4.1 Epidemiological fundamentals of risk assessment

Epidemiology, according to general definition, deals with the study of determinants of the occurrence of health-related conditions with the scope to identify the alterable causes and apply findings to control the problem (MacMahon and Trichopoulos, 1996). A central theme of epidemiology is the distinction between causal and non-causal statistical association between categories of events.

The concept of cause and causal inference is fundamental to epidemiology. A causal factor of a disease is *"an event, condition, or characteristic that plays an essential role in producing an occurrence of the disease"* (Rothman, 1986). Modern epidemiology has come to the conclusion that a disease can have more than one cause and a factor may be a causal factor for several diseases or conditions. Therefore, in order to fulfil the scope of epidemiology, that is to prevent disease by identifying determinants of the disease, it is frequently necessary to have a more comprehensive model of disease causation than that presented by a single necessary cause.

A number of different criteria have been used to distinguish causal statistical associations from non-causal ones. The most frequently used by epidemiologists is a set of criteria developed by Bradford Hill (1965) based on the Henle-Koch postulates and discussed in detail by Lilienfeld (1967). The use of these criteria in risk assessment in dental research has been discussed by Beck (1998) and Burt (2001). These criteria are as follows.

- *Consistency of association.* A factor is more likely to be causal if studies involving different populations, methods and time periods produce similar results of the relationship.
- *Strength of association.* The stronger the association, the more likely it is not entirely due to error.
- *Time sequence correct.* The factor must precede the occurrence of the disease.
- *Specificity of the association.* If the factor is related to other diseases, the association is less likely to be causal. This criterion may be applied less stringently today because of the multi-factorial nature of many chronic diseases and conditions.

- *Degree of exposure (dose-response effect).* The risk of developing the disease should be related to the degree of exposure to the factor. This criterion is considered as quite significant.
- *Biological plausibility.* The association should make sense in the light of current knowledge.
- *Experimental evidence.* Laboratory studies and randomised clinical trials testing interventions provide strong evidence in identifying the causality of the factor.

These criteria bear on the view of causal inference, which is a matter of well-informed judgement of the credibility of all available evidence and current knowledge. The more evidence provided on a factor, the more precise the inference about the causality of the factor which can be made. Factors identified in this study will be evaluated against these criteria for their link to the development of fluorosis.

Different types of epidemiological studies satisfy different criteria of causality. Cross-sectional and case-control studies are sometimes unable to answer questions about time sequence and cannot infer the causality of the association. However, this type of study can provide strong evidence concerning criteria of *consistency, strength* and *degree of exposure*. Hence, cross-sectional and case-control studies can set the fundamental knowledge of the epidemiology and sometimes can replace longitudinal studies, which can be difficult to conduct due to ethical considerations.

In the study of risk factors for dental fluorosis, *time sequence* can often be identified in this type of study when retrospective data collection is conducted. Fluorosis is a developmental change, which happens during the enamel formation period; therefore, the time of its initiation is identifiable. Fluoride exposure that takes place during that period may have an effect on the causal chain of fluorosis of teeth that are being formed. The criterion of *time sequence* is often satisfied in this case.

The criterion of *dose response effect* is another aspect of causative association. Whenever possible, this criterion must be evaluated for the identification of a risk factor to be valid. Therefore, continuous or ordinal measures of exposure have some preference over nominal ones. The exposure measurement in the study of fluorosis is discussed elsewhere in this chapter (see Section 5.2).

5.4.2 Risk factors for fluorosis among South Australian children

A number of factors have been identified as associated with the prevalence of dental fluorosis in this study population. Those factors are sex; the per cent of lifetime exposure to fluoride in the water; and several patterns of toothpaste use, namely the age commencing toothbrushing with toothpaste, the concentration of fluoride in toothpaste, an eating and/or licking toothpaste habit, and the amount of toothpaste used. The factors were evaluated against the criteria for a causal association as described above. Several criteria were not evaluated for all fluoride exposures such as *specificity of the association*, and *experimental evidence*. *Specificity of the association* may not be of importance because of multifactoriality of cause. *Experimental evidence* available supports the view that exposure to any source of fluoride during the tooth development period may pose a risk of developing dental fluorosis.

5.4.2.1 Exposure to fluoride in water

From Dean's era, living in an area with fluoride level in water of 0.8 ppm or higher meant a higher chance of having enamel mottling (Dean, 1942). The prevalence of fluorosis in an area with 0.8 to 1 ppm of fluoride carried an 18-fold higher risk of having fluorosis compared with an area where fluoride was negligible. However, the last half century had seen sharp increases in the prevalence of fluorosis in both areas with optimal and with negligible fluoride levels in water.

Fluorosis that was defined as having a TF score of 1 or more on the upper central incisors was present in a quarter of the study population. However, the prevalence of fluorosis in fluoridated Adelaide was only two times higher than that in other non-fluoridated areas. Although a comparison with Dean's figures can be difficult, it was obvious that the increase in the prevalence of fluorosis in non-fluoridated area was much sharper. That fact was consistent with findings from other studies that were summarised in recent systematic reviews (Rozier, 1999; NHMRC, 1999; CRD, 2000). Nevertheless, there is no doubt that fluoridated water posed a level of risk for dental fluorosis.

Exposure to fluoridated water as a risk factor for dental fluorosis satisfies a number of criteria of causal association. There was evidence of *consistency of association* as was reviewed from data available in numerous studies (Mascarenhas, 2000), which was confirmed in this study in bivariate and multivariate models with different case definitions. The *strength of association* was evidenced in high odds ratios reported in the studies reviewed (from 2.07 to 8.46). This study reported odds ratios of having fluorosis in that range, depending on case definitions used in multivariate models.

The *biological plausibility* of the association was clear, since fluoridated water is a source of systemic fluoride. Fluoride in water is biologically available. Therefore, after being consumed and absorbed, it can be available in the circulatory system and brought to bone and teeth. Exposure to fluoridated water during the tooth development period can increase the amount of fluoride in contact with developing enamel.

This study provided more specific evidence of the *time sequence* of the association. Previous studies often used residential location as a factor for exposure to fluoridated water. Current residential location might not indicate that individuals were specifically exposed to fluoride in the water during the risk period for developing fluorosis. This study employed a more detailed lifetime exposure to fluoride in the water in the first six years of life in evaluating the risk for fluorosis on early erupting teeth. This increased the certainty that individuals classified in the exposed group had some level of exposure to fluoride from the water during the enamel development period.

The study also evaluated evidence of a *dose response effect* of the exposure. Having a higher per cent of lifetime exposure to water fluoridation was associated with increased odds of having fluorosis. That was most pronounced in the models for the prevalence of fluorosis defined as having a TF score of 2+ and the models for cases of fluorosis defined by the FRI case definitions.

Therefore, there was evidence to support the view that exposure to fluoridated water was a risk factor for dental fluorosis in the study population.

5.4.2.2 Fluoride toothpaste

Evidence of fluoride toothpaste as a risk factor for dental fluorosis varies depending on study design and exposure measurement methods. In a review by Ripa (1991), nine out of ten studies could not find an association between the use of fluoride toothpaste and dental fluorosis. Those studies, however, were not designed to specifically evaluate such link. More recent studies that were designed to collect measurements of exposure to toothpaste reported a significant association between fluoride toothpaste and dental fluorosis. Ingestion of fluoride toothpaste was associated with a significantly higher prevalence of dental fluorosis (Rock and Sabieha, 1997). The patterns of exposure to fluoride toothpaste found to significantly increase the prevalence of fluorosis were age of toothbrushing commencement (Riordan, 1991; Pendrys, Katz and Morse, 1996; Lalumandier and Rozier, 1998; Mascarenhas and Burt, 1998; Pendrys and Katz, 1998; Kumar and Swango, 1999), brushing frequency (Pendrys, Katz and Morse, 1994), amount of toothpaste used (Evans, 1991), and ingesting toothpaste (Riordan, 1993a). This study was armed with specific items to measure these exposures and it found significant association between several patterns of fluoride toothpaste use with the prevalence of fluorosis. Therefore, the criterion of *consistency of association* between fluoride toothpaste use and dental fluorosis was satisfied.

The evidence of the *biological plausibility* of the association between fluoride toothpaste and dental fluorosis was supported by numerous studies. Although toothpaste is intended for topical use, its use among children is associated with a chance of systemic intake of fluoride. Fluoride in toothpaste is generally biologically available. Studies reported that children under the age of six years could ingest 25 to 65% of the toothpaste amount used per brushing (Ripa, 1991; Naccache et al., 1992). The amount of ingested fluoride from toothpaste depended on child age, the person who dispensed the toothpaste, the amount of toothpaste used per brushing, the concentration of fluoride in toothpaste, and the method of brushing and clearing the toothpaste (Levy et al., 2000).

This study identified several patterns of toothbrushing as associated with a higher prevalence of fluorosis. The patterns were the type of toothpaste used, the amount of toothpaste used per brushing, the age of brushing commencement, the frequency of brushing, and a licking and/or eating toothpaste habit. These patterns were indicators of ingestion of fluoride from the use of toothpaste by young children.

The type of toothpaste used, i.e. 1000-ppm fluoride toothpaste or <550-ppm fluoride toothpaste, was found to be significantly associated with the prevalence of fluorosis in this study population. The risk of having fluorosis on the central incisors and the early forming and later forming tooth surface zones classified by the FRI was higher with the use of standard concentration fluoride toothpaste. Children tended to ingest more toothpaste if they brushed their teeth early (Rock, 1994; Stephen, 1993). Therefore, it is natural to postulate that using higher concentration fluoride toothpaste could result in an increased systemic intake of fluoride compared with using low concentration fluoride toothpaste. Studies looking at the mean ingested fluoride from toothpaste reported a large difference in mean fluoride intake from toothpaste between 1450-ppm and 400-ppm fluoride toothpaste (Bentley, Ellwood and Davies, 1999). The difference in risk of having fluorosis between different concentrations of fluoride toothpaste can postulate a *dose response effect* of the fluoride toothpaste use in children.

The use of standard concentration fluoride toothpaste when toothbrushing was commenced was significant in the logistic regression models for fluorosis defined as having a TF score of 2+, and in the three models for cases defined by the two FRI classification case definitions. Use of standard toothpaste was consistently related with more than twice the odds of having fluorosis. The odds ratios were slightly higher than those found in a recent study, which reported an odds ratio of 1.6 for the use of adult toothpaste (Tabari et al., 2000).

Another indication of the *dose response effect* was the amount of toothpaste used per brushing, which was also found to have higher odds of having fluorosis defined as a TF score of 1 or more. The variation in the amount of toothpaste used tested in this study was between using a smear and a pea-sized amount or larger when children commenced their toothbrushing. A smear is a smaller amount than the generally recommended pea-sized amount of toothpaste. Using more than a smear amount of toothpaste when toothbrushing commenced, however, significantly increased the odds of having fluorosis in this study population. This result may call attention to recommendations on the amount of toothpaste to be used. Rock (Rock, 1994) also suggested that a pea-sized amount per brushing was too much for young children. A pea-sized amount of toothpaste may be around 0.314 gram (Levy et al., 2000). There has been no quantification of a smear amount of toothpaste. However, as pictorially indicated in the questionnaire (see Appendix 1), a smear amount asked in this study was markedly smaller than a pea-sized amount. This difference in the amount of toothpaste, and hence the amount of fluoride used in toothbrushing that may be ingested, could add to the total intake of fluoride in these children.

The age when toothbrushing with toothpaste commenced was significant in the model for the FRI Classification II cases of fluorosis. Commencing toothbrushing in the first year of life had three times higher odds of having fluorosis on later forming enamel surface than the commencement of toothbrushing with toothpaste after the second birthday. This was consistent with a study among children from non-fluoridated areas (Pendrys, Katz and Morse, 1996) where early toothbrushing had an odds ratio of 4.2. The age of toothbrushing commencement also had high but marginally non-significant odds ratios for having fluorosis on the upper central incisors. The findings from this study and the previous studies raise an issue of identifying an appropriate age to commence toothbrushing with toothpaste to balance the risk and benefit of this preventive measure.

More frequent toothbrushing with toothpaste was also a risk factor of having fluorosis on later forming tooth surfaces. This is another indicator of the *dose response effect* of toothbrushing with fluoride toothpaste. More brushing per day can mean more ingested toothpaste among young children.

Another aspect of toothpaste availability which is not directly related to toothbrushing is an eating and/or licking toothpaste habit by some young children. Some manufacturers make toothpaste for children with pleasant flavours in the hope of encouraging them to brush more often. However, there is a chance that children want to eat and/or lick the toothpaste when they have access to toothpaste. This habit can significantly increase an unnecessary intake of fluoride from toothpaste. An eating and/or licking toothpaste habit was found to significantly increase the chance of having fluorosis in almost all models for fluorosis. The estimated population attributable risk indicated that if this habit can be eliminated some 36%

of cases of fluorosis on front teeth could be prevented. Measures must be taken to control this unwanted intake of fluoride from toothpaste in young children.

To summarise, the criteria for a causal association between toothpaste use and dental fluorosis were satisfied. Therefore, there was sufficient evidence to consider fluoride toothpaste use as a risk factor for dental fluorosis in this study population.

5.4.2.3 Other factors

5.4.2.3.1 Sex

Sex was found to be significantly related to the prevalence of dental fluorosis in this study. The prevalence of fluorosis defined by any case definition was significantly higher among girls. For unknown reason, girls in this study tended to have higher exposure to fluoride from the water and tended to brush their teeth more extensively compared to boys.

There is conflicting evidence of the possible association between sex and dental fluorosis. Ismail (1990) reported that being a boy was associated with higher odds of having dental fluorosis in Canadian children. However, another study among Canadian children found that girls had significantly higher fluorosis experience (Maupome et al., 2003). Therefore, the criterion of *consistency of association* between sex and dental fluorosis is not satisfied.

The *biological plausibility* and *laboratory evidence* of the possible association between sex and dental fluorosis are not conclusive. Girls generally have earlier eruption of permanent teeth compared to boys. Therefore, it could be speculated that a girl’s teeth might have a shorter pre-eruptive period of exposure to fluoride. However, if girls were exposed to fluoride earlier than boys, the period of exposure might not differ between boys and girls.

Therefore, there was no conclusive evidence to identify sex as a risk factor for dental fluorosis in this study population. Sex might be considered as a risk marker or a risk indicator for the condition, at least in this South Australian child population.

5.4.2.3.2 Fluoride supplements and infant formula

Although a number of studies have identified fluoride supplements and infant formula as risk factors for dental fluorosis, there was no supportive evidence in this study. Fluoride supplements were used by only a small number of children, who predominantly lived in non-fluoridated areas. A significant proportion of the study population used infant formula. However, the two factors did not have any impact on the prevalence of fluorosis in the study population. This was consistent with the most recent finding by Riordan in Western Australian children (Riordan, 2002). Therefore, it could be inferred that fluoride supplements and infant formula were not significant contributory factors for fluorosis for this study population.

5.4.3 Population attributable risk for dental fluorosis in the study population

Quantifying the risk attributable to a specific factor in a population is a useful idea that has received considerable attention in population health research. There are numerous definitions of "attributable risk" available. One of the most widely used is the fraction of the total disease or condition experience in the population that would not have occurred if the factor was absent. However, one cannot equate population attributable risk estimate with the proportion of cases having a given risk factor (Rockhill, Newman and Weinberg, 1998). This estimate is a function of the prevalence of the factor in a population, i.e. the proportion of the population having that factor, and the increased likelihood of the condition associated with that factor. Population attributable risk estimates (PAR) are best used in population health and can have implications in public health planning. First, it can be used to prioritise public health interventions on the basis of the magnitude of the potential effect on the disease and the impact of the condition in the community. Second, these estimates indicate the potential reduction of cases in the population if the factor is modified or eliminated. Hence, it becomes a proxy measurement of the effectiveness of an intervention if it is used *post hoc* in comparison with previous findings. However, since these estimates are calculated from multivariate logistic regression and do not add up to 100%, it is not possible to get a reliable estimate of the total amount of disease or condition potentially preventable if the risk factor is eliminated from the population.

The risk assessment of dental fluorosis increasingly reports relative risk associated with exposure to fluoride sources. However, only a few studies reported population attributable risk estimates (Riordan, 1993a; Pendrys, Katz and Morse, 1994; Pendrys, 2000). The first two studies calculated population attributable risk from estimates of logistic regression models, hence, adjusting for exposure to other potential fluoride sources. The study by Griffin and co-workers (Griffin et al., 2002), focusing on estimating objectionable fluorosis attributable to water fluoridation, calculated PAR using a stratified design.

This study calculated the population attributable risk with the aim of identifying modifiable risk factors for fluorosis and discussing the advantages and disadvantages of measures to eliminate or modify those factors to prevent fluorosis. Several factors that attributed to the prevalence of dental fluorosis in the population were identified. At first glance, exposure to fluoride in the water had a greater population attributable risk estimate for the prevalence of fluorosis defined as having a TF score of 1+ and 2+. However, all significant patterns of fluoride toothpaste use combined explained the majority of fluorosis cases in the study population. To summarise, as far as the prevalence of fluorosis was concerned, use of fluoride toothpaste and exposure to fluoridated water were the two main exposures with an attributable risk for fluorosis in the South Australian children population in 2002/03.

As indicated by the population attributable risk estimates, targeting and modifying exposures to fluoridated water and fluoride toothpaste could reduce the prevalence of fluorosis in this study population. However, fluorosis is just one effect of the use of fluoride in dentistry. The other aspect, the protective effect of fluoride against caries, must be accounted for when any measure is considered to reduce fluorosis. The balance in the outcome of modifying a number of fluoride exposures will be discussed in Section 5.7. One thing that was obvious is that unwanted exposure to fluoride toothpaste such as an eating and/or licking toothpaste habit could be targeted to prevent fluorosis. It was estimated that if this unnecessary exposure were eliminated, more than a third of fluorosis cases could be prevented in this study population.

5.5 Dental caries among South Australian children

5.5.1 The prevalence and severity of dental caries among South Australian children

The prevalence and severity of deciduous and permanent dental caries were described in detail in this study. In general, caries experience was relatively low in this study population. Data on dental caries collected in this study allowed for calculation of caries experience at different ages that permitted inter-cohort comparison of caries. This approach was deemed as the most appropriate for the study objectives as it yielded multiple point estimates of several cohorts of children. Children from different birth cohorts could be compared at several anchor ages such as six and eight years. Caries experience at the time of the study in 2002/03 was also reported. However, these estimates differed between birth cohorts as children from different cohorts had a six-year-age span.

The decayed, missing and filled tooth surface index was used in this study. An often-cited opinion that the filled component of the dmf/DMF index was related to socioeconomic status was not true for this study population because the study sample was from school dental service users. Over 80% of the South Australian child population was enrolled in the school dental service. These children had equal access to care. There was no dependence on their household socioeconomic status. The missing tooth surface component was very low, and therefore could not contribute to the indices. Hence, the indices used reflected the pattern of dental caries in the South Australian child population.

The caries experience of the study population was compared with the published data on child caries experience in South Australia in 2000 (Armfield et al., 2004). The later data reported dmft/DMFT scores and the proportion of caries-free children at age 5 to 6 and age 12 for the SA population of children in the school dental service. Mean dmft scores were calculated for this study sample at age six to enable comparison with the South Australian child population data.

The prevalence of caries on deciduous teeth in the South Australian child population at age six in 2000 was compared with that of children from the 93/94 birth cohort at six years of age. This ensured a similarity in age, birth cohort and year of examination between the two studies. Some 30.7% of children of that birth cohort in this study had deciduous caries at age six compared to 31.5% of the child population in South Australia, indicating a similarity between two studies. The South Australian child population had a dmft score of 1.46 (SD 2.47) at age 5 to 6 in 2000, whereas this study sample had dmft score of 1.54 (SD 3.30) at age six. Again, this indicates the similarity between the two studies.

The pattern of caries experience between boys and girls was also similar between this study sample and the Australian data in 2000. The later reported higher mean deciduous caries experience among boys compared to girls. The reverse was true for permanent caries experience. Similar patterns were observed in this study at different ages.

5.5.2 Fluoride exposure, dental caries relationship

5.5.2.1 Exposure to fluoridated water and dental caries

The exposure to fluoridated water, measured as the per cent of lifetime exposed to fluoride in the water, was found related to caries experience in this study sample at different ages. There was a negative linear relationship between per cent lifetime exposure to water fluoridation and deciduous caries. The dose response effect was confirmed in bivariate analysis and the linear regression models. In this respect, the findings were consistent with previous studies conducted among Australian children (Slade et al., 1995a; 1996b; Spencer, 1996).

The relationship between exposure to fluoride in the water and permanent caries was less strong compared to the association between water fluoridation and deciduous caries. Several factors might be the reasons for this difference. First, the caries experience on permanent teeth was generally low at the ages studied in this sample. It reduced the power of the study to detect significant differences in caries of permanent dentition. Second, fissure sealant is much more commonly used in non-fluoridated areas compared to fluoridated areas (Armfield and Spencer, 2003, unpublished). Evidence is available for the effectiveness of fissure sealant when used to prevent caries in permanent teeth of children and adolescents (Rozier, 2001; Adair, 2003). Still, children who had no exposure to fluoride in the water had higher DMFS scores compared to those who had some level of exposure. In general, the caries preventive effect of water fluoridation was further confirmed in this study.

5.5.2.2 Exposure to fluoride toothpaste and dental caries

The age when toothbrushing with toothpaste commenced was significantly related to caries experience. The age of 24 months is the most commonly used in recommendations to commence using toothpaste. However, using toothpaste before 24 months of age was associated with lower caries experience compared with commencing toothpaste use after this age in this child population. This factor might be confounded by other behavioural or socioeconomic status factors which could also be related to caries. A study of early childhood caries in South Australian preschool children reported that mechanical toothbrushing (without toothpaste) before the age of 24 months was related to lower caries experience (Slade, 2004). This study could not separate toothpaste use from toothbrushing itself. However, if the mechanical cleaning of teeth by toothbrush before the age of two was effective, then the effect of age of toothbrushing commencement in this study could be confounded and the findings also partly explained.

The type of toothpaste (standard and low concentration fluoride toothpaste) was not significantly related to caries experience in this study. This finding was similar to that reported in a clinical trial of toothpaste (Winter, Holt and Williams, 1989). A systematic review of different concentrations of fluoride toothpaste reported a lower efficacy of 250-ppm fluoride toothpaste compared to 1450-ppm toothpaste (Ammari, Bloch-Zupan and Ashley, 2003). However, the evidence of the efficacy of 400 to 550-ppm fluoride toothpaste as was available for this study population was not conclusive in that review. The possibility existed that the lower efficacy of low concentration fluoride toothpaste was compensated by other exposures to fluoride and other components of toothbrushing practice in this study population.

One of the effective components of toothbrushing practice was frequency of toothbrushing per day. More frequent toothbrushing helped to reduce caries experience at different ages. An unnecessary exposure to fluoride from toothpaste by an eating and/or licking toothpaste habit did not have any effect on caries experience. There was no evidence from other studies about any effect of swallowing toothpaste on caries experience. Guidelines are often raised about preventing this habit among children.

5.5.3 Time trend of dental caries among South Australian children

The time trend analysis of caries in this study may be affected by three factors inherent to cohort analysis. These factors are age, period and cohort effects. These effects are often not separated from each other and may complicate the time trend analysis. This is true for the analysis of caries experience but it is less so with the analysis of fluorosis. The latter condition is a developmental condition with one-off onset. There may be some changes in the clinical appearance of fluorosis after tooth eruption. However, this process has yet to be documented. Therefore, the ageing effect was assumed to be similar between cohorts in the time trend analysis of fluorosis. On the other hand, all three factors, ageing, period and birth cohort effects, need attention in time trend analysis of caries experience.

The caries experience in the study population was age related, regardless of birth cohort. Deciduous caries experience in children peaked at age eight years and decreased subsequently after that age. Permanent caries experience was negligible at age six when the first permanent teeth erupt and increased with age. This pattern reflected the biological change in the process of ageing which impacts on caries experience, namely the number of teeth present and the accumulation of caries over time. The ageing effect must, therefore, be accounted for in any time trend comparisons of caries experience between birth cohorts. The use of anchor ages in this study ensured that the ageing effect was controlled for in the comparison between birth cohorts.

Birth cohort was the target for the time trend of caries experience in this study population. Birth cohort and period effects were correlated in this study analysis. The cohort factor defined the beginning of the period where external changes might affect the cohorts' caries experience at later ages. For example, change in exposure to fluoride could alter the accumulation of caries experience during that period. In this study, the policy measures introduced in the early 1990s were expected to change the exposure to fluoride among children in the three birth cohorts. The change in exposure could be in terms of the time of its occurrence, or in level of exposure. Several major changes in exposure pattern were observed. These included the increased use of low concentration fluoride toothpaste, decreased lifetime exposure to fluoridated water, and diminished use of fluoride supplements. Therefore, the period factor was expected to differ between birth cohorts. The question is whether the difference in period factor dictated the differences in caries experience of the three birth cohorts, controlled for the ageing effect.

Comparison of caries experience at different anchor ages revealed significant differences between the three birth cohorts. There was a trend of increase in caries experience across the three successive birth cohort groups at the anchor ages of eight and ten years. The increase at ages eight and ten was seen in the prevalence of deciduous and permanent caries, as well as in the higher mean of the dmfs/DMFS scores in the latest birth cohort. This trend was indicative of some actual changes in caries experienced by the three birth cohorts.

The trend of increasing caries experience among the study population was analogous to that reported for the Australian child population during that period (Armfield, Roberts-Thomson and Spencer, 2003). The latter population experienced an increase in caries experience since 1996. This further supported the presence of an actual change between birth cohorts.

There might be several possible reasons for the increase in caries experience of the later birth cohorts. The first possibility was that the trend was only a fluctuation of the disease distribution within the population. This possibility was less likely given the time period of six years between examinations of the earliest and the latest cohort. Also, the change was in parallel with the trend in the Australian child population.

Changes in exposure to fluoride, driven by the policy initiatives introduced in the early 1990s, have already been discussed in relation to fluorosis. These include changes in toothpaste use and the use of fluoride supplements. Reduction in the per cent of lifetime exposure to fluoridated water influenced by changing water consumption patterns was a further possibility. These changes in fluoride exposure deserved attention in a search for possible reasons for the increase in caries experience in the population.

The age of 24 months is often used in recommendations in regard to commencement of toothbrushing with toothpaste. Evidence in this study indicated that more than two-thirds of the children commenced their brushing with toothpaste before this age. Brushing after this age resulted in a lower prevalence of fluorosis but higher caries experience. This study indicated a linear relationship between age in month when toothbrushing commenced with caries experience. The earliest birth cohort was more likely to start toothbrushing in the first year of life. Therefore, this factor might be the reason for the increase in caries experience in the study population.

The later birth cohorts increasingly used low concentration fluoride toothpaste. Available evidence of the equivalency of the effectiveness of this type of toothpaste is not conclusive. Meta-analysis of toothpaste clinical trials indicated that the effectiveness of toothpaste was positively related with the concentration of fluoride (Marinho et al., 2003). Findings from this study did not indicate any significant difference in effectiveness against caries between low and standard concentration toothpaste. However, this change in fluoride exposure could not be ruled out as a reason for the increasing trend of caries in this study population.

Only a few children ever used fluoride supplements in this study population. Even fewer children used them on regular basis (data not shown). The effectiveness of fluoride supplementation in the prevention of caries was not confirmed in this study. The anti-caries effectiveness of fluoride supplements was often not convincing, as indicated in reviews of literature (Ismail, 1994; Burt, 1999; Newbrun, 1999). Therefore, it was not possible to conclude that a reduction in fluoride supplements use was a reason for the increase in caries experience.

There was a decreasing trend in the per cent of lifetime exposure to fluoridated water across birth cohorts. This might be the result of changes in behaviour in water consumption such as increased use of home filtering equipment and bottle and tank water. Water fluoridation is effective in preventing caries. Findings in this study indicated that a reduction in the per cent of lifetime exposure resulted in a significant increase in caries experience at age six and eight. The use of non-public water was found related to higher caries experience in South Australian children (Armfield and Spencer, 2004). Likewise, the use of non-public water beverages was found to be related to higher caries experience in the US child population (Marshall et al., 2003). Therefore, it is possible that the reduction in exposure to fluoridated water was partially linked with the increase in caries experience. Further research is required to confirm the findings and to plan appropriate measures to counter the increasing trend of caries among children in Australia.

5.6 The perception of dental appearance and oral health-related quality of life of South Australian children

5.6.1 Perception of dental appearance

Recent studies on fluorosis often focus on the effect of fluorosis on the perception of dental appearance of the affected children and their surroundings. Available evidence suggested that the affected children and their surroundings could discern changes in tooth colour caused by fluorotic lesions (Clark et al., 1993; Riordan, 1993c; Ellwood and O'Mullane, 1995; Sigurjons et al., 2004). Findings of the present study indicated that children and their parents perceived tooth staining caused by fluorotic lesions. This perception was more obvious with TF scores of 2 or higher. The explanation may be that a fluorotic lesion defined as a TF score of 1 can be difficult to discern when the tooth is wet. There was still more than half the children and their parents who had a TF score of 1 who perceived a change in the colour of the teeth. The popular opinion that fluorosis is discernable only to trained professionals is not supported by the findings of this study. It was clear that children and their parents could detect the presence of fluorotic lesions.

However, the perception of the presence of a change in tooth colour (associated with fluorotic lesions) was not always related to the perception of the attractiveness of teeth. Children with a TF score of 1 were even more likely to perceive their teeth as attractive or very attractive compared with children with a TF score of 0 or 2+. The latter two groups were very similar in perceived attractiveness of their teeth. This finding was similar to that reported by other studies (Ellwood and O'Mullane, 1995; Hawley, Ellwood and Davies, 1996; Sigurjons et al., 2004). Hawley, Ellwood and Davies (1996) reported that TF scores of 1 or 2 even enhanced the appearance of teeth as perceived by children.

The perception of a need for treatment due to changed colour of the teeth further supported the difference in perception of attractiveness of the teeth. Parents and children who had a TF score of 1 were less likely to perceive such a need compared to those who had no fluorosis and those who had a TF score of 2 or higher. It was not unexpected that parents and children who had more severe fluorosis would be more likely to perceive tooth staining and, hence, a need for treatment to correct it. However, that group was very similar to the group who had no fluorosis. An explanation may be that fluorosis-free children might be more likely to have other non-fluorotic lesions such as enamel defects or early carious lesions. Those non-fluorotic lesions were not captured and classified by the two indices used in this study. However, Ellwood and O'Mullane (1995), recording both fluorosis and other non-fluorotic lesions, reported an inverse relationship between the prevalence of fluorosis and other demarcated opacities. In this case, being fluorosis-free is not always tantamount to being free from discoloration of the tooth.

The aesthetics of tooth colour is often difficult to quantify and it is highly subjective and prone to individual variation. Nevertheless, this study suggested that the level of aesthetically objectionable fluorosis was low in the South Australian child population. Satisfaction with dental appearance was found to be not strongly related with fluorosis on the children's front teeth. Other factors such as occlusal traits or other non-fluorotic discoloration might also have an impact on the acceptability of the dental appearance in the South Australian child population.

5.6.2 Perception of oral health-related quality of life

Measurements of perception of oral health-related quality of life have become increasingly popular patient-based measures of oral health. These measures are in contrast to bio-medial measures which concentrate on clinical parameters. Sociological aspects of oral health place a greater emphasis on the subjective experience of conditions and consequences of those conditions for the behaviours of individuals (Locker, 1989). Interest in the outcome of oral conditions has been the subject of significant research activity over the past ten or so years. Researchers and policymakers have recognised that perceptions of oral health are vital to planning oral health programs.

There has been a lack of attention to the potential impact of fluorosis on oral health-related quality of life. Given the recent increase in the prevalence of fluorosis and the rise in public attention to fluorosis as a side effect of fluoride use, the potential impact of fluorosis on oral health-related quality of life deserves consideration. This study is one of only a few to report on the impact of fluorosis on the oral health-related quality of life of affected children and their parents.

Mild fluorosis was found to be discernable by children and their parents. The impact of mild fluorosis on the perception of dental appearance, however, was less pronounced in this child population. Some fluorosis was tantamount to lower caries experience – the other side of the balance of risk and benefit of fluoride use. Caries experience seemed to have a more pronounced impact by causing more oral symptoms and functional limitations. Children and their parents who had mild fluorosis were even better off in terms of emotional wellbeing and social wellbeing when other factors were controlled for in multivariate models. This rather unexpected finding might be explained by the fact that better oral health was often perceived as being without caries. The psychological impact of fluorosis on the perception of dental appearance, if any, was outweighed by a feeling of being free from the impact of caries.

To summarise, fluorosis was often discernable by the affected children and, to a lesser extent, by their parents. However, this present study indicated that mild fluorosis did not have a negative impact on the perception of dental appearance, as well as the perception of oral health-related quality of life (measured by the four domains) in this child population. The current level of fluorosis experience in the South Australian child population was not expected to have major impact on quality of life of children and their family at least in the foreseeable future.

5.7 Fluoride exposure, dental fluorosis and caries: a working balance

Fluoride has been, is and will remain an important factor in caries prevention. Fluoridated water is no longer the only source of fluoride. The current generation of children is exposed to numerous fluoride sources, each of which has different risks and benefits. Identifying and maintaining an effective balance of the caries prevention benefit and the risk of fluorosis is crucial to population oral health researchers. This is unlikely to mean the removal of any of the proven effective fluoride sources. Rather, it means a balancing the benefits and risks of all available fluoride measures.

Water fluoridation has confirmed effectiveness in the prevention of dental caries (Newbrun, 1989b; Rozier, 1995; Spencer, 1998). Fluoride from the water can be equally accessible to everyone in a community at low cost. "Water fluoridation is probably the most significant step we can take toward reducing the disparities in dental caries" (Burt, 2002). Water is the vehicle to deliver fluoride to the individuals based on the estimation of their physiological needs. Fluoridated water constantly delivers a low dose of fluoride which is necessary for balancing the re-mineralisation and de-mineralisation circle on the enamel surface (ten Cate, 1999). The balance between the re-mineralisation and de-mineralisation processes is central in controlling and managing dental caries.

The use of fluoride toothpaste in oral health is the most popular but more individualised approach to the prevention of dental caries. This preventive approach is based on two parallel coordinated acts: the mechanical cleaning of tooth surfaces and the anti-caries effect of fluoride from toothpaste. Toothpaste is designed primarily for topical use. However, some toothpaste is retained in the mouth after brushing and can be swallowed, which adds to the systemic intake of fluoride. This preventive measure depends on number of factors. The availability of different types of toothpaste and associated advice for their use are external factors that are regulated on the community level. Individual factors are knowledge and toothbrushing behaviours. These individual factors, in turn, depend on information given with oral healthcare products and associated guidelines on their use. All these factors need to be addressed to create a balance of benefit and risk in toothpaste use.

Several fluoride exposures in this study were considered appropriate to be modified in order to balance the benefit and risk of fluoride use. Those factors were exposure to fluoridated water; factors related to fluoride toothpaste use, namely age of commencing toothbrushing with toothpaste, frequency of brushing, amount of toothpaste used, and type of toothpaste; and an eating and/or licking toothpaste habit. All these factors are modifiable. However, their modification may shift the balance of benefit and risk. A modification could be considered appropriate if it would result in a lower risk of having fluorosis without a reduction of the caries preventive benefit of the exposure.

5.7.1 Exposure to fluoridated water

Exposure to fluoridated water was evaluated in this study as the per cent of lifetime exposure which reflects both time and degree of exposure. This composite variable was used to test the dose-response effect of the exposure on fluorosis and caries.

Exposure to fluoridated water was found to increase the risk of having dental fluorosis in this study population. Some 40% of fluorosis cases in the population could be attributed to the use of fluoridated water. This association has been confirmed in numerous studies dating from the 1930s. There is no doubt that a change of exposure to fluoridated water would alter the proportion of children with fluorosis in a population. However, the question was how this modification of the exposure to fluoridated water would affect caries experience in that population.

In the scenario when exposure to water fluoridation was eliminated in a population similar to this study population, dramatic changes in both fluorosis and caries experience would have occurred. The prevalence of dental fluorosis, defined as having a TF score of 1 on central incisors, would have been reduced by some 19%. Some 10% of those children would have been prevented from having a TF score of 2 or more. However, this reduction would be at the expense of a sharp increase in dental caries. Some additional 1.25 and 1.88 decayed, missing or filled deciduous surfaces would have resulted for six-year-old and eight-year-old children respectively. These increases would have been substantial given the mean number of surfaces with deciduous caries experience was 1.45 and 2.46 at age six and eight years old.

When the per cent of lifetime exposure to fluoridated water was reduced from over 50% of lifetime to some but less than or equal to 50% of lifetime, a reduction in the prevalence of fluorosis defined by the same case definition would be only 1% of children. However, this insignificant change in fluorosis was associated with an increase in caries experience, especially at age eight with an increase of 1.35 surfaces with deciduous caries experience.

Given South Australian child population under 14 years old of 287,000 (ABS, 2001), the majority of whom live in fluoridated areas, there would be a significant increase in dental caries experience and, hence, increased dental treatment need if a reduction in exposure to fluoridated water occurred. Dental caries was found to impact on the perception of oral health and oral health-related quality of life in this study population. On the other hand, fluorosis at the severity level observed in this population was related to lower caries experience and perceived better oral health.

Water fluoridation has been found to reduce inequalities in oral health between social classes (Slade et al., 1995b; Riley, Lennon and Ellwood, 1999; Burt, 2002). The greater absolute reduction in caries experience was observed in lower social classes, as underlying caries levels are greater (Riley, Lennon and Ellwood, 1999). Water fluoridation thus acts to reduce oral health inequalities by reducing the difference in absolute caries levels between deprived and affluent classes.

To summarise, the exposure to fluoridated water has proven effectiveness in the prevention of caries, although it is associated with a risk of having fluorosis. Modifying exposure to fluoridated water in order to reduce the risk of having fluorosis could shift the balance towards significantly lowering the caries protective benefits of fluoride. Water fluoridation continues to be "the cornerstone of an ideal caries prevention program" (Newbrun, 1989a).

5.7.2 Exposure to fluoride toothpaste

Exposure to fluoride toothpaste was evaluated in this study population by different components of toothpaste use. Those components might differ in their risk/benefit relationship and thus might be the focus of individual policy interventions.

5.7.2.1 Type of toothpaste used when toothbrushing is commenced

The type of toothpaste (standard and low concentration fluoride) used in the first six years of life needs to be evaluated for its risk/benefit relationship because this period is significant in the development of fluorosis on aesthetically important teeth. Low concentration fluoride toothpaste has been designed primarily to reduce the risk of fluorosis, and therefore there would be little justification in evaluating its risk/benefit ratio in older children.

Low concentration fluoride toothpaste available in Australia contains 400 to 550 ppm of fluoride. Evidence on the anti-caries efficacy of this type of toothpaste was scarce and not conclusive (Bloch-Zupan, 2001; Ammari, Bloch-Zupan and Ashley, 2003). Winter, Holt and Williams (1989) reported that 5-year-old children who used 550-ppm fluoride toothpaste (test) had slightly higher but non-significant mean dmfs after a 3-year study compared with children who used 1050-ppm fluoride toothpaste (control). However, the difference in caries experience between the test and control groups was still clear four years after the end of the study although no further intervention was applied (Holt, 1995). A study that provided free 1450-ppm and 440-ppm fluoride toothpaste to deprived children reported lower efficacy of 440-ppm toothpaste compared to the higher concentration fluoride toothpaste (Davies et al., 2002). However, the tested toothpaste in that study had a higher fluoride concentration (1450 ppm) than standard fluoride toothpaste in Australia (1000 ppm).

This present study did not find a significant difference in caries experience between children who used standard and low concentration fluoride toothpaste at different anchor ages. However, the similar effectiveness of the two types of toothpaste might be explained by the fact that the majority of children in this study were protected by water fluoridation, whereas the other two studies were among children from non-fluoridated areas. Nevertheless, more conclusive evidence of the efficacy of low concentration fluoride toothpaste is still needed.

The effect of low concentration fluoride toothpaste use on the reduction of fluorosis has been confirmed in this study as well as in the other two studies. The consistency of this finding indicates that this type of toothpaste has fulfilled the aim of its use. Therefore, it is sensible to advise its use among children in areas where the risk of having fluorosis or concern in the population about fluorosis is high.

5.7.2.2 Age of commencement of toothbrushing with toothpaste

Several decades ago, it was often advised to start the use of toothpaste soon after the first tooth erupted. However, the general recommendation across the last decade has been to delay toothpaste use until 24 months of age in order to prevent fluorosis. The choice of this age was probably an attempt to balance the risk of fluorosis and the anti-caries efficacy of toothpaste. However, this recommendation may not result in a clear-cut favourable balance of risk and benefit. This study reported that commencing toothbrushing before 24 months of age was linked with significantly lower caries experience but with significantly higher prevalence of fluorosis.

In the search for an appropriate age to start toothpaste use, this study identified a period from 18 months to 30 months when commencing toothbrushing with toothpaste would result in a small reduction in fluorosis without significant increase in caries experience. Given the fact that over 40% of children commenced brushing with toothpaste before 18 months of age, and over 20% of children started toothbrushing after 30 months of age, there was a considerable proportion of the population that could be targeted in order to achieve a more appropriate exposure to fluoride from toothpaste use. The search for an appropriate age to start toothbrushing with toothpaste requires ongoing research. For instance, it may be necessary to consider age of commencement separately for different water fluoridation situations and different levels of risk for caries in a population.

5.7.2.3 Frequency of toothbrushing

Given that 60% of children brushed their teeth once a day or less when they commenced toothbrushing with toothpaste, there would be significant gains if guidelines on frequency of brushing were adhered to appropriately. Brushing twice a day in the first years of life did not have significant effect on fluorosis, whereas it significantly reduced the mean of the dmfs scores at subsequent ages. The finding on the effect of toothbrushing frequency on fluorosis was similar to that of other authors (Mascarenhas and Burt, 1998; Maupome et al., 2003). More frequent toothbrushing is known to prevent dental caries in children and it was documented in a major systematic review of toothpaste use (Marinho et al., 2003). Therefore, findings of this study further endorse recommendation of twice-daily toothbrushing.

5.7.2.4 Amount of toothpaste used per brushing

The amount of toothpaste used directly relates to the quantity of fluoride that may be ingested by young children. A pea-sized amount of toothpaste per brushing is the common advice on appropriate amount of toothpaste. However, Rock indicated that this amount might even be too much for young children when starting toothbrushing (Rock, 1994). This study found that using a pea-sized or larger amount of toothpaste when toothbrushing commenced was a risk factor for fluorosis. Some 16% of fluorosis cases defined as having a TF score of 1 on the central incisors was attributed to this factor. Using a smear amount of toothpaste did not result in significantly higher caries experience. However, the appropriate amount of toothpaste used per brushing is still a sensitive issue and may need to be considered based on other factors such as caries level in the population and water fluoridation status. In an area where water fluoridation was available and caries level was low, children would be recommended to use a smear amount of toothpaste when they commenced their toothbrushing.

5.7.2.5 Eating and/or licking toothpaste habits

The habit of eating and/or licking toothpaste among small children has not had enough attention. This habit may lead to excessive ingestion of fluoride from toothpaste without necessarily contributing to a caries protective effect. This habit has been found to significantly increase risk of having fluorosis elsewhere (Mascarenhas and Burt, 1998) and this has been confirmed by this study. An eating and/or licking toothpaste habit was attributed with 36% of fluorosis cases in this study population. Almost 50% of children in this study were reported to have this habit. This fact might be indicative of a lack of attention in advising parent to control children's access to toothpaste. Therefore, it is important to address this issue.

If an eating and/or licking toothpaste habit were eliminated, some 36% of fluorosis cases would have been prevented in this study population. The reduction in exposure to fluoride from toothpaste would not have an effect on the dental caries experience in the population.

5.7.3 Water fluoridation and fluoride toothpaste, a synchronised approach

There have long been programs with combined exposures to different sources of fluoride in order to maximise effectiveness of caries prevention and minimise risks for fluorosis. The most obvious example of such programs is a combination between the two most popular and effective programs: water fluoridation and fluoride toothpaste use. However, the two programs are often endorsed without a coherent link with each other. This study reported a striking similarity in toothbrushing practice between children having different per cent of lifetime exposure to water fluoridation. Since the benefit and risk of fluoride use have become a prominent issue, a more synchronised approach to these two programs warrants attention.

Water fluoridation and fluoride toothpaste have proved to be highly effective in prevention of dental caries. There are both similar and distinctive characteristics of either approach. The two programs are population-based approaches that are regulated by the public health authorities and the dental profession. There is also a significant individualised component of the two programs. Variations are observed between members of the community in exposure to fluoride from either of the programs. The variation in exposure to fluoride from water is reflected in different levels of public water consumption, which may be dependent on attitude towards public water. The variation in exposure to fluoride toothpaste is much more complex. On the community level, the availability of different products and associated advice on their use influence the exposure to fluoride from this source. On the individual level, exposure to fluoride toothpaste depends on behaviours towards toothbrushing practice and toothpaste use. In either program, knowledge of the appropriate use of the fluoride source is essential, even if not always sufficient. It is also important not to separate the information related to the two programs. Advice may be disseminated to the public by means of dental education programs, and through joint effort with other health and early childhood services which are widely used by parents of young children in Australia.

The findings of this study suggested differential effects of toothbrushing practice on dental fluorosis and caries between groups with different levels of exposure to fluoridated water. Changing the pattern of toothbrushing practice in children with or without exposure to fluoridated water may result in a different trade-off between risk and benefit. For instance, commencing toothbrushing with toothpaste before 24 months of age among children who had no exposure to fluoridated water reduced mean dmfs scores at age six and eight by more than one surface without an increase in the prevalence of fluorosis. On the other hand, commencing toothbrushing with toothpaste before this age by children who were exposed to fluoridated water increased the prevalence of fluorosis without a significant gain in caries prevention. Similar findings were observed in the use of standard and low concentration fluoride toothpaste and the amount of toothpaste used per brushing. Among children with more than 50% of their lifetime exposure to fluoridated water, using standard concentration fluoride toothpaste was associated with almost three times higher the risk of having a TF score of 2+ on the central incisors compared to the use of low concentration fluoride toothpaste. However, these two groups did not significantly differ in caries experience at age six and eight. Using more than a smear of toothpaste among children with more than 50% of their lifetime exposure to water fluoridation significantly increased the risk of having fluorosis without a significant gain in caries experience measured at age six and eight.

From biological point of view, this differential effect of fluoride is explainable. In a population with appropriate exposure to fluoride, an increase in exposure may increase the risk of fluorosis with little discernable improvement in caries experience. On the other hand, an increase in exposure to fluoride in a population without appropriate exposure to fluoride would shift the balance towards considerable benefit in caries prevention without a substantial increase in risk of fluorosis.

5.7.4 Suggested guidelines for a synchronised fluoride use

A number of suggested guidelines may be drawn from the findings of this study. They have been based on a careful balancing of risk and benefit of different exposure to fluoride. They include:

- Water fluoridation remains an effective community program. Modifying this program would alter the balance towards reduced benefits of fluoride use.
- Specific action is to be taken to prevent the habit of eating and/or licking toothpaste by young children. The use of fluoride toothpaste by children must be under adult supervision. This will reduce the risk of having fluorosis in a population without an increase in caries experience.
- The use of standard concentration fluoride toothpaste is recommended in children who have no exposure to fluoridated water. Low concentration fluoride toothpaste is advisable for children who live in areas with fluoridated water.
- Children are advised to commence their brushing with toothpaste in an age range of 18 to 30 months. However, children who live in non-fluoridated area can start toothbrushing with toothpaste earlier within this age range.

- Children who live in a fluoridated area are advised to use a smear of toothpaste per brushing when they first start toothbrushing. Children who live in non-fluoridated areas can start toothbrushing with a pea-sized amount of toothpaste per brushing.
- Children are advised to brush their teeth at least twice daily irrespective of their fluoridation status.

Advice on the use of toothpaste and the information on water fluoridation status must be disseminated to parents and caregivers before or as soon as possible after the birth of a child. This is of importance since the first years of life are critical in terms of the prevention of fluorosis. Therefore, dental health education must be integrated with other health programs. A system of early childhood care is available to all Australian children right from birth that can serve as a disseminator of that information.

5.8 Implications of the study findings

5.8.1 Research implications

While the findings of this study contribute to the knowledge of the relationship between fluoride exposure, dental fluorosis and caries, further research could address some of the limitations as well as address new research questions raised from this study.

This study documented a decreasing trend in the prevalence of dental fluorosis across successive birth cohorts. Further research is required to confirm this trend. Opportunities will emerge to examine COHS participants in South Australia who were born in 1995 to 1998 inclusive. The fluoride exposure history of those children has already been collected in the COHS 2002/03. Those children would be expected to have a prevalence of fluorosis at least similar to that reported for the 93/94 birth cohort of this study.

Despite an extensive literature on dental fluorosis, surprisingly little is known about the outcomes of children and their teeth with mild dental fluorosis. No prospective studies have reported the extent of any alteration in the appearance of mild fluorosis that may occur over a decade or more due to post-eruptive changes in enamel. The proportion of affected people who receive aesthetic dental treatment for fluorosis and any long-term impact on quality of life have not been documented. Nor is it known whether lay perceptions of the appearance of a child with mild fluorosis change as the child ages (whether or not the clinical appearance changes). This study sample can serve as a baseline for a prospective study to document the natural history of fluorosis, changes in perception of dental appearance and oral health, and treatments that may be perceived and utilised by the sample.

This study indicated the importance of the understanding patterns of exposure to fluoride among children in assessing the benefit and risk of fluoride exposure. Further research is needed to investigate factors that may be behind those patterns of exposure to fluoride in the population.

This study reported a difference in the prevalence of fluorosis between boys and girls. The available evidence was equivocal on sex as a risk factor for fluorosis. Research will need to explore differences in exposure to fluoride observed between boys and girls in this study.

The increasing trend of caries experience across birth cohorts observed in this study has prompted investigation for its possible causes. It was not yet clear if the increase in caries was as a result of change in exposure to fluoride observed in the later birth cohort. Evidence suggested that change in consumption of non-public water might have been responsible for recent increase in caries experience in South Australian children (Armfield and Spencer, 2004). Therefore, research will need to address attitudes towards and behaviours in public water usage. The caries experience of children who were born after 1994 will need to be closely monitored. Such surveillance is possible owing to the electronic management system information and clinical record used in the South Australian Dental Service. A similar data capture and analysis scheme will need to be employed to enable comparability with the results reported in this study.

The suggested synchronised approach between water fluoridation and the use of toothpaste in the prevention of dental caries has been drawn from data available in this study. Despite the fact that this approach is explainable in the light of the current understanding of the use of fluoride, it should be subject to further research within the same child population and other child populations using different methodologies. Opportunities exist to evaluate the findings of the study in a multi-state Australian sample of the Child Oral Health Study 2002–05 in terms of the association of exposure to water fluoridation and toothpaste with caries experience. However, data on fluorosis experience will not be available. The effectiveness of toothbrushing with toothpaste within different levels of exposure to fluoridated water will be evaluated. One of the research recommendations by the MRC Working Group on fluoridation (MRC, 2002) was to incorporate fluorosis as one of the outcome measures in any prospective epidemiological studies of fluoridation and dental caries. In that case, it would be able to evaluate a "trade-off" between fluoride exposure, dental fluorosis and caries. Such evaluation would provide a platform to assess the synchronised approach between water fluoridation and toothbrushing in the prevention of caries in children.

5.8.2 Implications for population oral health

The study provided evidence of the effect of policy initiatives which were introduced in the early 1990s to influence exposure to discretionary fluorides in order to reduce the prevalence of fluorosis. The policy initiatives were the introduction and promotion of low concentration fluoride toothpaste; more restricted use of fluoride supplements; and reduction of fluoride in infant formula powder. The use of a pea-sized amount of toothpaste and avoidance of toothpaste swallowing were also recommended. It was suggested to delay toothbrushing with toothpaste until the second birthday to reduce the swallowing of toothpaste among children.

This study has provided evidence that the policy initiatives were widely implemented. Low concentration fluoride toothpaste quickly became popular among South Australian children. Most children reported using a pea-sized or smaller amount of toothpaste per brushing. Only a few children reported using fluoride supplements and this number was declining across birth cohorts. However, the majority of children commenced their toothbrushing with toothpaste before the age of two, despite the recommendation made in the early 1990s.

The study provided evidence of a decline in the prevalence and severity of fluorosis among the South Australian child population. This decline was found to relate to the introduction and widespread use of low concentration fluoride toothpaste among the later birth cohorts. This result was highly indicative of the effectiveness of the policy initiatives to reduce exposure to fluoride.

The prevalence and severity of fluorosis in the South Australian child population were found to be declining. There were no perception on the part of the population that fluorosis was negatively affecting quality of life of affected individuals. Therefore, the current fluorosis experience in the South Australian child population did not meet criteria to be considered a public health problem, according to the two criteria proposed by Burt and Eklund (1999). The criteria are: 1) there is a condition or situation that is widespread and has an actual or potential cause of morbidity or mortality; 2) there is a perception on the part of the public, government or public health authorities that the condition is a public health problem. Nevertheless, fluorosis experience in the population always needs close attention because it is an indication of the balance between benefit and risk of the use of fluoride in prevention of caries.

This study indicated that dental caries is still widespread among South Australian children and it has a measurable impact on the perception of oral health and oral health-related quality of life of the children. Dental caries is still a public health problem in the study population. The prevention of dental caries in children continues to be in the agenda of the dental public health in Australia.

6. Conclusion

This study aimed to evaluate the outcomes of a series of policy initiatives to reduce fluoride exposure among young children to assure an appropriate balance in risk of fluorosis and benefit in caries prevention. The strengths of the study were its sound sampling technique, improved data capture and detailed analytical approaches.

The following conclusions have been drawn from the study:

1. There was a trend towards lower exposure to fluoride from discretionary sources across birth cohorts. The findings were suggestive of a similar pattern of fluoride toothpaste use between children from fluoridated and non-fluoridated areas.

2. Exposure to fluoridated water was found to be declining. There was a significant proportion of children who reported not using public water. The decline in exposure to fluoridated water was also likely to be linked with a more frequent use of water filters and bottle water.

3. The prevalence of dental fluorosis in 8–13-year-old South Australian children in 2002/03, defined as having a TF score of 1+ or 2+ on the central incisors, was 26.9% and 11.8% respectively. The vast majority of cases of fluorosis were of very mild and mild severity. The prevalence of fluorosis in South Australian children was in the lower range reported from other studies among western populations.

4. The population initiatives initiated in the early 1990s aiming at reducing fluoride exposure in order to reduce the prevalence and severity of fluorosis were effective. The study indicated that the population initiatives were widely implemented among children. The most notable change was the use of low concentration fluoride toothpaste which is specifically formulated for use by children. There was a dominant pattern of the recommended pea-sized amount of toothpaste being used when children commenced toothbrushing. Fluoride supplement use was low and continued to decrease across birth cohorts. Incorrect use of fluoride supplements, i.e. use by children living in optimally fluoridated area, was negligible.

5. These changes in fluoride exposure among children were associated with the prevalence and severity of dental fluorosis in this population. There was a marked decline in the prevalence of fluorosis across birth cohorts who were at different stages of tooth development when the initiatives were introduced. Children who were born at the introduction of the initiatives had significantly lower prevalence of fluorosis

compared with who were born prior to the introduction of the policy initiatives and whose first few years of life were not affected by the initiatives.

6. There might be several reasons for the declining trend of fluorosis. The most likely reason was the use of low concentration fluoride toothpaste. This was confirmed by the results of logistic regression models. The reduction in fluoride supplements use, and manufacturers' reduction in fluoride level in infant formula could have played a certain role in the declining trend of fluorosis. This was one of the desired effects of the population initiatives. However, the effect of changes in exposure to fluoride in those sources could not be quantified.

7. Several factors were identified as risk factors for fluorosis in the study population. These included exposure to fluoridated water, and several patterns of the use of toothpaste. These findings were consistent with evidence available from other studies. Exposure to fluoridated water, besides its well-established effectiveness against caries, carries certain risk for fluorosis. Using 1000-ppm fluoride toothpaste in the early years, using more than smear of toothpaste when start toothbrushing, and an eating and/or licking toothpaste habit were significant risk factors for fluorosis. Among these toothpaste-related factors, eliminating an eating and/or licking toothpaste habit among children could prevent more than a third of cases of fluorosis.

8. Fluorosis could be discerned by a proportion of affected children and their parents. This resulted in a level of a perceived need for treatment to correct colour of teeth. Children with a TF score of 1 were more likely to perceive their teeth as attractive and less likely to perceive a need for correction of the colour of their teeth compared to children who had either no fluorosis or a TF score of 2+. Fluorosis did not have a negative impact on the perception of oral health and oral health-related quality of life of the South Australian child population. Caries experience and presence of socially unacceptable occlusal traits impacted on the oral health-related quality of life of the child population and their family.

9. Caries experience of the South Australian child population was low. There was a strong inverse linear relationship between lifetime exposure to fluoridated water and deciduous caries experience. A relationship between lifetime exposure to fluoridated water and caries experience in the permanent dentition was weaker but still significant. Age of commencement of toothbrushing with toothpaste was associated with caries experience in this child population. Frequent brushing was also linked with lower caries experience. The use of low concentration fluoride toothpaste was not found to be associated with caries experience.

10. There were some indications of an increase in the prevalence and severity of caries across birth cohorts in bivariate analyses. This increasing trend was most likely associated with the decline in lifetime exposure to fluoridated water. The reduction in exposure to other discretionary sources of fluoride might also have an effect on caries experience. Further research is needed to confirm this increasing trend and factors behind the trend.

11. The study provided evidence to further support the effectiveness of water fluoridation in prevention of caries in this child population. Modifying this community program would reduce fluorosis with the cost of an increase in caries experience. Such an increase in caries would lead to an impact on oral health-related quality of life of children. Use of fluoride toothpaste would be modified depending on baseline caries level and water fluoridation status in order to reduce fluorosis while preserving its anti-caries benefits.

Bibliography

AAPCN (1995). Fluoride supplementation for children: interim policy recommendations. American Academy of Pediatrics Committee on Nutrition. *Pediatrics* **95**: 777.

Aasenden R, Peebles TC (1974). Effects of fluoride supplementation from birth on human deciduous and permanent teeth. *Arch Oral Biol* **19**: 321-6.

ABS (2001). 2001 Census Basic Community Profile and Snapshot. Canberra, Australian Bureau of Statistics.

Adair SM, Hanes CM, Russell CM, Whitford GM (1999). Dental caries and fluorosis among children in a rural Georgia area. *Pediatr Dent* **21**: 81-5.

Adair SM (2003). The role of sealants in caries prevention programs. *J Calif Dent Assoc* **31**:221-7.

Al-Alousi W, Jackson D, Compton G, Jenkins OC (1975). Enamel mottling in a fluoride and in a non-fluoride community. A study. *Br Dent J* **138**: 56-60.

Ammari AB, Bloch-Zupan A, Ashley PF (2003). Systematic review of studies comparing the anti-caries efficacy of children's toothpaste containing 600 ppm of fluoride or less with high fluoride toothpastes of 1,000 ppm or above. *Caries Res* **37**: 85-92.

Angelillo IF, Torre I, Nobile CG, Villari P (1999). Caries and fluorosis prevalence in communities with different concentrations of fluoride in the water. *Caries Res* **33**: 114-22.

Aoba T, Fejerskov O (2002). Dental fluorosis: chemistry and biology. *Crit Rev Oral Biol Med* **13**: 155-70.

Armfield JM, Roberts-Thomson KF, Slade G, Spencer AJ (2004). Dental health differences between boys and girls. The Child Dental Health Survey, Australia 2000. Adelaide, Australian Research Centre for Population Oral Health.

Armfield JM, Roberts-Thomson KF, Spencer AJ (2003). The Child Dental Health Survey, Australia 1999. Trend across the 1990s. Adelaide, Australian Research Centre for Population Oral Health.

Armfield JM, Spencer AJ (2004). Consumption of nonpublic water: implications for children's caries experience. *Community Dent Oral Epidemiol* **32**: 283-96.

Astrom AN, Awadia AK, Bjorvatn K (1999). Perceptions of susceptibility to oral health hazards: a study of women in different cultures. *Community Dent Oral Epidemiol* **27**: 268-74.

Astrom AN, Mashoto K (2002). Determinants of self-rated oral health status among school children in northern Tanzania. *Int J Paediatr Dent* **12**: 90-100.

Atchison KA, Dolan TA (1990). Development of the Geriatric Oral Health Assessment Index. *J Dent Educ* **54**: 680-7.

Awadia AK, Birkeland JM, Haugejorden O, Bjorvatn K (2000). An attempt to explain why Tanzanian children drinking water containing 0.2 or 3.6 mg fluoride per liter exhibit a similar level of dental fluorosis. *Clin Oral Investig* **4**: 238-44.

Bagramian RA, Narendran S, Ward M (1989). Relationship of dental caries and fluorosis to fluoride supplement history in a non-fluoridated sample of schoolchildren. *Adv Dent Res* **3**: 161-7.

Bardsen A (1999). "Risk periods" associated with the development of dental fluorosis in maxillary permanent central incisors: a meta-analysis. *Acta Odontol Scand* **57**: 247-56.

Bardsen A, Bjorvatn K (1998). Risk periods in the development of dental fluorosis. *Clin Oral Investig* **2**: 155-60.

Barnard PD (1956). Dental Survey of State school children in New South Wales. Canberra, National Health and Research Council.

Bawden JW, Deaton TG, Koch GG, Crawford BP (1992). Fluoride uptake in hard tissues of fetal guinea pigs in response to various dose regimens. *Archives of Oral Biology* **37**: 929-933.

Beck JD (1998). Risk revisited. *Community Dent Oral Epidemiol* **26**: 220-5.

Beltran-Aguilar ED, Griffin SO, Lockwood SA (2002). Prevalence and trends in enamel fluorosis in the United States from the 1930s to the 1980s. *J Am Dent Assoc* **133**: 157-65.

Bentley EM, Ellwood RP, Davies RM (1999). Fluoride ingestion from toothpaste by young children. *Br Dent J* **186**: 460-2.

Bloch-Zupan A (2001). Is the fluoride concentration limit of 1,500 ppm in cosmetics (EU Guideline) still up-to-date? *Caries Res* **35 Suppl S1**: 22-5.

Brothwell DJ, Limeback H (1999). Fluorosis risk in grade 2 students residing in a rural area with widely varying natural fluoride. *Community Dent Oral Epidemiol* **27**: 130-6.

Bruzzi P, Green SB, Byar DP, Brinton LA, Schairer C (1985). Estimating the population attributable risk for multiple risk factors using case-control data. *Am J Epidemiol* **122**: 904-14.

Burt B, A., Eklund SA (1999). Dentistry, Dental Practice and the Community. Philadelphia, Saunders.

Burt BA (1992). The changing patterns of systemic fluoride intake. *J Dent Res* **71**: 1228-37.

Burt BA (1995). Fifty years of water fluoridation. *Br Dent J* **178**: 49-50.

Burt BA (1999). The case for eliminating the use of dietary fluoride supplements for young children. *J Public Health Dent* **59**: 269-74.

Burt BA (2001). Definitions of risk. *J Dent Educ* **65**: 1007-8.

Burt BA (2002). Fluoridation and social equity. *J Public Health Dent* **62**: 195-200.

Burt BA, Keels MA, Heller KE (2000). The effects of a break in water fluoridation on the development of dental caries and fluorosis. *J Dent Res* **79**: 761-9.

Burt BA, Keels MA, Heller KE (2003). Fluorosis development in seven age cohorts after an 11-month break in water fluoridation. *J Dent Res* **82**: 64-8.

Butler WJ, Segreto V, Collins E (1985). Prevalence of dental mottling in school-aged lifetime residents of 16 Texas communities. *Am J Public Health* **75**: 1408-12.

Carr LM (1982). Dental health of children in Australia 1977-1980. *Aust Dent J* **27**: 169-75.

Carr LM (1983). Dental health of children in Australia 1977-1982. *Aust Dent J* **28**: 269-76.

Carr LM (1988). Dental health of children in Australia, 1977-1985. *Aust Dent J* **33**: 205-11.

Carvalho JC, Declerck D, Vinckier F (1998). Oral health status in Belgian 3- to 5-year-old children. *Clin Oral Investig* **2**: 26-30.

CDC (2001). Recommendations for Using Fluoride to Prevent and Control Dental Caries in the United States. Atlanta, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Chowdhury NG, Brown RH, Shepherd MG (1990). Fluoride intake of infants in New Zealand. *J Dent Res* **69**: 1828-33.

Clark DC (1994). Trends in prevalence of dental fluorosis in North America. *Community Dent Oral Epidemiol* **22**: 148-52.

Clark DC (1995). Evaluation of aesthetics for the different classifications of the Tooth Surface Index of Fluorosis. *Community Dent Oral Epidemiol* **23**: 80-3.

Clark DC, Hann HJ, Williamson MF, Berkowitz J (1993). Aesthetic concerns of children and parents in relation to different classifications of the Tooth Surface Index of Fluorosis. *Community Dent Oral Epidemiol* **21**: 360-4.

Clark DC, Hann HJ, Williamson MF, Berkowitz J (1994). Influence of exposure to various fluoride technologies on the prevalence of dental fluorosis. *Community Dent Oral Epidemiol* **22**: 461-4.

Clarkson JJ, O'Mullane DM (1992). Prevalence of enamel defects/fluorosis in fluoridated and non- fluoridated areas in Ireland. *Community Dent Oral Epidemiol* **20**: 196-9.

Cochran JA, Ketley CE, Duckworth RM, et al. (2004). Development of a standardized method for comparing fluoride ingested from toothpaste by 1.5-3.5-year-old children in seven European countries. Part 2: Ingestion results. *Community Dent Oral Epidemiol* **32 Suppl 1**: 47-53.

Cons NC, Jenny J, Kohout F (1986). The Dental Aesthetic Index. Iowa, Iowa University Press.

Cons NC, Jenny J, Kohout FJ, Songpaisan Y, Jotikastira D (1989). Utility of the dental aesthetic index in industrialized and developing countries. *J Public Health Dent* **49**: 163-6.

CRD (2000). A Systematic Review of Public Water Fluoridation 2000. York, Centre for Review and Dissemination, The University of York.

Cremer HD, Buttner W (1970). Absorption of fluorides. *Monogr Ser World Health Organ* **59**: 75-91.

Davies GM, Worthington HV, Ellwood RP, et al. (2002). A randomised controlled trial of the effectiveness of providing free fluoride toothpaste from the age of 12 months on reducing caries in 5-6 year old children. *Community Dent Health* **19**: 131-6.

Davies MJ, Spencer AJ, Slade GD. Trends in dental caries experience of school children in Australia - 1977 to 1993. *Aus Dent J* **42**: 389-94.

Dean HT (1934). Classification of mottled enamel diagnosis. *J Am Dent Assoc* **21**: 1421-6.

Dean HT (1935). Studies on the minimal threshold of the dental sign of chronic endemic fluorosis (mottled enamel). *Public Health Rep* **50**: 1719-29.

Dean HT (1942). The investigation of physiological effects by the epidemiological method. Washington DC, American Association for the Advancement of Science.

Den Besten PK (1999). Mechanism and timing of fluoride effects on developing enamel. *J Public Health Dent* **59**: 247-51.

Dillman D, A. (1978). Mail and telephone survey: the Total Design Method. New York, John Willey.

Dowell TB, Joyston-Bechal S (1981). Fluoride supplements--age related dosages. *Br Dent J* **150**: 273-5.

Driscoll WS, Horowitz HS (1979). Dosage recommendations for dietary fluoride supplements. *Am J Dis Child* **133**: 683-4.

Driscoll WS, Horowitz HS, Meyers RJ, Heifetz SB, Kingman A, Zimmerman ER (1983). Prevalence of dental caries and dental fluorosis in areas with optimal and above-optimal water fluoride concentrations. *J Am Dent Assoc* **107**: 42-7.

Driscoll WS, Horowitz HS, Meyers RJ, Heifetz SB, Kingman A, Zimmerman ER (1986). Prevalence of dental caries and dental fluorosis in areas with negligible, optimal, and above-optimal fluoride concentrations in drinking water. *J Am Dent Assoc* **113**: 29-33.

Ellwood RP, O'Mullane DM (1994a). The demographic and social variation in the prevalence of dental enamel opacities in north Wales. *Community Dent Health* **11**: 192-6.

Ellwood RP, O'Mullane DM (1994b). Tooth brushing behaviour in twelve year old children and dental enamel. *J Ir Dent Assoc* **40**: 12-5.

Ellwood RP, O'Mullane D (1995). Enamel opacities and dental esthetics. *J Public Health Dent* **55**: 171-6.

Ellwood RP, Cortea DF, O'Mullane DM (1996). A photographic study of developmental defects of enamel in Brazilian school children. *Int Dent J* **46**: 69-75.

Evans DJ (1991). A study of developmental defects in enamel in 10 year-old high social class children residing in a non-fluoridated area. *Community Dent Health* **8**: 31-38.

Evans RW (1989). Changes in dental fluorosis following an adjustment to the fluoride concentration of Hong Kong's water supplies. *Adv Dent Res* **3**: 154-60.

Evans RW, Stamm JW (1991). Dental fluorosis following downward adjustment of fluoride in drinking water. *J Public Health Dent* **51**: 91-8.

Evans RW (1993). An epidemiological assessment of the chronological distribution of dental fluorosis in human maxillary central incisors. *J Dent Res* **72**: 883-90.

Evans RW, Darvell BW (1995). Refining the estimate of the critical period for susceptibility to enamel fluorosis in human maxillary central incisors. *J Public Health Dent* **55**: 238-49.

FDI (1982). FDI Commission on Oral Health, Research and Epidemiology Technical Report Nnmber 15. An epidemiological index of developmental defects of dental enamel (DDE Index). *Int Dent J* **32**: 159-67.

Fein NJ, Cerklewski FL (2001). Fluoride content of foods made with mechanically separated chicken. *J Agric Food Chem* **49**: 4284-6.

Fejerskov O, Johnson NW, Silverstone LM (1974). The ultrastructure of fluorosed human dental enamel. *Scand J Dent Res* **82**: 357-72.

Fejerskov O, Stephen KW, Richards A, Speirs R (1987). Combined effect of systemic and topical fluoride treatments on human deciduous teeth--case studies. *Caries Res* **21**: 452-9.

Fejerskov O, Manji F, Baelum V (1988). Dental fluorosis: a handbook for health workers. Copenhagen, Munksgaard.

Fejerskov O, Manji F, Baelum V (1990). The nature and mechanisms of dental fluorosis in man. *J Dent Res* **69 Spec No**: 692-700; discussion 721.

Fejerskov O, Larsen MJ, Richards A, Baelum V (1994). Dental tissue effects of fluoride. *Adv Dent Res* **8**: 15-31.

Feng XP, Newton JT, Robinson PG (2001). The impact of dental appearance on perceptions of personal characteristics among Chinese people in the United Kingdom. *Int Dent J* **51**: 282-6.

Fomon SJ, Ekstrand J (1999). Fluoride intake by infants. *J Public Health Dent* **59**: 229-34.

Fomon SJ, Ekstrand J, Ziegler EE (2000). Fluoride intake and prevalence of dental fluorosis: trends in fluoride intake with special attention to infants. *J Public Health Dent* **60**: 131-9.

Griffin SO, Beltran ED, Lockwood SA, Barker LK (2002). Esthetically objectionable fluorosis attributable to water fluoridation. *Community Dent Oral Epidemiol* **30**: 199-209.

Guha-Chowdhury N, Drummond BK, Smillie AC (1996). Total fluoride intake in children aged 3 to 4 years--a longitudinal study. *J Dent Res* **75**: 1451-7.

Hawley GM, Ellwood RP, Davies RM (1996). Dental caries, fluorosis and the cosmetic implications of different TF scores in 14-year-old adolescents. *Community Dent Health* **13**: 189-92.

Heilman JR, Kiritsy MC, Levy SM, Wefel JS (1997). Fluoride concentrations of infant foods. *J Am Dent Assoc* **128**: 857-63.

Heller KE, Eklund SA, Burt BA (1997). Dental caries and dental fluorosis at varying water fluoride concentrations. *J Public Health Dent* **57**: 136-43.

Hellwig E, Klimek J (1985). Caries prevalence and dental fluorosis in German children in areas with different concentrations of fluoride in drinking water supplies. *Caries Res* **19**: 278-83.

Hill AB (1965). The environment and the disease: association or causation. *Proc R Soc Med* **58**: 295-300.

Holloway PJ, Ellwood RP (1997). The prevalence, causes and cosmetic importance of dental fluorosis in the United Kingdom: a review. *Community Dent Health* **14**: 148-55.

Holm AK, Andersson R (1982). Enamel mineralization disturbances in 12-year-old children with known early exposure to fluorides. *Community Dent Oral Epidemiol* **10**: 335-9.

Holt RD (1995). The pattern of caries in a group of 5-year-old children and in the same cohort at 9 years of age. *Community Dent Health* **12**: 93-9.

Holt RD, Morris CE, Winter GB, Downer MC (1994). Enamel opacities and dental caries in children who used a low fluoride toothpaste between 2 and 5 years of age. *Int Dent J* **44**: 331-41.

Horowitz HS (1992). The need for toothpastes with lower than conventional fluoride concentrations for preschool-aged children. *J Public Health Dent* **52**: 216-21.

Horowitz HS (1999). Proper use of fluoride products in fluoridated communities. *Lancet* **353**: 1462.

Horowitz HS, Driscoll WS, Meyers RJ, Heifetz SB, Kingman A (1984). A new method for assessing the prevalence of dental fluorosis--the Tooth Surface Index of Fluorosis. *J Am Dent Assoc* **109**: 37-41.

Hoskin GW, Spencer AJ (1993). Personal perceptions of dental fluorosis in South Australian children. Concensus Conference: Appropriate fluoride exposure for infants and children, Perth, Western Australia.

Hoskin GW (1997). Social impact of dental fluorosis in South Australian school children. MPH thesis. The University of Adelaide.

Ismail AI, Brodeur JM, Kavanagh M, Boisclair G, Tessier C, Picotte L (1990). Prevalence of dental caries and dental fluorosis in students, 11-17 years of age, in fluoridated and non-fluoridated cities in Quebec. *Caries Res* **24**: 290-7.

Ismail AI (1994). Fluoride supplements: current effectiveness, side effects, and recommendations. *Community Dent Oral Epidemiol* **22**: 164-72.

Ismail AI, Messer JG, Hornett PJ (1998). Prevalence of dental caries and fluorosis in seven- to 12-year-old children in northern Newfoundland and Forteau, Labrador. *J Can Dent Assoc* **64**: 118-24.

Ismail AI, Bandekar RR (1999). Fluoride supplements and fluorosis: a meta-analysis. *Community Dent Oral Epidemiol* **27**: 48-56.

Jackson RD, Kelly SA, Katz B, Brizendine E, Stookey GK (1999). Dental fluorosis in children residing in communities with different water fluoride levels: 33-month follow-up. *Pediatr Dent* **21**: 248-54.

Jenny J, Cons NC (1996). Comparing and contrasting two orthodontic indices, the Index of Orthodontic Treatment need and the Dental Aesthetic Index. *Am J Orthod Dentofacial Orthop* **110**: 410-6.

Jobson MD, Grimm SE, 3rd, Banks K, Henley G (2000). The effects of water filtration systems on fluoride: Washington, D.C. metropolitan area. *ASDC J Dent Child* **67**: 350-4, 302, 304.

Johnson M, Harkness M, Crowther P, Herbison P (2000). A comparison of two methods of assessing orthodontic treatment need in the mixed dentition: DAI and IOTN. *Aust Orthod J* **16**: 82-7.

Jokovic A, Locker D, Stephens M, Kenny D, Tompson B, Guyatt G (2002). Validity and reliability of a questionnaire for measuring child oral-health-related quality of life. *J Dent Res* **81**: 459-63.

Jokovic A, Locker D, Stephens M, Kenny D, Tompson B, Guyatt G (2003). Measuring parental perceptions of child oral health-related quality of life. *J Public Health Dent* **63**: 67-72.

Jokovic A, Locker D, Guyatt G (2004). How well do parents know their children? Implications for proxy reporting of child health-related quality of life. *Qual Life Res* **13**: 1297-307.

Kumar JV, Green EL, Wallace W, Carnahan T (1989). Trends in dental fluorosis and dental caries prevalences in Newburgh and Kingston, NY. *Am J Public Health* **79**: 565-9.

Kumar JV, Swango PA (1999). Fluoride exposure and dental fluorosis in Newburgh and Kingston, New York: policy implications. *Community Dent Oral Epidemiol* **27**: 171-80.

Lalumandier JA, Rozier RG (1995). The prevalence and risk factors of fluorosis among patients in a pediatric dental practice. *Pediatr Dent* **17**: 19-25.

Lalumandier JA, Rozier RG (1998). Parents' satisfaction with children's tooth color: fluorosis as a contributing factor. *J Am Dent Assoc* **129**: 1000-6.

Landis JR, Koch GG (1977). The measurement of observer agreement for categorical data. *Biometrics* **33**: 159-74.

Leao A, Sheiham A (1996). The development of a socio-dental measure of dental impacts on daily living. *Community Dent Health* **13**: 22-6.

Leverett D (1986). Prevalence of dental fluorosis in fluoridated and nonfluoridated communities--a preliminary investigation. *J Public Health Dent* **46**: 184-7.

Levy S, Kiritsy M, Warren J (1995). Sources of fluoride intake in children. *J Public Health Dent* **55**: 39-52.

Levy SM, Kiritsy MC, Slager SL, Warren JJ, Kohout FJ (1997). Patterns of fluoride dentifrice use among infants. *Pediatr Dent* **19**: 50-5.

Levy SM, Guha-Chowdhury N (1999). Total fluoride intake and implications for dietary fluoride supplementation. *J Public Health Dent* **59**: 211-23.

Levy S, McGrady J, Bhuridej P, Warren J, Heilman JR, Wefel JS (2000). Factors affecting dentifrice use and ingestion among a sample of US preschoolers. *Pediart Dent* **22**: 389-394.

Levy SM, Warren JJ, Davis CS, Kirchner HL, Kanellis MJ, Wefel JS (2001). Patterns of fluoride intake from birth to 36 months. *J Public Health Dent* **61**: 70-7.

Levy SM, Warren JJ, Broffitt B (2003). Patterns of fluoride intake from 36 to 72 months of age. *J Public Health Dent* **63**: 211-20.

Lilienfield A (1967). Foundation of epidemiology. New York, Oxford University Press.

Locker D (1989). An introduction to behavioural science and medicine, Routledge.

MacMahon B, Trichopoulos D (1996). Principles of epidemiology. Boston, Little, Brown and Company.

Manji F, Baelum V, Fejerskov O, Gemert W (1986). Enamel changes in two low-fluoride areas of Kenya. *Caries Res* **20**: 371-80.

Marinho VC, Higgins JP, Sheiham A, Logan S (2003). Fluoride toothpastes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev*: CD002278.

Marshall TA, Levy SM, Broffitt B, et al. (2003). Dental caries and beverage consumption in young children. *Pediatrics* **112**: e184-91.

Marthaler TM (2004). Changes in dental caries 1953-2003. *Caries Res* **38**: 173-81.

Mascarenhas AK (2000). Risk factors for dental fluorosis: a review of the recent literature. *Pediatr Dent* **22**: 269-77.

Mascarenhas AK, Burt BA (1998). Fluorosis risk from early exposure to fluoride toothpaste. *Community Dent Oral Epidemiol* **26**: 241-8.

Maupome G, Shulman JD, Clark DC, Levy SM (2003). Socio-demographic features and fluoride technologies contributing to higher fluorosis scores in permanent teeth of Canadian children. *Caries Res* **37**: 327-34.

McClure FJ (1943). Ingestion of fluoride and dental caries: quantitative relations based on food and water requirements of children one to twelve years old. *Am J Dis Child* **66**: 362-369.

McGrath C, Bedi R (2001). An evaluation of a new measure of oral health related quality of life--OHQoL-UK(W). *Community Dent Health* **18**: 138-43.

Morgan L, Allred E, Tavares M, Bellinger D, Needleman H (1998). Investigation of the possible associations between fluorosis, fluoride exposure, and childhood behavior problems. *Pediatr Dent* **20**: 244-52.

Moss SJ (1999). The case for retaining the current supplementation schedule. *J Public Health Dent* **59**: 259-62.

MRC (2002). Water fluoridation and health, Medical Research Council.

Munro B, H. (1994). Statistical methods for healthcare research, Ellis Batten Page.

Murray JJ, Shaw L (1979). Classification and prevalence of enamel opacities in the human deciduous and permanent dentitions. *Arch Oral Biol* **24**: 7-13.

Naccache H, Simard PL, Trahan L, et al. (1992). Factors affecting the ingestion of fluoride dentifrice by children. *J Public Health Dent* **52**: 222-6.

National Institute of Health (1987). Oral health surveys of the National Institute of Dental Research. Diagnostic Criteria and Procedures. Washington DC. US Department of Health and Human Services.

Newbrun E (1989a). Cariology. Chicago, Quintessence Publishing.

Newbrun E (1989b). Effectiveness of water fluoridation. *J Public Health Dent* **49**: 279-89.

Newbrun E (1992). Current regulations and recommendations concerning water fluoridation, fluoride supplements, and topical fluoride agents. *J Dent Res* **71**: 1255-65.

Newbrun E (1999). The case for reducing the current Council on Dental Therapeutics fluoride supplementation schedule. *J Public Health Dent* **59**: 263-8.

Newton JT, Prabhu N, Robinson PG (2003). The impact of dental appearance on the appraisal of personal characteristics. *Int J Prosthodont* **16**: 429-34.

NHMRC (1991). The effectiveness of water fluoridation. Canberra, National Institute of Health and Research Council.

NHMRC (1993a). Working paper on interim recommendations on fluoride supplementation. Canberra, National Institute of Health and Research Council Expert Advisory Panel on Discretionary Fluorides.

NHMRC (1993b). Health Department of Western Australia and the University of Western Australia. Consensus Conference: Appropriate fluoride exposure for infants and children, Perth, Western Australia.

NHMRC (1999). Review of water fluoridation and fluoride intake from discretionary fluoride supplements. Melbourne, National Health and Research Council.

Ophaug RH, Singer L, Harland BF (1980a). Estimated fluoride intake of 6-month-old infants in four dietary regions of the United States. *Am J Clin Nutr* **33**: 324-7.

Ophaug RH, Singer L, Harland BF (1980b). Estimated fluoride intake of average two-year-old children in four dietary regions of the United States. *J Dent Res* **59**: 777-81.

Ophaug RH, Singer L, Harland BF (1985). Dietary fluoride intake of 6-month and 2-year-old children in four dietary regions of the United States. *Am J Clin Nutr* **42**: 701-7.

Ophaug R, Singer L (1988). Fluoride intake of infants and young children and the effect of supplemental and nondietary sources of fluoride. *Compendium* **9**: 68, 70-2, 74-5.

Osuji OO, Leake JL, Chipman ML, Nikiforuk G, Locker D, Levine N (1988). Risk factors for dental fluorosis in a fluoridated community. *J Dent Res* **67**: 1488-92.

Paiva SM, Lima YB, Cury JA (2003). Fluoride intake by Brazilian children from two communities with fluoridated water. *Community Dent Oral Epidemiol* **31**: 184-91.

Palmer JD, Anderson RJ, Downer MC (1984). Guidelines for prevalence studies of dental caries. *Community Dent Health* **1**: 55-66.

Pendrys DG, Katz RV (1989). Risk of enamel fluorosis associated with fluoride supplementation, infant formula, and fluoride dentifrice use. *Am J Epidemiol* **130**: 1199-208.

Pendrys DG (1990). The fluorosis risk index: a method for investigating risk factors. *J Public Health Dent* **50**: 291-8.

Pendrys DG, Morse DE (1990). Use of fluoride supplementation by children living in fluoridated communities. *ASDC J Dent Child* **57**: 343-7.

Pendrys DG, Stamm JW (1990). Relationship of total fluoride intake to beneficial effects and enamel fluorosis. *J Dent Res* **69 Spec No**: 529-38; discussion 556-7.

Pendrys DG, Katz RV, Morse DE (1994). Risk factors for enamel fluorosis in a fluoridated population. *Am J Epidemiol* **140**: 461-71.

Pendrys DG, Katz RV, Morse DE (1996). Risk factors for enamel fluorosis in a nonfluoridated population. *Am J Epidemiol* **143**: 808-15.

Pendrys DG, Katz RV (1998). Risk factors for enamel fluorosis in optimally fluoridated children born after the US manufacturers' decision to reduce the fluoride concentration of infant formula. *Am J Epidemiol* **148**: 967-74.

Pendrys DG (2000). Risk of enamel fluorosis in nonfluoridated and optimally fluoridated populations: considerations for the dental professional. *J Am Dent Assoc* **131**: 746-55.

Pereira AC, Da Cunha FL, Meneghim Mde C, Werner CW (2000). Dental caries and fluorosis prevalence study in a nonfluoridated Brazilian community: trend analysis and toothpaste association. *ASDC J Dent Child* **67**: 132-5, 83.

Peres KG, Latorre Mdo R, Peres MA, Traebert J, Panizzi M (2003). [Impact of dental caries and dental fluorosis on 12-year-old schoolchildren's self-perception of appearance and chewing]. *Cad Saude Publica* **19**: 323-30.

Puzio A (2000). Dental fluorosis: assessment of risk factors associated with fluoride exposure. MPH thesis. The University of Adelaide.

Puzio A, Spencer A, Brennan D (1993). Fluorosis and fluoride exposure in South Australian children. Consensus Conference: Appropriate fluoride exposure for infants and children, Perth, Western Australia.

Reisine ST (1988). The impact of dental conditions on social functioning and the quality of life. *Annu Rev Public Health* **9**: 1-19.

Richman LC, Eliason M (1982). Psychological characteristics of children with cleft lip and palate: intellectual, achievement, behavioral and personality variables. *Cleft Palate J* **19**: 249-57.

Riley JC, Lennon MA, Ellwood RP (1999). The effect of water fluoridation and social inequalities on dental caries in 5-year-old children. *Int J Epidemiol* **28**: 300-5.

Riordan PJ (1991). Dental caries and fluoride exposure in Western Australia. *J Dent Res* **70**: 1029-34.

Riordan PJ (1993a). Dental fluorosis, dental caries and fluoride exposure among 7-year-olds. *Caries Res* **27**: 71-7.

Riordan PJ (1993b). Fluoride supplements in caries prevention: a literature review and proposal for a new dosage schedule. *J Public Health Dent* **53**: 174-89.

Riordan PJ (1993c). Perceptions of dental fluorosis. *J Dent Res* **72**: 1268-74.

Riordan PJ (1993d). Specialist clinicians' perceptions of dental fluorosis. *ASDC J Dent Child* **60**: 315-20.

Riordan PJ (1996). The place of fluoride supplements in caries prevention today. *Aust Dent J* **41**: 335-42.

Riordan PJ (1999). Fluoride supplements for young children: an analysis of the literature focusing on benefits and risks. *Community Dent Oral Epidemiol* **27**: 72-83.

Riordan PJ (2002). Dental fluorosis decline after changes to supplement and toothpaste regimens. *Community Dent Oral Epidemiol* **30**: 233-40.

Riordan PJ, Banks JA (1991). Dental fluorosis and fluoride exposure in Western Australia. *J Dent Res* **70**: 1022-8.

Ripa LW (1991). A critique of topical fluoride methods (dentifrices, mouthrinses, operator-, and self-applied gels) in an era of decreased caries and increased fluorosis prevalence. *J Public Health Dent* **51**: 23-41.

Ripa LW (1993). A half-century of community water fluoridation in the United States: review and commentary. *J Public Health Dent* **53**: 17-44.

Robinson C, Brookes SJ, Bonass WA, Shore RC, Kirkham J (1997). Enamel maturation. *Ciba Found Symp* **205**: 156-70; discussion 170-4.

Robinson C, Connell S, Kirkham J, Brookes SJ, Shore RC, Smith AM (2004). The effect of fluoride on the developing tooth. *Caries Res* **38**: 268-76.

Robinson J (26 October 2004). Introduction of low fluoride toothpaste, Colgate Palmolive Australia. Personal communication.

Robinson PG, Nalweyiso N, Busiingye J, Whitworth J (2003). Oral-health-related Quality of Life in a Group of Children in Rural Uganda. Goteborg, The 81st General Session of the International Association for Dental Research.

Rock WP (1994). Young children and fluoride toothpaste. *Br Dent J* **177**: 17-20.

Rock WP, Sabieha AM (1997). The relationship between reported toothpaste usage in infancy and fluorosis of permanent incisors. *Br Dent J* **183**: 165-70.

Rockhill B, Newman B, Weinberg C (1998). Use and misuse of population attributable fractions. *Am J Public Health* **88**: 15-9.

Rodd HD, Davidson LE (1997). The aesthetic management of severe dental fluorosis in the young patient. *Dent Update* **24**: 408-11.

Rothman KJ (1986). Modern epidemiology. Boston, Little, Brown and Company.

Rozier RG (1995). A new era for community water fluoridation? Achievements after one-half century and challenges ahead. *J Public Health Dent* **55**: 3-5.

Rozier RG (1999). The prevalence and severity of enamel fluorosis in North American children. *J Public Health Dent* **59**: 239-46.

Rozier RG (2001). Effectiveness of methods used by dental professionals for the primary prevention of dental caries. *J Dent Educ* **65**: 1063-72.

Russell AL (1961). The differential diagnosis of fluoride and nonfluoride enamel opacities. *J Public Health Dent* **21**: 143-6.

Segreto VA, Collins EM, Camann D, Smith CT (1984). A current study of mottled enamel in Texas. *J Am Dent Assoc* **108**: 56-9.

Selwitz RH, Nowjack-Raymer RE, Kingman A, Driscoll WS (1998). Dental caries and dental fluorosis among schoolchildren who were lifelong residents of communities having either low or optimal levels of fluoride in drinking water. *J Public Health Dent* **58**: 28-35.

Shaw WC (1981). The influence of children's dentofacial appearance on their social attractiveness as judged by peers and lay adults. *Am J Orthod* **79**: 399-415.

Shaw WC, Humphreys S (1982). Influence of children's dentofacial appearance on teacher expectations. *Community Dent Oral Epidemiol* **10**: 313-9.

Shaw WC, Rees G, Dawe M, Charles CR (1985). The influence of dentofacial appearance on the social attractiveness of young adults. *Am J Orthod* **87**: 21-6.

Sigurjons H, Cochran JA, Ketley CE, Holbrook WP, Lennon MA, O'Mullane DM (2004). Parental perception of fluorosis among 8-year-old children living in three communities in Iceland, Ireland and England. *Community Dent Oral Epidemiol* **32 Suppl 1**: 34-8.

Silva M, Reynolds EC (1996). Fluoride content of infant formulae in Australia. *Aust Dent J* **41**: 37-42.

Singh KA, Spencer AJ, Armfield JM (2003). Relative effects of pre- and posteruption water fluoride on caries experience of permanent first molars. *J Public Health Dent* **63**: 11-9.

Skotowski MC, Hunt RJ, Levy SM (1995). Risk factors for dental fluorosis in pediatric dental patients. *J Public Health Dent* **55**: 154-9.

Slade G (2004). Risk factors for dental caries among South Australian 5-year-olds. Adelaide, The University of Adelaide & South Australian Dental Service.

Slade GD, Davies MJ, Spencer AJ, Stewart JF (1995a). Associations between exposure to fluoridated drinking water and dental caries experience among children in two Australian states. *J Public Health Dent* **55**: 218-28.

Slade GD, Spencer AJ (1994). Development and evaluation of the Oral Health Impact Profile. *Community Dent Health* **11**: 3-11.

Slade GD, Spencer AJ, Davies MJ, Burrow D (1996a). Intra-oral distribution and impact of caries experience among South Australian school children. *Aust Dent J* **41**: 343-50.

Slade GD, Spencer AJ, Davies MJ, Stewart JF (1995b). Influence of exposure to fluoridated water on socioeconomic inequalities in children's caries experience. *Community Dent Oral Epidemiol* **24**: 89-100.

Slade GD, Spencer AJ, Davies MJ, Stewart JF (1996b). Caries experience among children in fluoridated Townsville and unfluoridated Brisbane. *Aust N Z J Public Health* **20**: 623-9.

Spencer AJ (1989). Low concentration fluoride toothpaste-recommendation for children's use. Letter of recommendation to Colgate Palmolive, Australia. The University of Adelaide.

Spencer AJ, Davies M, Slade G, Brennan D (1994). Caries prevalence in Australasia. *Int Dent J* **44**: 415-23.

Spencer AJ, Slade GD, Davies M (1996). Water fluoridation in Australia. *Community Dent Health* **13 Suppl 2**: 27-37.

Spencer AJ (1998). New, or biased, evidence on water fluoridation? *Aust N Z J Public Health* **22**: 149-54.

Stephen KW (1993). Dentifrices: recent clinical findings and implications for use. *Int Dent J* **43**: 549-53.

Stephen KW, Macpherson LM, Gilmour WH, Stuart RA, Merrett MC (2002). A blind caries and fluorosis prevalence study of school-children in naturally fluoridated and nonfluoridated townships of Morayshire, Scotland. *Community Dent Oral Epidemiol* **30**: 70-9.

Sundstrom B, Jongebloed WL, Arends J (1978). Fluorosed human enamel. A SEM investigation of the anatomical surface and outer and inner regions of mildly fluorosed enamel. *Caries Res* **12**: 329-38.

Szpunar SM, Burt BA (1987). Trends in the prevalence of dental fluorosis in the United States: a review. *J Public Health Dent* **47**: 71-9.

Szpunar SM, Burt BA (1988). Dental caries, fluorosis, and fluoride exposure in Michigan schoolchildren. *J Dent Res* **67**: 802-6.

Szpunar SM, Burt BA (1990). Fluoride exposure in Michigan schoolchildren. *J Public Health Dent* **50**: 18-23.

Szpunar SM, Burt BA (1992). Evaluation of appropriate use of dietary fluoride supplements in the US. *Community Dent Oral Epidemiol* **20**: 148-54.

Tabari ED, Ellwood R, Rugg-Gunn AJ, Evans DJ, Davies RM (2000). Dental fluorosis in permanent incisor teeth in relation to water fluoridation, social deprivation and toothpaste use in infancy. *Br Dent J* **189**: 216-20.

Tarvit DJ, Freer TJ (1998). Assessing malocclusion--the time factor. *Br J Orthod* **25**: 31-4.

ten Cate JM (1999). Current concepts on the theories of the mechanism of action of fluoride. *Acta Odontologica Scandinavica* **57**: 325-329.

Thylstrup A, Fejerskov O (1979). A scanning electron microscopic and microradiographic study of pits in fluorosed human enamel. *Scand J Dent Res* **87**: 105-14.

van Palenstein Helderman WH, Mkasabuni E (1993). Impact of dental fluorosis on the perception of wellbeing in an endemic fluorosis area in Tanzania. *Community Dent Oral Epidemiol* **21**: 243-4.

Wang NJ, Gropen AM, Ogaard B (1997). Risk factors associated with fluorosis in a non-fluoridated population in Norway. *Community Dent Oral Epidemiol* **25**: 396-401.

Weatherell JA, Deutsch D, Robinson C, Hallsworth AS (1977). Assimilation of fluoride by enamel throughout the life of the tooth. *Caries Res* **11 Suppl 1**: 85-115.

Weatherell JA, Hallsworth AS, Robinson C (1972). Fluoride in the labial surface of permanent anterior teeth. *Caries Res* **6**: 67-8.

Wenzel A, Thylstrup A (1982). Dental fluorosis and localized enamel opacities in fluoride and nonfluoride Danish communities. *Caries Res* **16**: 340-8.

Whelton HP, Ketley CE, McSweeney F, O'Mullane DM (2004). A review of fluorosis in the European Union: prevalence, risk factors and aesthetic issues. *Community Dent Oral Epidemiol* **32 Suppl 1**: 9-18.

Whitford GM (1983). Fluorides: metabolism, mechanisms of action and safety. *Dent Hyg (Chic)* **57**: 16-8, 20-2, 24-9.

Whitford GM, Pashley DH (1984). Fluoride absorption: the influence of gastric acidity. *Calcif Tissue Int* **36**: 302-7.

World Health Organisation (1987). Oral health surveys: basic methods. 3rd Edn. Geneva: WHO.

World Health Organisation (1998). Oral health surveys: basic methods. 4th Edn. Geneva: WHO.

Wiktorsson AM, Martinsson T, Zimmerman M (1994). Prevalence of fluorosis and other enamel defects related to caries among adults in communities with optimal and low water fluoride concentrations. *Community Dent Health* **11**: 75-8.

Winter GB, Holt RD, Williams BF (1989). Clinical trial of a low-fluoride toothpaste for young children. *Int Dent J* **39**: 227-35.

Woltgens JH, Etty EJ, Nieuwland WM, Lyaruu DM (1989). Use of fluoride by young children and prevalence of mottled enamel. *Adv Dent Res* **3**: 177-82.

Yoder KM, Mabelya L, Robison VA, Dunipace AJ, Brizendine EJ, Stookey GK (1998). Severe dental fluorosis in a Tanzanian population consuming water with negligible fluoride concentration. *Community Dent Oral Epidemiol* **26**: 382-93.

Zohouri FV, Rugg-Gunn AJ (2000). Total fluoride intake and urinary excretion in 4-year-old Iranian children residing in low-fluoride areas. *Br J Nutr* **83**: 15-25.

Zohouri FV, Rugg-Gunn AJ, Fletcher ES, et al. (2004). Changes in water intake of Northumbrian adolescents 1980 to 2000. *Br Dent J* **196**: 547-52; discussion 537.

Appendix 1:

The Child Oral Health Study's questionnaire

South Australian Dental Service

ARCPOH
Australian Research Centre for POPULATION ORAL HEALTH

THE UNIVERSITY OF ADELAIDE AUSTRALIA

CHILD ORAL HEALTH STUDY 2002/2003

Dear Parent/Guardian,

Thank you for agreeing to participate in the Child Oral Health Study. Please fill in the forms below and the questionnaire. All information you provide will be strictly confidential.

CONSENT FORM

CHILD'S FIRST NAME: .... **CHILD'S SURNAME:** ....

ADDRESS: .... **TOWN/SUBURB**: ....

STATE: .... **POSTCODE:** .... **TELEPHONE: (__ __)** __ __ __ __ __ __ __ __
(Area code) (Number)

SCHOOL: .... **YEAR LEVEL**: ....

I, *(please print your name in full)* ...., have read the accompanying cover letter and consent to provide information for the Child Oral Health Study 2002/2003.

In giving my consent I understand that:

a) I am free to withdraw my consent at any time, and this will not affect dental advice or treatment in the management of my child's health, now or in the future;
b) The study is for the purpose of research which, although designed to improve the dental health of children in Australia, may not directly benefit my child; and
c) The confidentiality of information that I provide for the study will be safeguarded.
d) I understand what my participation includes. It includes filling in one questionnaire and allowing that information from my child's regular dental examination visits at the School Dental Service clinic to be used for research purposes only. My consent is given freely.
e) I am aware that I can make a copy of this Consent Form and the attached information letter when completed.

Signature of parent or guardian: .... **Date:** ....

In case we need to contact you in future for research purposes, it would be useful to know of another person who can help the researchers contact you. The researchers will contact that person only if you cannot be contacted.

GIVEN NAME: .... **SURNAME:** ....

ADDRESS: .... **SUBURB**: ....

STATE: .... **POSTCODE:** .... **TELEPHONE: (__ __)** __ __ __ __ __ __ __ __
(Area code) (Number)

Is this person your mother, brother, friend etc.? ....

CLINIC USE ONLY – All details must be completed

EXAMINATION DATE	/ / day month year	DATE OF BIRTH	/ / day month year	ID	C					

PLEASE READ THIS BEFORE STARTING THE QUESTIONNAIRE

- All of the questions in the questionnaire that refer to 'your child' concern the child named on the Consent Form at the front of this booklet.
- All of your answers are valuable to us, so please complete all questions to the best of your knowledge. If you are uncertain about a question, please ring FREECALL 1800-333-370 for advice.
- Please ignore the small numbers next to boxes; they are for office use only.

EXAMPLES OF QUESTIONS

- Some questions require you to tick only one box. For example:

Has your child ever used mouthrinse?
(Tick one box only)

☑1 Yes
☐2 No
☐3 Don't know

- Other questions may allow you to give multiple answers. For example:

When does your child usually brush his/her teeth?
(Tick as many boxes as applicable)

☑1 Before breakfast
☐2 After breakfast
☑3 After lunch
☑4 After dinner
☐5 Immediately before bed
☐6 At other times

- There will always be instructions next to the question telling you how many boxes you can tick. These instructions will be written in *italic* writing.
- Some of the questions ask for information about specific time periods of your child's life as in the following example. For questions like this, please tick one box for each time period as shown below unless indicated otherwise.

The child in this example brushed his/her teeth **less than once a day when he/she started brushing**, **once a day at age five** and **once a day now**. This child's details should be filled in as follows:

EXAMPLE QUESTION	**WHEN HE/SHE STARTED BRUSHING**	**AT AGE 5**	**NOW**
How often did/does your child brush his/her teeth with toothpaste?	☑1 Less than once a day ☐2 Once a day ☐3 Twice a day ☐4 More than twice a day	☐1 Less than once a day ☑2 Once a day ☐3 Twice a day ☐4 More than twice a day	☐1 Less than once a day ☑2 Once a day ☐3 Twice a day ☐4 More than twice a day

- Some questions require a written answer, as in these examples:

At what age did your child start taking fluoride tablets? 8 Years 6 Months

OR

What brand of infant formula did you use? Enfamil

- The questions should take you around 20 minutes to complete. If you need help filling in the questionnaire, please don't hesitate to give us a call on FREECALL 1800-333-370.

PLEASE START THE QUESTIONNAIRE ON THE FOLLOWING PAGE:

CHILD ORAL HEALTH STUDY 2002/2003

Dental Practices

1a **Has your child ever brushed his/her teeth with toothpaste (with or without help from an adult)?** ***(Tick one box only)***

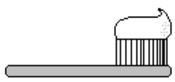
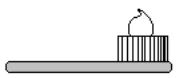
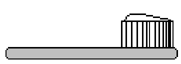
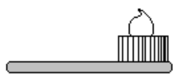
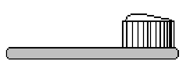
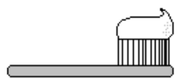
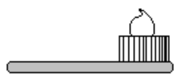
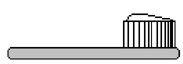
☐$_1$ Yes

☐$_2$ No → **GO TO QUESTION 5**

1b **At what age did he/she start brushing with toothpaste (with or without help from an adult)?** *(Write age)*

.... Years .... Months

2 ***For the following questions, please tick one box only for each time period in your child's life.***

	WHEN YOUR CHILD STARTED BRUSHING	AT AGE 5	NOW
a) **How often did/does your child brush his/her teeth with toothpaste?**	☐$_1$ Less than once a day ☐$_2$ Once a day ☐$_3$ Twice a day ☐$_4$ More than twice a day	☐$_1$ Less than once a day ☐$_2$ Once a day ☐$_3$ Twice a day ☐$_4$ More than twice a day	☐$_1$ Less than once a day ☐$_2$ Once a day ☐$_3$ Twice a day ☐$_4$ More than twice a day
b) **What type of toothpaste did/does your child use?**	☐$_1$ Standard fluoride toothpaste ☐$_2$ Children's toothpaste ☐$_3$ Non-fluoridated paste ☐$_4$ Don't know/not sure	☐$_1$ Standard fluoride toothpaste ☐$_2$ Children's toothpaste ☐$_3$ Non-fluoridated paste ☐$_4$ Don't know/not sure	☐$_1$ Standard fluoride toothpaste ☐$_2$ Children's toothpaste ☐$_3$ Non-fluoridated paste ☐$_4$ Don't know/not sure
c) **Have you noticed your child eating or licking toothpaste?**	☐$_1$ Often ☐$_2$ Sometimes ☐$_3$ Never	☐$_1$ Often ☐$_2$ Sometimes ☐$_3$ Never	☐$_1$ Often ☐$_2$ Sometimes ☐$_3$ Never
d) **What size of toothbrush did/does your child use?**	*(If your child uses an electric toothbrush, please tick 'Small size')* ☐$_1$ Small size ☐$_2$ Regular size	☐$_1$ Small size ☐$_2$ Regular size	☐$_1$ Small size ☐$_2$ Regular size
e) **After tooth brushing did/does your child usually…**	☐$_1$ just swallow ☐$_2$ rinse and swallow ☐$_3$ rinse and spit ☐$_4$ just spit ☐$_5$ other ☐$_6$ don't know	☐$_1$ just swallow ☐$_2$ rinse and swallow ☐$_3$ rinse and spit ☐$_4$ just spit ☐$_5$ other ☐$_6$ don't know	☐$_1$ just swallow ☐$_2$ rinse and swallow ☐$_3$ rinse and spit ☐$_4$ just spit ☐$_5$ other ☐$_6$ don't know
f) **How much toothpaste did/does your child (or do you) use on his/her toothbrush?**	☐$_1$  ☐$_2$  ☐$_3$ 	☐$_1$  ☐$_2$  ☐$_3$ 	☐$_1$  ☐$_2$  ☐$_3$ 

3 **How did/do you assist your child to brush his/her teeth?** (*Tick one box only for each time period)*

WHEN YOUR CHILD STARTED BRUSHING	AT AGE 5	NOW
☐1 Applied toothpaste & brushed teeth	☐1 Applied toothpaste & brushed teeth	☐1 Applied toothpaste & brushed teeth
☐2 Put toothpaste on his/her brush only	☐2 Put toothpaste on his/her brush only	☐2 Put toothpaste on his/her brush only
☐3 Just watched and gave advice	☐3 Just watched and gave advice	☐3 Just watched and gave advice
☐4 Helped him/her in a different way	☐4 Helped him/her in a different way	☐4 Helped him/her in a different way
☐5 Did not help him/her brush	☐5 Did not help him/her brush	☐5 Did not help him/her brush

4 **When did/does your child usually brush his/her teeth?**
(Tick as many boxes as applicable for each time period)

WHEN YOUR CHILD STARTED BRUSHING	AT AGE 5	NOW
☐1 Before breakfast	☐1 Before breakfast	☐1 Before breakfast
☐2 After breakfast	☐2 After breakfast	☐2 After breakfast
☐3 After lunch	☐3 After lunch	☐3 After lunch
☐4 After dinner	☐4 After dinner	☐4 After dinner
☐5 Immediately before bed	☐5 Immediately before bed	☐5 Immediately before bed
☐6 At other times	☐6 At other times	☐6 At other times

5 **Has your child ever taken fluoride tablets or drops?** *(Tick one box only)*

☐1 Yes, fluoride tablets only
☐2 Yes, fluoride drops only
☐3 Yes, fluoride tablets and fluoride drops
☐4 No → **GO TO QUESTION 11**
☐5 Don't know → **GO TO QUESTION 11**

6 **At what age did your child …**

start taking fluoride tablets or drops? .... Years .... Months
(Write age or '0' if used since birth)

stop taking fluoride tablets or drops? .... Years .... Months
(Write age or 'still taking')

7 **How many fluoride tablets or drops did/does your child take at a time? e.g. ½ tablet, 2 drops.**
(Write number of tablets or drops or '0' if not taken at this age)

BIRTH – 6 MONTHS	6 MONTHS – 4 YEARS	OVER 4 YEARS
.... tablet/s	.... tablet/s	.... tablet/s
.... drop/s	.... drop/s	.... drop/s

8 **How often did /does your child take the number of tablets or drops you wrote in Question 7?**
(Tick one box only for each age group)

BIRTH – 6 MONTHS	6 MONTHS – 4 YEARS	OVER 4 YEARS
☐1 More than once a day	☐1 More than once a day	☐1 More than once a day
☐2 Once a day	☐2 Once a day	☐2 Once a day
☐3 5 to 6 times a week	☐3 5 to 6 times a week	☐3 5 to 6 times a week
☐4 2 to 4 times a week	☐4 2 to 4 times a week	☐4 2 to 4 times a week
☐5 Once a week	☐5 Once a week	☐5 Once a week
☐6 Infrequently/varied	☐6 Infrequently/varied	☐6 Infrequently/varied
☐7 Did not take at this age	☐7 Did not take at this age	☐7 Did not take at this age

9 **What time of day did/does your child usually take fluoride tablets or drops?**

(Tick as many boxes as applicable)

BIRTH – 6 MONTHS	6 MONTHS – 4 YEARS	OVER 4 YEARS
☐1 Before breakfast	☐1 Before breakfast	☐1 Before breakfast
☐2 After breakfast	☐2 After breakfast	☐2 After breakfast
☐3 After lunch	☐3 After lunch	☐3 After lunch
☐4 After dinner	☐4 After dinner	☐4 After dinner
☐5 In the hour before bed	☐5 In the hour before bed	☐5 In the hour before bed
☐6 At other times	☐6 At other times	☐6 At other times

10 **How did/does your child usually take fluoride tablets or drops?** *(Tick as many boxes as applicable)*

☐1 Swallowing
☐2 Chewing and swallowing
☐3 Dissolved in a glass of water
☐4 Dissolved in a litre of water
☐5 Taken in another way

11 **Has your child ever used <u>fluoride</u> mouthrinse?** *(Tick one box only)*

Please note that not all mouthrinses contain fluoride. If possible, check the ingredients on the bottle.

☐1 Yes
☐2 No → **GO TO QUESTION 14**
☐3 Don't know → **GO TO QUESTION 14**

12 **At what age did your child …**

start using fluoride mouthrinse? .... Years .... Months
(Write age or '0' if used since birth)

stop using fluoride mouthrinse? .... Years .... Months
(Write age or 'still taking')

13 **How often did/does your child use fluoride mouthrinse at the following times?**
(Tick one box only for each time period)

When he/she started using it	Now or when he/she stopped using it
☐1 Every day	☐1 Every day
☐2 A few times a week	☐2 A few times a week
☐3 Once a week	☐3 Once a week
☐4 Infrequently	☐4 Infrequently

14 **Has your child ever had fluoride gel applied to his/her teeth by someone <u>outside</u> the School Dental Service?** (i.e. private dental practice or home application) *(Tick one box only)*

Private dental practice	Home application
☐1 Yes *(write number of times)* .... times	☐1 Yes *(write number of times)* .... times
☐2 No	☐2 No
☐3 Don't know	☐3 Don't know

Birth Place & Residential Movements

15 Please read the example below and then complete the table on the next page.

Write the name of each suburb, town or location your child has lived in, and the years that he/she lived there. **You are able to list one residence more than once if your usual source of water has changed over time**. Only include places where your child has lived for six months or more.

Then tick a box to indicate your child's usual source of drinking water at home and at school, and the water used in cooking food for your child.

PLEASE NOTE:

We refer to two different types of filtered water in the table below: **carbon/charcoal** and **osmosis/distillation**.

Carbon/charcoal filtered: Refers to **carbon** or **charcoal** filters (e.g. 'Pura Tap', 'Aqua Pure')
Osmosis/distillation filtered: Refers to **reverse osmosis** or **distillation** systems

EXAMPLE:

- This is an example of a child who has lived at their current address in Unley, SA since 1995 where she has used **unfiltered tap water at home and for cooking**. **At school she drank spring water**.
- Prior to that she lived for **two months** in Mount Barker. As she lived there for less than six months it is not included in the table.
- Prior to that she lived for nine months in Gawler where she used **filtered tap water from a bench top charcoal filter (Carbon/charcoal filtered) at home** and **tank water for cooking**.
- This child only lived in Gawler for part of a year, so the same year has been written in the "From" and "To" boxes.
- Her details would be filled in as follows:

Suburb, town or location (Start at current residence of 6 months or more)	Country/ Australian State or Territory	Years of residence		*(Please tick one box only below in each column where applicable)*			
		From	To	What was your child's usual source of water?	At home	At school	For cooking
1. Unley	SA	1995	2002	Tap/mains 1	✓		✓
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
				Spring/mineral 5		✓	
				Bore 6			
				Don't know 7			
2. Gawler	SA	1994	1994	Tap/mains 1			
				Carbon/charcoal filtered 2	✓		
				Osmosis/distillation filtered 3			
				Tank 4			✓
				Spring/mineral 5			
				Bore 6			
				Don't know 7			

If you have any trouble filling this table in, please don't hesitate to give us a call on the Child Oral Health Study Hotline: 1800-333-370.
We would be more than happy to help you fill it in!

We have given you enough spaces for six residences/entries. If you run out of spaces please attach an extra sheet of paper following the same format as in our table.

Remember: **Carbon/charcoal filtered:** Refers to **carbon** and **charcoal** filters (e.g. 'Pura Tap', 'Aqua Pure')
Osmosis/distillation filtered: Refers to **reverse osmosis** and **distillation** systems

<u>You are able to list one residence more than once if your usual source of water has changed over time.</u>

Suburb, town or location (<u>Start at current residence of 6 months or more</u>)	**Country/ Australian State or Territory**	**Years of residence**		***(Please tick one box only below in each column where applicable)***			
		From	**To**	**What was your child's <u>usual</u> source of water?**	**At home**	**At school**	**For cooking**
				Tap/mains 1			
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
1. ……………………..	……………	……….	……….	Spring/mineral 5			
				Bore 6			
				Don't know 7			
				Tap/mains 1			
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
2. ……………………..	……………	……….	……….	Spring/mineral 5			
				Bore 6			
				Don't know 7			
				Tap/mains 1			
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
3. ……………………..	……………	……….	……….	Spring/mineral 5			
				Bore 6			
				Don't know 7			
				Tap/mains 1			
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
4. ……………………..	……………	……….	……….	Spring/mineral 5			
				Bore 6			
				Don't know 7			
				Tap/mains 1			
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
5. ……………………..	……………	……….	……….	Spring/mineral 5			
				Bore 6			
				Don't know 7			
				Tap/mains 1			
				Carbon/charcoal filtered 2			
				Osmosis/distillation filtered 3			
				Tank 4			
				Spring/mineral 5			
6. ……………………..	……………	……….	……….	Bore 6			
				Don't know 7			

Dietary Intake

16

Think about the types of fluids your child drinks. These could include milk, fruit juice, soft drinks, spring water, tank water and tap/mains water etc.

At each residence you listed on the previous page, how much of the total amount of fluids drunk was tap/mains water?

Please complete the table below. (*Tick one box only for each residence/ entry you stated on the previous page)*

In our example below **more than half** of what this child drank was tap water.

	Almost none1	Less than half2	About half3	More than half4	Almost all5
EXAMPLE→				✓	
Residence/ entry 1 on previous page					
Residence/ entry 2 on previous page					
Residence/ entry 3 on previous page					
Residence/ entry 4 on previous page					
Residence/ entry 5 on previous page					
Residence/ entry 6 on previous page					

17

In regards to the following list of foods, which did your child eat during each time period?
Only include food that he/she ate **at least one time a day**.
(*Tick as many boxes as applicable in each age group)*

In our example below the child drank breast milk from **Birth – 6 months** and from **6 months – 12 months**.

	Birth – 6 months	6 – 12 months	At 2 years	At 3 years
Example for breast milk →	✓	✓		
Breast milk				
Infant formula				
Cow's milk				
Soy milk				
Infant cereals				
Processed infant chicken				
Processed infant seafood				
Other processed infant food				
Grape juice				
Soft drink				

18 **In the table below, please write the number of serves of food your child eats in a usual day, AND how many serves he/she usually eats in the last hour before bed.** Please use the standard serves as listed below.

EXAMPLE: In our example below this child eats 3 serves of fruit in a usual day, with 1 of these 3 serves of fruit eaten in the last hour before the child goes to bed.

Enter the number of serves your child eats of each food or '0' if he/she does not usually eat the food.			
	Standard Serve	**In a usual ↓ day (total)↓**	**How many of those eaten in a usual day are eaten in the last ↓hour before bed ↓**
EXAMPLE FOR FRUIT →	1 medium piece or 2 small pieces	3	1
Fruit and natural unsweetened fruit juice	1 medium piece or 2 small pieces or 1 medium glass	…………	…………
Sweetened fruit drinks/juices	1 medium glass	…………	…………
Sweetened (non-diet) soft drinks, mineral waters, cordial and sports drinks	1 medium glass	…………	…………
Artificially sweetened (diet/low calorie) soft drinks, mineral water and cordial	1 medium glass	…………	…………
Plain milk	1 medium glass	…………	…………
Flavoured milk (Milo, chocolate milk, Nesquik, etc.)	1 medium glass	…………	…………
Sweetened dairy products	1 cup yoghurt or 2 scoops ice-cream or ½ cup custard	…………	…………
Breakfast cereal – please specify main types: 1. __________________ 2. __________________	1 cup	…………	…………
Biscuits, cakes and puddings	2 biscuits or 1 slice cake or 1 cup cake	…………	…………
Table sugar (in tea, Milo, on cereal, etc.)	1 teaspoon	…………	…………
Chocolate and sugar-based confectionery	1 bar of chocolate or 4-5 lollies	…………	…………
Syrups, jams and sweet spreads (honey, jam, Nutella, maple syrup, etc.)	1 tablespoon	…………	…………
Muesli bars and health bars	1 muesli bar	…………	…………

19 **Was your child ever fed infant formula?** (*Tick one box only)*

- ☐1 Yes
- ☐2 No → **GO TO QUESTION 22**
- ☐3 Don't know → **GO TO QUESTION 22**

20 **What brands of infant formula was he/she fed?** *(Please write brands)*

1. .... **2.** .... **3.** ....

OFFICE USE ONLY

21 **What did you usually add to the infant formula for your child?** *(Tick one box only)*

- ☐1 Tap water
- ☐2 Carbon/charcoal filtered tap water
- ☐3 Osmosis/distillation filtered tap water
- ☐4 Mineral/Spring water
- ☐5 Tank water

General Information

22 **Was your child born prematurely? (i.e. before 37 weeks)** *(Tick one box only)*

- ☐1 Yes
- ☐2 No
- ☐3 Don't know

23 **What was the birth weight of your child?** *(Tick one box only and write weight in spaces provided)*

☐1 ____. ____ Kilograms (e.g. 3.2 kg) **OR** _____ pounds _____ ounces

☐2 Don't know

Characteristics of the Household

The following questions are about your household. These questions will help to decide if different methods of preventing dental problems work equally well for all groups within the community and to ensure that the researchers obtain an accurate cross-section of households.

24 **In which country was your child born?** ....
(Write name of country)

OFFICE USE ONLY

25 **Is your child of Aboriginal or Torres Strait Islander origin?** *(Tick one box only)*

- ☐1 No
- ☐2 Yes, Aboriginal
- ☐3 Yes, Torres Strait Islander
- ☐4 Yes, Aboriginal and Torres Strait Islander

26 **Does your child live in a one-parent household?** *(Tick one box only)*

- ☐1 Yes
- ☐2 No

27 **Please complete the table below.**

If your child lives in a one-parent household, please fill in one column for yourself. If he/she lives in a two-parent household, please fill in both columns for yourself and your partner.

QUESTION	↓ Parent or Guardian (A)	↓ Parent or Guardian (B)
a) **What is your age?**	.... Years	.... Years
b) **What is your sex?**	☐1 Male ☐2 Female	☐1 Male ☐2 Female
c) **In which country were you born?** *(Write country)*	....	....
d) **Are you of Aboriginal or Torres Strait Islander origin?** *(Tick one box only)*	☐1 No ☐2 Yes, Aboriginal ☐3 Yes, Torres Strait Islander ☐4 Yes, Aboriginal & Torres Strait Islander	☐1 No ☐2 Yes, Aboriginal ☐3 Yes, Torres Strait Islander ☐4 Yes, Aboriginal & Torres Strait Islander
e) **What is the highest level of education you have?** *(Tick one box only)*	☐1 Some high school ☐2 Completed high school ☐3 Some vocational training (i.e. trade) ☐4 Completed vocational training ☐5 Some University or College ☐6 Completed University or College	☐1 Some high school ☐2 Completed high school ☐3 Some vocational training (i.e. trade) ☐4 Completed vocational training ☐5 Some University or College ☐6 Completed University or College
f) **What is your usual occupation?** *(Write description, e.g. Accounts clerk)*	....	....
g) **Please write a brief description of your usual type of work,** *(e.g. in charge of invoicing, supervisor in a large firm, mowing lawns)*	....	....
h) **Do you currently have full time or part time work of any kind?** *(Tick one box only)*	☐1 Yes, full-time ☐2 Yes, part-time ☐3 No, not currently working	☐1 Yes, full-time ☐2 Yes, part-time ☐3 No, not currently working
i) **How many teeth have you had pulled out due to tooth decay?**	*(Write number)*	*(Write number)* ....
j) **How many fillings do you have in your mouth?**	*(Write number)*	*(Write number)* ....

28 **Which category does your total household income (before tax) fall into?** Include any salaries, pensions, allowances, benefits, etc from all persons in the household. *(Tick one box only)*

Household income per year

☐1 Up to $20,000
☐2 $20,001 to $40,000
☐3 $40,001 to $60,000
☐4 $60,001 to $80,000
☐5 $80,000 to $100,000
☐6 Over 100,000

OFFICE USE ONLY			
C1			
C2			
F1			
F2			

29 **How many people are dependent on this total household income, including yourself?**

(Write number) .... Adults .... Children

C					

30

The following questions are general statements regarding the dental health of your child.
The answers are on a five-point scale, where 1 means 'Definitely yes' and 5 'Definitely no'.
(Circle one number for each row)

Please answer the following statements and circle one number	**Definitely Yes** ... **Definitely No**
a) My child practises acceptable home dental behaviour.	1 -------- 2 -------- 3 -------- 4 -------- 5
b) My child receives adequate dental care.	1 -------- 2 -------- 3 -------- 4 -------- 5
c) My child needs dental care, but I put it off.	1 -------- 2 -------- 3 -------- 4 -------- 5
d) My child needs dental care, but he/she puts it off.	1 -------- 2 -------- 3 -------- 4 -------- 5
e) My child brushes his/her teeth well.	1 -------- 2 -------- 3 -------- 4 -------- 5
f) My child controls between-meal snacking well.	1 -------- 2 -------- 3 -------- 4 -------- 5
g) My child considers his/her dental health to be important.	1 -------- 2 -------- 3 -------- 4 -------- 5

Your Comments

Thank you. Your contribution to this study is greatly appreciated. Please take a moment to check that you have answered each question and have signed the consent form, then post the completed questionnaire and consent form in the **reply paid envelope** provided to:

Child Oral Health Study 2002/2003
ARCPOH – Dental School
The University of Adelaide
Reply Paid 498
Adelaide SA 5001

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

....
....
....
....
....
....
....
....
....
....
....
....

Thank you for your support!

Appendix 2:

Manual for Staff of School Dental Service

South Australian Dental Service
Frome Road
Adelaide SA 5000
Ph: (08) 8222-8222

Australian Research Centre for Population Oral Health
The University of Adelaide
Box 498 GPO
Adelaide SA 5001
FREECALL 1800-3333-70

Child Oral Health Study 2002/2003

Manual for Staff of School Dental Service

August 2002

TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND TO THE CHILD FLUORIDE STUDY

Historical Background

One of the centrepieces of Australia's and many other countries' population strategies for the prevention and control of dental caries has been the fluoridation of public water supplies. In Australia water fluoridation was implemented in many cities in the late 1960s and 1970s.

Although decreases in child caries prevalence and a substantial reduction in child caries experience in these Australian cities after 1965 provided evidence of the benefits of water fluoridation (Spencer, 1986), further monitoring showed that child caries experience had fallen in non-fluoridated Australian cities and in countries without fluoridation programs. This provided fuel for the controversy regarding the effectiveness of water fluoridation in the late 1980's and has lead to the need for purposeful research.

The Child Fluoride Study (CFS), initiated in 1991 by Spencer, Davies and Slade, had a data collection period of 5 years and has provided evidence for the effectiveness of lifetime exposure to water fluoridation in reducing childhood caries experience. The research indicated a more substantial benefit in the deciduous dentition and in the situations where diffusion of exposure from fluoridated to non-fluoridated areas (the halo effect) was minimised. The reduced benefit in the permanent dentition was thought to reflect the low caries activity in these teeth through primary school years and possible confounding by other fluoride exposures and dietary pattens.

The CFS 1991 is one of only seven studies identified and drawn upon from the international literature in a recent NHMRC review (1999). It has been cited as a pivotal study of the 1990s on the effectiveness of water fluoridation. The CFS 1991 received positive attention in Locker's report prepared for Ontario's public consultation on water fluoridation in 1999 and is referenced in the 2001 US Centres for Disease Control & Prevention recommendations for using fluoride to prevent and control dental caries in the USA.

More recently the CFS 1991 has been used to examine pre- and post-eruptive exposure and caries experience of six year old molars (Singh et al), the effect of consumption of non-tap water on the benefits of water fluoridation (Armfield et al) and the exposure to water fluoridation and the incidence/increment of dental caries (Spencer et al).

However, the CFS 1991 has not been without its criticisms. Methodological issues that could now be improved upon have become apparent. These include:

- More refined measures of exposure to fluoridated water for drinking, including water filters, mineral/spring water, tank/rain water at home verses school and water sources for cooking.
- Improved measures of exposure to other fluorides including commencement, frequency and dose across key life stages.
- Measurement of dietary patterns, particularly timing of foods and drinks across the day and key dental preventive behaviours.
- Observation of both cavitated and pre-cavitated lesions where differential effects of fluoride exposure are expected.

It is for these reasons that we have sought to repeat the Child Fluoride Study in 2002/03.

Description and Aims of the Study

The current CFS extends the previous CFS in 1991. New methodological issues will be dealt with, which will lead to the improved precision of both exposure and disease measurement in the study.

The objectives of the CFS are to establish the prevalence of dental caries and caries experience among 5-17-year-old children and analyse their association with differing exposure to fluoridated water supplies and other sources of fluoride. The study will also analyse the incidence and increment of dental caries over a period of 3 years (±12 months) follow-up period and their association with prior exposure to fluoridated water supplies and other sources of fluoride.

The current CFS is a study involving at least 30,000 children from various States of Australia. Children from fluoridated and non-fluoridated metropolitan and rural regions within each State will be included.

2. OVERVIEW OF PROCEDURES

Introduction

The aim of the study is to collect data about 5 to 17 year-old children, who are visiting your School Dental Service for routine examination, treatment or follow-up.

We will collect data from the parents of these children through a **questionnaire** (part of an enrolment package). The other type of data we are interested in are the children's' **dental health data**, which will be collected through the software package EXACT. The baseline information will be collected from 9th September 2002 to 8th September 2003. For metropolitan Adelaide, this period might be shorter.

There are four organizations involved in the collection and processing of this information. Each of these organisations has specific functions to facilitate the flow of information:

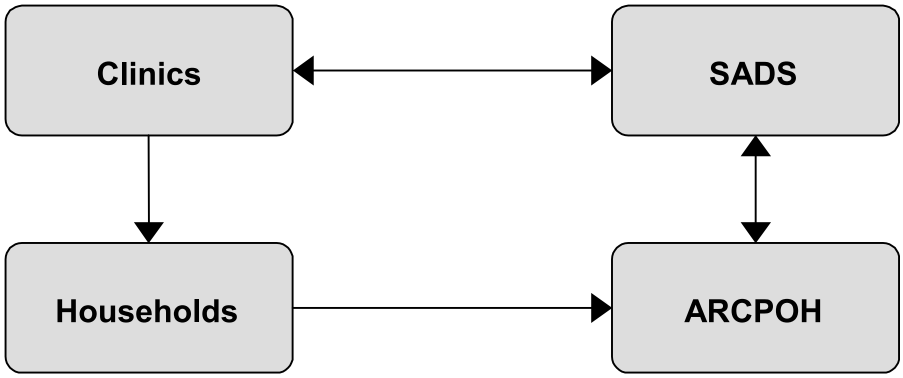
- Clinics (School Dental Service),
- SADS Evaluation Unit,
- Households (parents of children visiting the School Dental Service)
- ARCPOH (Australian Research Centre for Population Oral Health, Dental School, The University of Adelaide).

The following flow chart depicts the flow of information to and from each of those points as well as the tasks that need to be accomplished. Descriptions of these tasks follow.

Flow of Information (First Year)

Clinic Tasks
- Sample children at time of usual examination, issue questionnaire (enrolment package) and add child's details onto questionnaire
- Record identification number from questionnaire into EXACT
- Record examination data into EXACT

SADS Evaluation Unit Tasks
- Receive material (enrolment package) from ARCPOH and forward to clinics
- Issue reminder card to all sampled children after one week
- Address and post follow-up notices
- Compile participating children's examination data (EXACT) and forward to ARCPOH



Parental Tasks
- Complete consent form and questionnaire and return to ARCPOH in reply paid envelope

ARCPOH Adelaide Tasks
- Forward material (enrolment package) to SADS
- Process household questionnaires from participating parents
- Receive examination data (EXACT) from SADS and process
- Merge questionnaires and examination data
- Conduct error checks and resolve
- Analyse and report on baseline findings using merged data files

Clinic Tasks

The clinic is the point at which children are sampled and issued with an enrolment package, which includes the questionnaire. Prior to issuing the enrolment package, the questionnaire must be marked with the child's name, date of examination and date of birth. The unique identifying number must be transcribed from the questionnaire into EXACT in the specified field. The enrolment package, which seeks the parent's consent for participation, is taken home by the child. The details of sampling and the enrolment package are described in Chapter 3.

At the clinic, information about each sampled child is then recorded in two locations:

a) The child's identification number is transcribed from the questionnaire into EXACT.
b) Examination data are entered into EXACT following rules outlined in Chapter 4.

Parent Tasks

Parents receive the enrolment package directly from the clinic at their child's dental examination, or via their child if they are not present at the examination. Parents who choose to participate in the study complete the questionnaire and the covering consent form and post it to ARCPOH, using the reply paid envelope provided in the enrolment package.

SADS Evaluation Unit Tasks

The Evaluation Unit of SADS acts as the central communication point between clinics and ARCPOH. Hence it receives and forwards the examination data in EXACT to ARCPOH of those children whose parents consented for them to participate. It will store the examination data of non-participating parents and pass them on once a consent form is received. It also receives the reminder cards and follow-up letters from ARCPOH and forwards them to the parents.

ARCPOH (Australian Research Centre for Population Oral Health) Tasks

ARCPOH is part of the University of Adelaide, and is situated within the Dental School.

ARCPOH will deliver all required materials to SADS. ARCPOH will also receive and process questionnaires from consenting parents, and will access the examination data from SADS (clinics). Using the identification number, data from each source will be merged allowing researchers to conduct error checks and resolve incompatibilities between questionnaires and examination data. The merged file will then be analysed and reported on at baseline.

3. CHILD SELECTION

Sampling

Children will be sampled for this study according to their current age and date of birth. Only children aged between 5 and 17 inclusive at the time of examination are to be sampled during the enrolment period, which is from 9 September 2002 to 8th September 2003. The sampling procedure is similar to that employed in the Child Dental Health Survey up to the introduction of EXACT. However, there are different sampling ratios for different locations:

a. In Adelaide (Linden Park, Wandana, Madison Park, Parafield Gardens, Aberfoyle Park, Hallett Cove, Reynella South and Seaton Park), children born on the 1st to the 10th of each month are to be sampled.

b. In Mount Barker, Berri, Loxton, Renmark, Port Pirie West, Airdale and Peterborough, children born on the 1st to the 20th of each month are to be sampled.

c. In Naracoorte children born on the 1st to the 20th of each month are to be sampled. The only exception is children living in Lucindale/Padthaway, where every child has to be sampled (see point d below).

d. Children from Lucindale and Padthaway, which either use the services in Naracoorte or Bordertown, and children using the services in Kingscote, the Southern Vale mobile, Kingston mobile and Mount Gambier will all have to be sampled.

Children will be sampled when they present for their routine examination or re-examination (new course of care). It will therefore take one year to accumulate the total number of children required for the study, except for the Adelaide Metropolitan clinics, which will take approximately 6 months. Please see Chapter 5 for details on procedures beyond the enrolment period.

All children for whom a date of birth is unknown are to be excluded from the survey.

Enrolment Package

Sampled children will be given an enrolment package containing an introductory letter, a consent form and questionnaire to be taken home for completion by their parents, and a reply paid envelope. Completed parental information will be returned directly to the researchers at the University of Adelaide in a reply paid envelope. In some instances, parents who attend the dental clinic may have time to complete the form while waiting for their child to be treated. In such circumstances, the completed questionnaire should be forwarded to ARCPOH each fortnight, along with other routine mail.

<u>If parents should refuse to participate, enter an 'R' into the EXACT Survey 1 field instead of the survey ID</u> from the questionnaire. This is very important, as it will tell ARCPOH how many parents have been approached and how many refused to participate.

IMPORTANT: If you have already entered the ID and the package is returned to you at a later stage, please overwrite the ID in EXACT with a letter 'R' and discard the package.

Please see Appendix C point 1 for information on how the information package will be delivered to you.

Details of the enrolment package are on the following page:

COVERING LETTER FROM ARCPOH AND SADS

The letter provides an introduction to the study and encourages parents to participate. The letter is enclosed because it is important that participants be assured that the study is being conducted and supervised by those responsible for the provision of service and, that the significance of the study is sufficient to warrant active participation. Please see Appendix A for a copy of the covering letter.

PARENTAL QUESTIONNAIRE

The parental questionnaire contains important items of information that will allow the researchers to assess the impact of various factors on the dental health of children. These factors include fluoride exposure, dental hygiene behaviour, dietary intake and household characteristics.

Before issuing the enrolment package it is necessary to record the child's name and further details on the front cover of the questionnaire. (Please refer to the following page for the exact location of where to write this information.)

1) Write the **Child's Name** in the consent form box on the front cover of the questionnaire.

2) Write the **Examination Date**, which is the date when the child is examined and initially sampled and examined, in the box at the bottom of the front cover of the questionnaire.

3) Write the child's **Date of Birth** in the box at the bottom of the front cover of the questionnaire.

These items must be recorded to ensure that parents answer questions about the correct child, and to ensure that completed questionnaires (subsequently posted to ARCPOH) can be properly identified and matched to examination findings. The matching process will be facilitated by the use of the identification number which appears in the 'Clinic use only" box. This is a unique number which is printed onto the questionnaire, which always starts with C followed by a 5 digit code. This identification number must be transcribed by you from the questionnaire into EXACT.

Therefore, before issuing the enrolment package, ensure that the identification number at the lower right of the questionnaire cover page is recorded into EXACT.

REPLY PAID ENVELOPE

Parents are requested to forward completed questionnaires directly to ARCPOH using the reply paid envelope provided in the information package.

Important: Following enrolment, a child may return stating they have lost their information package. A replacement questionnaire may be given out, but the child's previous ID number has to be retrieved from EXACT and transcribed onto the questionnaire **in two locations**. Firstly, the ID number is transcribed in the usual place at the lower right hand corner on the cover of the questionnaire. It must also be written on the top of the last page of the questionnaire (see Appendix B).

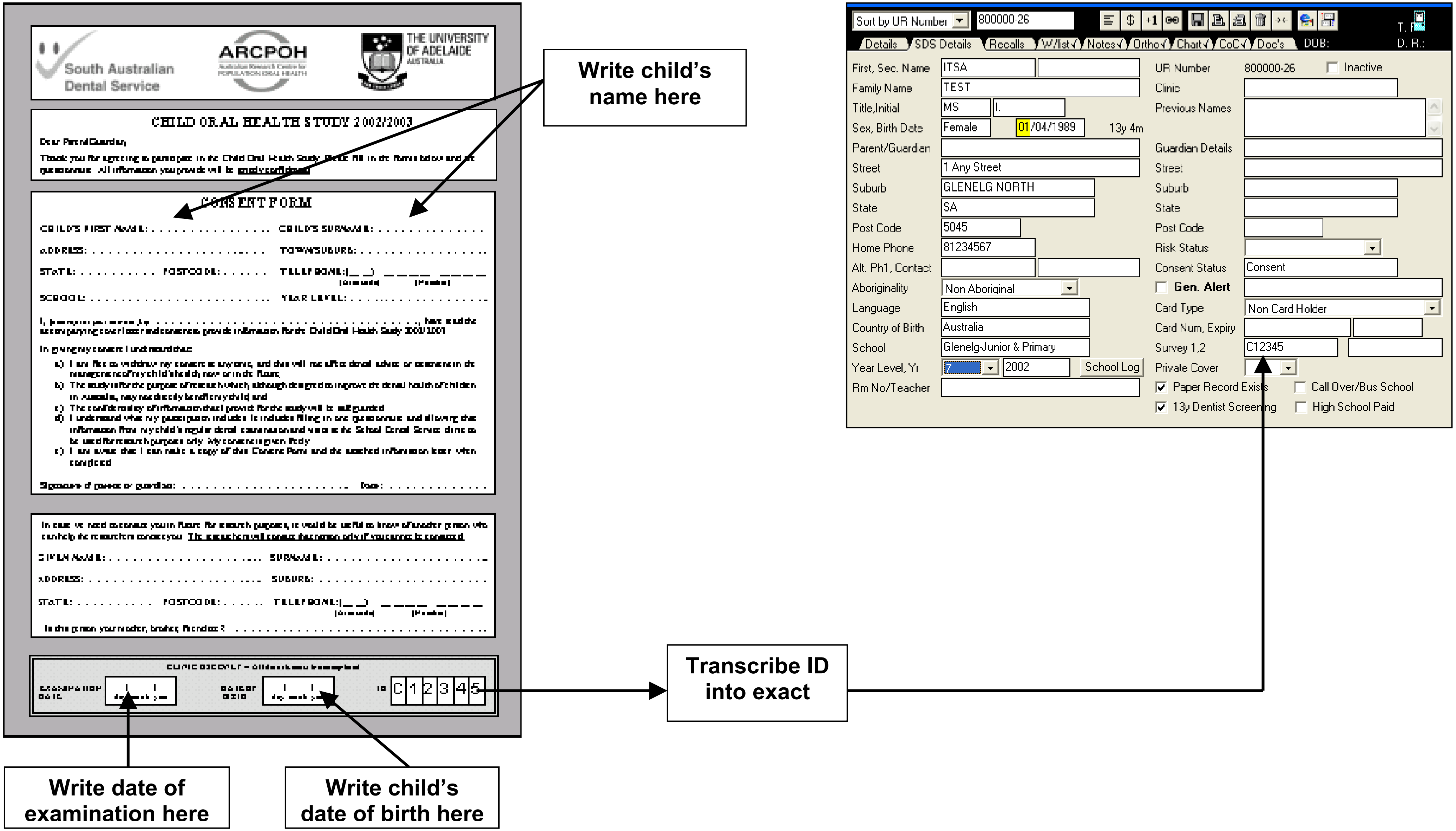
Of course all other details (child's name, date of examination and date of birth) also have to be put on the first page of the replacement questionnaire as shown on the following page.

See Appendix C point 2, which shows how the replacement package will be delivered to you.

WHAT TO DO WHEN ISSUING THE ENROLMENT PACKAGE

FRONT COVER OF QUESTIONNAIRE

SDS DETAILS SCREEN IN EXACT



4. RECORDING CLINICAL DATA

General Rules for recording clinical data

1) When a filling or a lesion on a posterior tooth, or a caries lesion on an anterior tooth extends beyond the line angle onto another surface, then the other surface is also scored as affected. However, a proximal filling on an anterior tooth is not considered to involve the adjacent labial or lingual surface unless it extends at least one third of the distance towards the opposite proximal surface.

2) On anterior teeth, the examiner should make a determination of the reason for crown placement. If crown was placed for any reason other than caries, such as fracture, malformation or aesthetics, the tooth is coded as ADA item nos. 529 or 578.

3) Teeth that are banded or bracketed for orthodontic treatment are examined in the usual manner and all visible surfaces are scored.

4) Certain teeth, notably first bicuspids, may have been extracted as part of orthodontic treatment. The examiner must make the determination that the teeth were extracted for orthodontic reasons rather than caries. These teeth are coded differently (for example as 311_O, 313_O or 316_O) and will be excluded from the DMFS analysis.

5) In general, when the same tooth surface is both carious and filled, only the caries is called. Note that only one call may be made for a given surface. If two or more conditions exist on the same surface, then caries receives precedence over a restoration.

6) Fractured or missing restorations are scored as if the restoration were intact. If caries is found within or adjacent to the margins of a fractured or missing restoration, DECAY should be recorded.

7) In case of supernumerary teeth, only one tooth is called or the tooth space. The examiner must decide which tooth is the 'legitimate' occupant of the space.

8) A tooth is considered to be in eruption when any part of its crown projects through the gum.

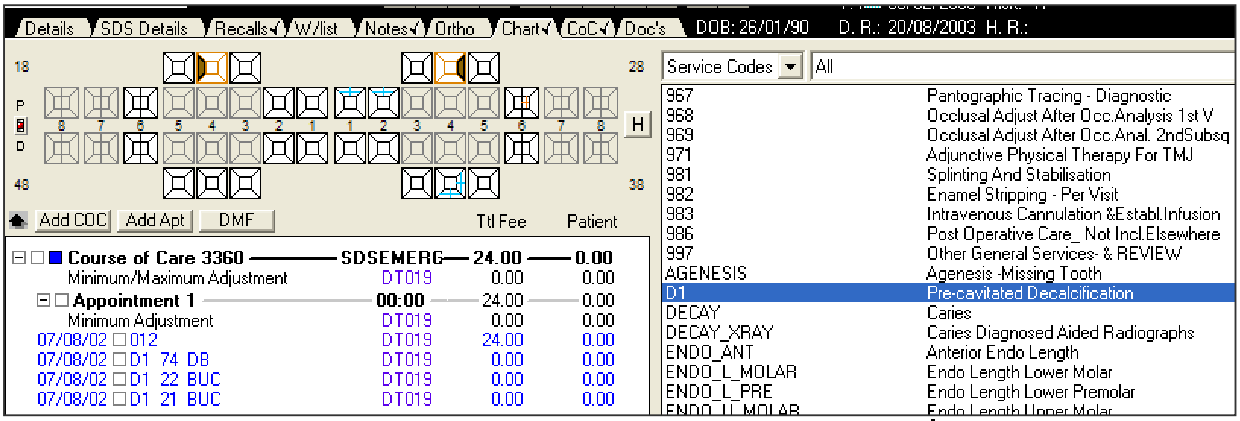
Two new options in the EXACT Patient Chart Screen

All data are to be recorded as usual into EXACT, except for two new options in the EXACT Patient Chart Screen.

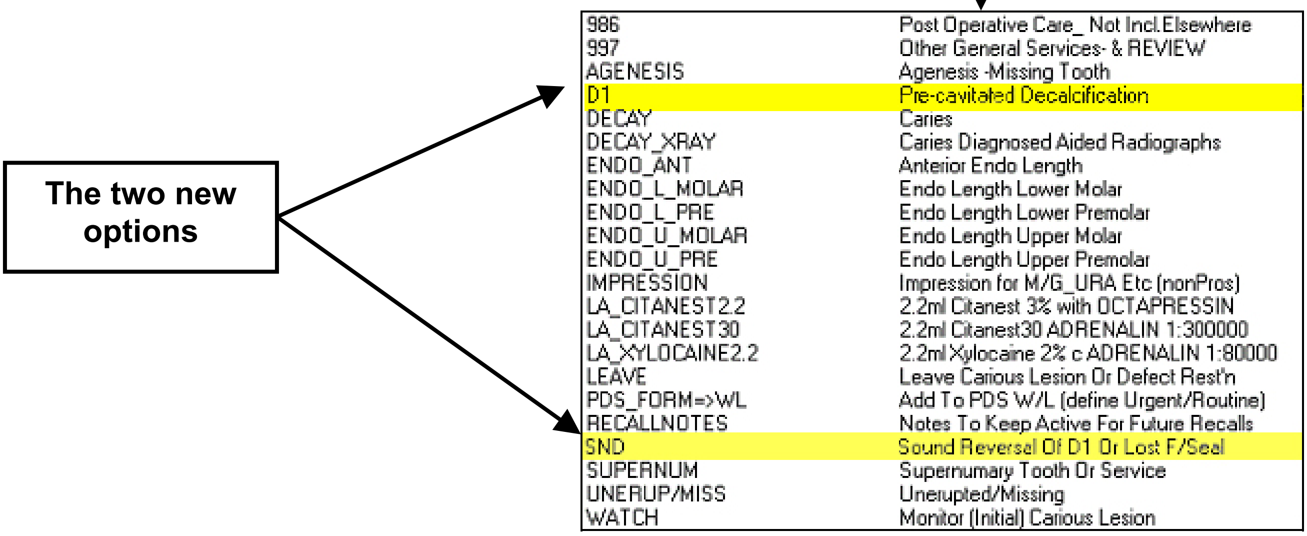
These new options are **D1** (pre-cavitated decalcification) and **SND** (sound reversal of D1 or lost Fissure Sealant), which are explained in this chapter.

What do these options look like in EXACT?

These new options are displayed in the Patient Chart Screen:



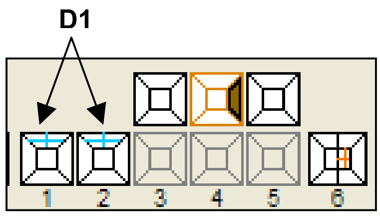
A closer look at the right hand column, displays the following:



The new D1 option

D1 means pre-cavitated decalcification and the early stages of caries disease activity.

The following image shows an example of D1 lesions on 21 Labial and 22 Labial surfaces in the EXACT Patient Chart Screen. Please notice that D1 is displayed as a pale blue cross in the colour-coding scheme of EXACT.



To enable you to diagnose D1 in comparison to Decay/Caries, the following definitions will give you a guideline.

D1/ pre-cavitated decalcification:
Demineralised lesions detected by drying with a triplex syringe for 30 seconds and with the aid of good lighting should be recorded as D1 lesions.

Non-cavitated lesion:
Lack of macroscopic loss of tooth substance demineralisation of enamel or dentine.

Procedure for diagnosis:

Clean teeth with gauze;
Isolate teeth **one quadrant** at a time with cotton rolls;
Dry quadrant for 30 seconds;
Use good lighting.

The diagnosis of **pre-cavitated decalcification (D1)** is made if:

- On smooth tooth surfaces:
  - White area is apparent (**at least** 1mm width) with no change of surface contour visible when dry.
  - Location – caries susceptible area, eg. gingival margin.
  - Chalky white or light brown colour with matt (chalky) appearance after drying.
  - Not well demarcated.
- In pits and fissures:
  - Pits and fissures coloured light or dark brown at the base and/or demineralisation/chalky white appearance evident on the sides of the pits and fissures.

NOTE: Stained pits and fissures should not be coded as D1.

The following are images of D1:

DECAY/CARIES

Coronal surfaces are coded using the following criteria (based on Radike, 1968):

Frank lesions are coded as Decay and occur when cavitation **and** softening of the cavity floor are present. Cavitation is defined as a discontinuity of the enamel surface caused by the loss of tooth substance, sufficient to require restoration. It must be distinguished from factures, erosion and abrasion.

Lesions not showing frank cavitation may still be coded as decayed under the following circumstances:

a) Pits and fissures:

The local area is coded as decay when opacity or discolouration indicating adjacent undermining of enamel occurs.

b) Smooth surfaces on buccal and lingual surfaces:

The area is coded as decay if the surface is etched or there is a white spot **and** if dentine seems to be involved as indicated by softness or discolouration of dentine.

c) Proximal Surfaces:

As in b). Also:

1. If marginal ridge shows darkening/shadowing as evidence of undermined enamel the surface is carious.
2. Transillumination (for anterior teeth): a loss of translucency producing a characteristic shadow in a calculus and stain-free proximal surface is adequate evidence of caries.

NOTE: - Staining and pigmentation are not by themselves evidence of caries
- Erosion, abrasion, hypoplasia, attrition, fractures, mottled enamel and enamel opacities on exposed hard surfaces are not classified as carious.

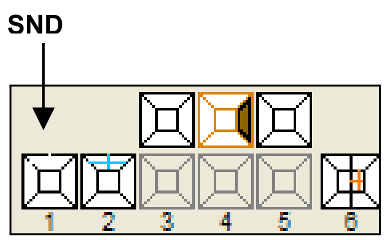
THE NEW SOUND OPTION

Tooth surfaces are usually displayed as sound when you are entering a new patient's dental details in the EXACT Patient Chart Screen. However, there are two conditions in which a surface might reverse back to sound at subsequent appointments.

- Pre-cavitated decalcified lesions are reversible to Sound.
- Fissure sealants may be lost and the surface may revert to Sound.

This new option is called 'SND' in the EXACT Patient Chart Screen and means sound reversal of decalcified surfaces or a lost Fissure sealant leaving a sound tooth surface.

The following image shows an example of a subsequent course of care - a 'Sound' reversal of the D1 on 21 Labial surface equivalent to return to a sound surface. Please notice the white cross in the colour-coding scheme of EXACT.



5. PROCEDURES FOR LONGITUDINAL DATA COLLECTION

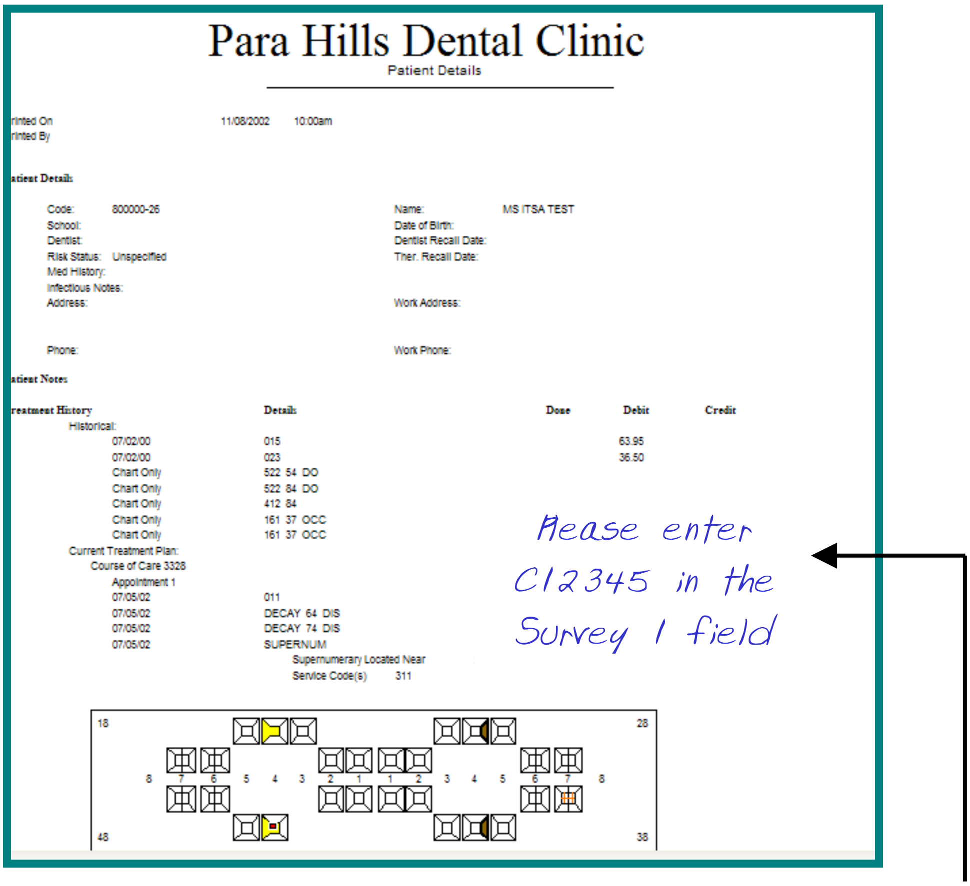
Clinical data will be recorded for each child enrolled in the study for a period of three years from the date of enrolment. The researchers will undertake to inform clinicians of the progress of the study, via SADS, as results become available.

Procedures for the on-going maintenance of the study are as follows.

WHAT TO DO WHEN A CHILD TRANSFERS TO OR FROM ANOTHER CLINIC

A. When a child leaves your clinic

When a child transfers to another School Dental Service clinic a transfer sheet is prepared and which is given to the child/parent. This transfer sheet looks as follows:


Para Hills Dental Clinic

Patient Details

rinted On 11/08/2002 10:00am

rinted By

atient Details

Code:	800000-26	Name:	MS ITSA TEST
School:		Date of Birth:	
Dentist:		Dentist Recall Date:	
Risk Status:	Unspecified	Ther. Recall Date:	
Med History:			
Infectious Notes:			
Address:		Work Address:	
Phone:		Work Phone:	

atient Notes

reatment History	Details	Done	Debit	Credit
Historical:				
07/02/00	015		63.95	
07/02/00	023		36.50	
Chart Only	522 54 DO			
Chart Only	522 84 DO			
Chart Only	412 84			
Chart Only	161 37 OCC			
Chart Only	161 37 OCC			
Current Treatment Plan:				
Course of Care 3328				
Appointment 1				
07/05/02	011			
07/05/02	DECAY 64 DIS			
07/05/02	DECAY 74 DIS			
07/05/02	SUPERNUM			
	Supernumerary Located Near			
	Service Code(s) 311			

When a child leaves your clinic, look up the ID for the Child Oral Health Study in EXACT (*Survey 1* field) as shown on page X. If the child is enrolled in the study, write the ID in handwriting on the transfer sheet. This note should say:

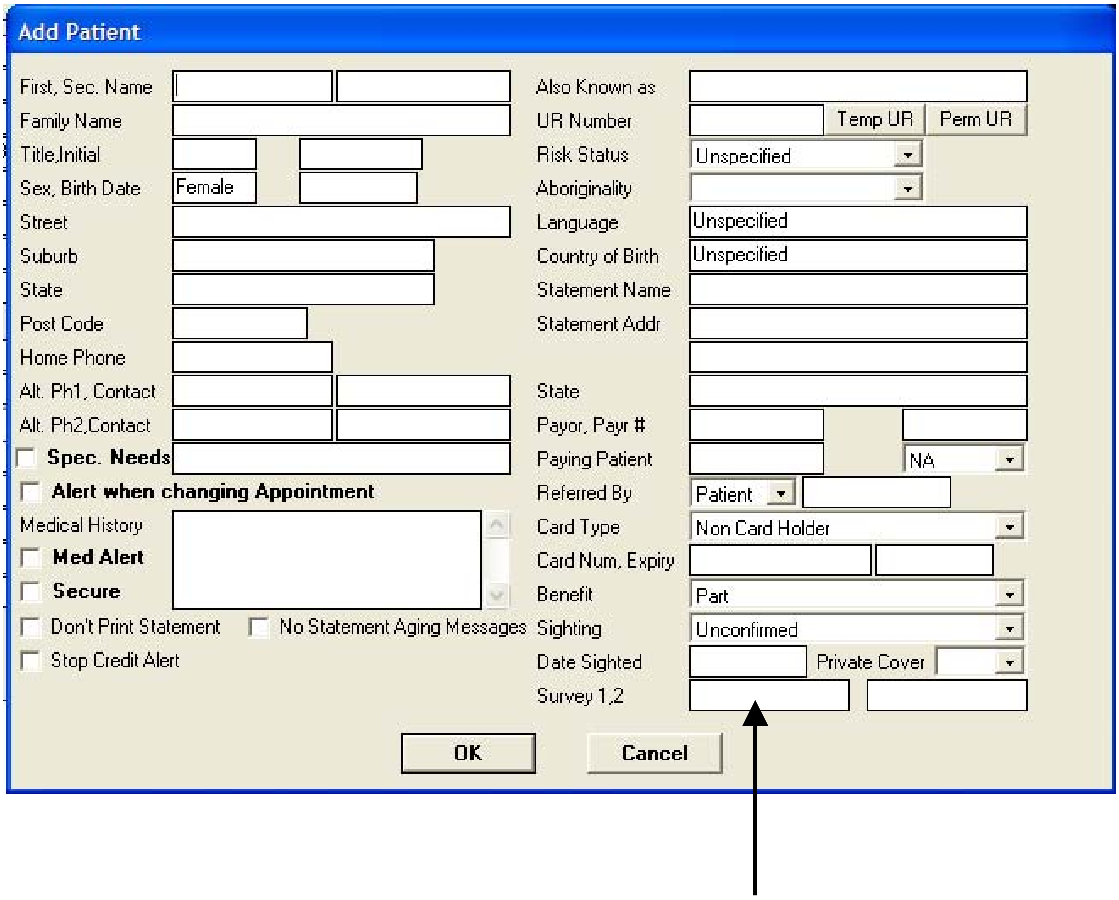
'*Please enter* **[child's ID]** *in the Survey 1 field*.'

This is so that the staff at the child's new School Dental Service clinic are able to enter the child's ID into EXACT (see next page). This procedure will enable the researcher to follow children and retrieve their examination data during the life of the study.

In near future there will be a new field displayed on the EXACT transfer sheet, which will be called *Survey 1*. This field will display the child's ID automatically and you will not have to handwrite any notes. SADS will inform you about this change.

B. When a child transfers to your clinic

When you receive a transfer sheet (as shown on the last page) from a child/parents, when they enrol at your clinic, you will usually enter their details into EXACT ('Add Patient' screen as shown below).



If there is a handwritten note on the transfer sheet, the ID has to be transcribed into EXACT in the *Survey 1* field on the 'Add Patient' screen (see above).

If there is no handwritten note, please don't enter anything in the *Survey 1* field.

In the near future you will find a printed *Survey 1* ID on the transfer sheet, which you will transcribe into this field. SADS will notify you about this change.

OTHER ON-GOING PROCEDURES

At the end of the enrolment period (8th September 2003) the researchers at ARCPOH will prepare a list of all children for whom consent has been obtained. This list will be forwarded to SADS, where these children only will show their ID in EXCACT, while all other children will show an 'R'. The children with an ID in EXACT will form the core of the data collection for the following three years as they progress through the School Dental Service. However, for each child being examined, the entries in the survey system will be the same and follow the rules outlined in Chapter 4.

6. SUMMARY OF CLINICAL PROCEDURES

When a child with a selected date of birth presents for examination, do the following:

1) Record child's name, the date of exam and date of birth on the questionnaire.
2) Transcribe the child's ID from the lower right corner of the questionnaire's front cover into EXACT, put the questionnaire in one of the A4 envelopes and hand it to the child (or parents if present).
3) Conduct examination and enter data into EXACT.

All clinics will be provided with an initial supply of:

- A4 envelopes (part of the enrolment package), which include one introduction letter and a reply paid envelope
- Questionnaires with ID printed on front and back page (part of the enrolment package), which have to be put into the A4 envelope after filling in the details and transcribing the child's ID in EXACT
- Replacement enrolment packages, which use the same envelopes, but use questionnaires that do not have an ID printed on front and back page.

See Appendix C for further information.

Requests of additional supplies of the enrolment package and replacement enrolment package should be directed to the researchers at ARCPOH by telephoning FREECALL 1800-3333-70.

Any queries from either yourself, or the public may be directed to the researchers on FREECALL 1800-333-370.

7. QUESTIONS AND ANSWERS

A series of questions and answers to issues which may be raised by parents of children who are patients of the School Dental Service, and others such as teachers and school principals have been prepared. The following questions and answers may assist in addressing a brief query directed to you. Any more substantive matters, or time-consuming inquiries should be directed to the researchers at ARCPOH. A toll free number 1800-333-370 has been provided to permit interested parties in South Australia to speak with the researchers directly.

What is the purpose of the study?

The aim of the study is to investigate the impact of various factors on children's dental health in order to find the most effective treatment to prevent tooth decay in children. These factors include dental hygiene behaviour, dietary patterns, dental care and fluoride exposure on children's dental health.

Why are there questions about fluoride included? Is the questionnaire about the impact of fluoride on caries?

The study investigates the impact of various factors to children's' dental health. The impact of fluoride is one of a number of factors, which are being investigated in this study. Other factors are the impact of dental hygiene behaviour, dietary patterns and dental care.

Why has my child been selected?

A sample of children receiving care from the School Dental Service in Adelaide and rural South Australia are being invited to participate. The School Dental Service provides the best means of identifying a representative group of children in South Australia for this study. The selection procedure is random, and is based on birth date.

Why is the study conducted in this State, this town?

The School Dental Service in South Australia provides dental care to a very large proportion of all children in South Australia. This is important for a study that wishes to follow a large number of children over several years.

How important are the questions in the questionnaire?

All the questions are directly related to the aims of the study, and are therefore important. The first page asks about your whereabouts, so that we can re-contact you if need should be. Question 1 to question 14 are about dental practices and question 15 where you lived and question 16 to question 22 are about dietary intake of your child and some general questions. Each question is very important for the study and should be answered. Particularly question 24 to 30, which ask for characteristics of your household, are important so that we can assess whether different methods for preventing dental decay work equally well across all groups within the community and to ensure that the researchers get an accurate representative cross-section of households.

What if I can't remember all the details?

It is important to complete the questionnaire to the best of your ability. If you can't remember some details, try conferring with another member of the family, or come back to the question after a few minutes. It is possible that you may not be able to recall some detail. Please mark 'don't know' as a response in that instance.

Should I complete all of the questions?

Every question is directly related to the aims of the study. It is therefore important to complete the questionnaire to the best of your ability. If there is a question that presents particular difficulty for you, please telephone the researchers for clarification.

What if I object to a question?

Each item of information is important to enable the researchers to develop as complete a picture as possible about children's dental disease in South Australia. Some items are included to permit an examination for how dental health varies for different social groups and which treatments are most effective. It is important therefore, for the study to include people with different social backgrounds. All personal information is strictly confidential. No individuals will be identifiable from the results of the study, which will include some thousands of other children/parents. If a particular question presents a problem for you, please discuss your concern with the researchers by telephone. An incomplete questionnaire completed to the best of your ability will still be of value for some parts of the study.

Why do they want to know how much I earn, my country of birth?

Each item of information is important to enable the researchers to develop as complete a picture as possible. People in Australia have many different social backgrounds. A study of how to improve the dental health of Australian children will need to consider how the range of experiences that people have had can influence dental health and which treatments are most effective for people with different backgrounds.

Who gets to know my information?

Only the researchers directly concerned with the project at the University of Adelaide will see the information provided to you. The clinical information will only be forwarded to the researchers after your consent has been processed. No results of the study will refer to individuals. Your personal information will not be forwarded to the School Dental Service clinics. Clinics are used only for the collection of clinical information that is forwarded to the researchers.

How is my confidentiality maintained?

Only the researchers directly concerned with the project will see the information provided by you. All documents will be maintained in a secure environment, and will be destroyed after the completion of the study. Computer files containing your information identified by your ID number but not by name, will be stored on one computer system only, which will have a password to allow access by the researchers only. Consent forms will be separated from the questionnaires and both documents will be securely locked up at all times.

Will this affect the treatment of my child?

Your decision to participate, or not to participate will not affect any current or future treatment received by your child by the School Dental Service.

APPENDICES

Appendix A: Introduction Letter

South Australian Dental Service

ARCPOH Australian Research Centre for Population Oral Health

The University of Adelaide Australia

An invitation to you and your child...

Dear Parent/Guardian,

The 2002 Child Oral Health Study is underway and we wish to offer you the chance to be a part of it!

Researchers at The University of Adelaide in association with the South Australian Dental Service are conducting a study into the oral health of South Australian school children. The results of this research will be important in the fight against childhood oral problems such as tooth decay and will help in planning dental care for school children.

Your child has been randomly chosen, along with other children from your school community, to take part in this study. This is an opportunity for your family to be a part of our research that will have an impact on the oral health of future South Australians.

Enclosed is a questionnaire, which includes questions about your child's toothbrushing habits, diet, sources of drinking water and some information about your household. You will also find a consent form. Completing the consent form confirms your willingness to take part in the study and permits us to access some information from your child's regular dental examinations at their School Dental Service clinic. We also ask that you provide your contact details in case we need to come back to you in future e.g. to confirm some information.

Your responses to the questionnaire and results from your child's dental visit are strictly confidential and will only be used by the researchers at The University of Adelaide. The results of the study will be reported in statistical form only and the identity of your child will not be revealed.

So please, take the time to fill in our questionnaire and return it along with the consent form in the reply paid envelope provided. The questions will only take you about 20 minutes to complete.

If you have any questions about the study or the questionnaire, please don't hesitate to call the Child Oral Health Study Hotline on FREECALL 1800-3333-70.

With your help we can make a real difference to the oral quality of life for children, just like yours!

Many thanks,

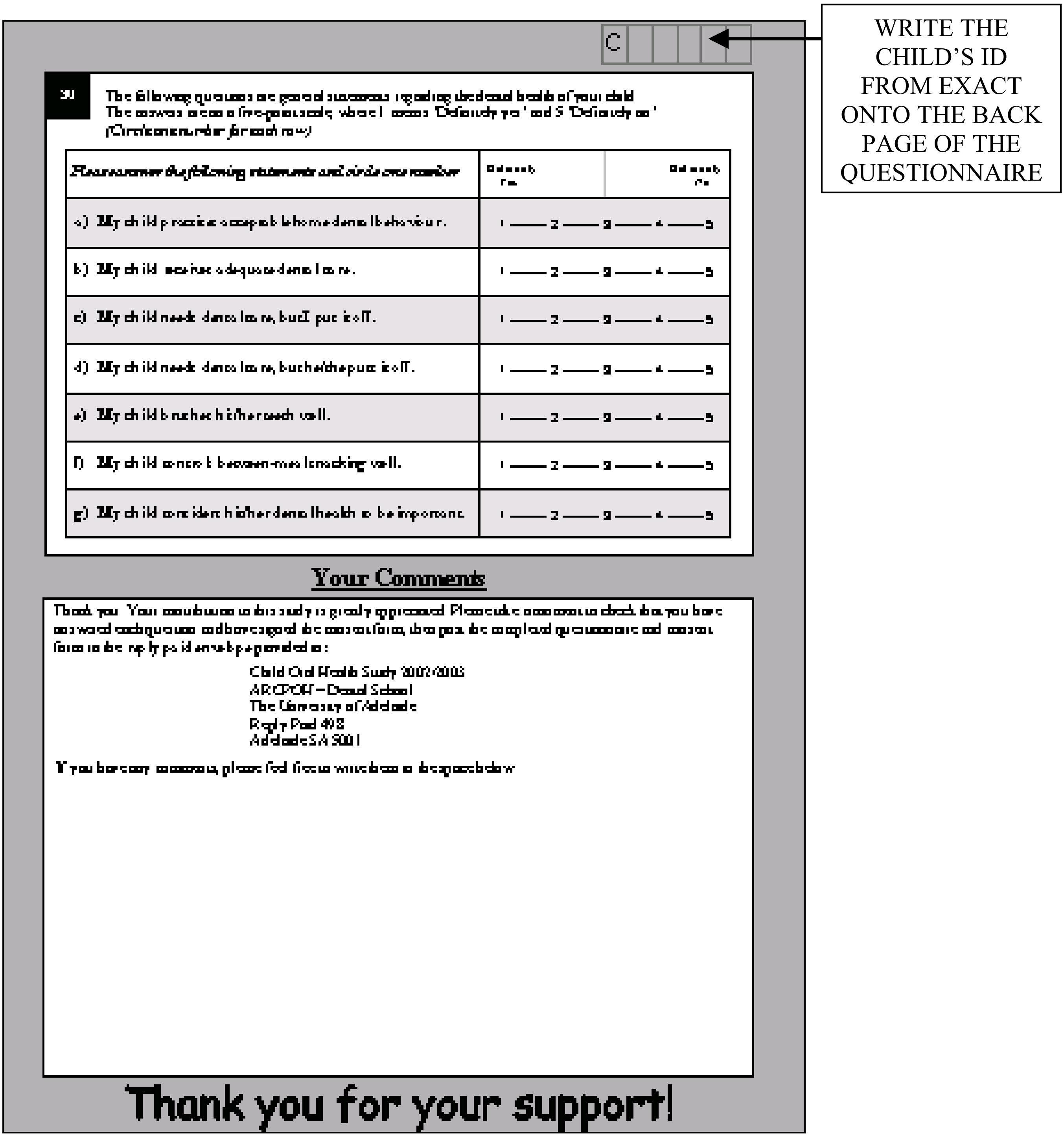
Professor A John Spencer **Principal Investigator** **ARCPOH, University of Adelaide**	**Dr David Burrow** **Director** **Statewide Dental Service/SA Dental Service**

Thank you for your support!

Appendix B: Additional entry of child's ID on Replacement Questionnaires

When handing out a replacement package, please enter all the child's details on the first page (as described on page 9) and then copy the ID from EXACT into the boxes at the bottom of the first page of the questionnaire.

The second location on the questionnaire, that you need to copy the ID, is on the back page of the questionnaire:

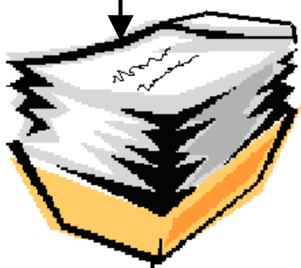


Appendix C: Material delivered to you

1) The Introduction Package

Questionnaires with ID

Envelopes filled with Introduction letter and reply paid envelope.

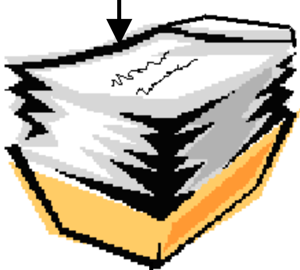


This is the <u>introduction package</u> that you will forward to the selected children

2) The Replacement Package

Questionnaires - no ID

Envelopes filled with the introduction letter and reply paid envelope



This is the <u>replacement package</u> to be used if the child or parent has lost the introduction package

Appendix 3:

The Child Perception and Parental Perception questionnaires

ARCPOH
Australian Research Centre for POPULATION ORAL HEALTH

THE UNIVERSITY OF ADELAIDE AUSTRALIA

DENTAL SCHOOL
FACULTY OF HEALTH SCIENCES

A JOHN SPENCER
PROFESSOR OF SOCIAL AND PREVENTIVE DENTISTRY
THE UNIVERSITY OF ADELAIDE SA 5005
AUSTRALIA
TELEPHONE 61 8 8303 5438
FACSIMILE 61 8 8303 4858
john.spencer@adelaide.edu.au

25 September 2003

Dear Parents of Mike Moradi

DENTAL APPEARANCE OF SOUTH AUSTRALIAN CHILDREN

Dental health preventive measures need continual evaluation in order to improve their outcomes. One of the efforts to pursue that aim–the study “Dental Appearance of South Australian Children” –is underway and we wish to offer you the chance to be a part of it.

Mike has been randomly chosen, along with other children from your school community, to take part in this study. Your participation can make a real contribution to the research that aims to improve oral health of Australian children. The findings of this research, combined with the information you have already provided in the Child Oral Health Study, will be important in ensuring the maximal benefits of measures that protect children from oral problems.

Participation in this study includes allowing Mike’s teeth to be examined for changes in the appearance of tooth enamel and teeth irregularities at your local school dental clinic and completing questionnaires concerning yours and Mike’s opinions about the appearance of Mike’s teeth.

The examination is similar to a normal dental check-up with more detailed examination of tooth colour and teeth irregularities. It will be conducted by a team of qualified dentists from The University of Adelaide in standardized conditions. In some cases, photographs of the front teeth only will be taken. No X-ray or medication will be used.

If you are willing to participate, please complete the enclosed consent form with your contact details, the questionnaires, and return **both forms** in the enclosed reply-paid envelop to:

Australian Research Centre for Population Oral Health
Dental School, The University of Adelaide. SA 5005

If you and/or Mike find it difficult to complete the questionnaires you may attend the examination only. If so, please complete and return the consent form to us.

After receiving a positive response from you, we will contact you to organise a dental examination at your convenience.

When the study completes, you will be sent a brief summary of the research findings.

If you have any queries, please contact Professor A John Spencer or Dr Loc Do on Toll-Free 1800 3333 70 or (08) 8303 3964 for Adelaide residents.

Your assistance is greatly appreciated and your contribution is valued.

A John Spencer
Professor of Social and Preventive Dentistry

DENTAL APPEARANCE OF SOUTH AUSTRALIAN CHILDREN

Dear Parent/Guardian

Thank you for agreeing to participate in this study. Please fill in this form and send it back to us. All information from you and your child will be strictly confidential.

CONSENT FORM

CHILD'S FIRST NAME: ………………… **CHILD'S SURNAME:** …………………

ADDRESS: ………………… **TOWN/SUBURB** …………………

STATE ………… **POSTCODE** ………… **TELEPHONE** (---- ----) (---- ---- ---- ---- ---- ---- ---- ----)
Area code Number

SCHOOL ………………… **YEAR LEVEL** …………………

I, ………………………………… have read the description of the project titled
(*Print parent's or guardian's name in full)*
"Dental Appearance of South Australian Children" in accompanying Information Sheet. I consent for my child to participate in that study. In giving my consent I understand that:

1. I and my child are free to withdraw from the study any time and that this will not affect medical advice in management of his/her health, now or in the future
2. The study is for the purpose of research which, although designed to improve dental health of children in Australia, may not directly benefit my child;
3. The confidentiality of information, which I provide for the study, will be safeguarded, and
4. I am aware that I can retain a copy of this Consent Form, if desired, and the attached Information Sheet.

Signature of Parent/Guardian ………………………………… **Date** ……/……/……

DENTAL APPEARANCE OF SOUTH AUSTRALIAN CHILDREN
QUESTIONNAIRE FOR CHILD 8–10 YEAR-OLD

Hello and welcome to the Dental Appearance Study,

Thank you for helping us with our study.

This questionnaire is about the effects of conditions of your teeth and mouth on your wellbeing and everyday life, and their effects on your family. By answering this questionnaire, you will help us to learn more about young people's experiences.

PLEASE REMEMBER:

1. **Please answer each question as accurately as you can.**
2. Do not write your name on the questionnaire.
3. This is not a test and there are no right or wrong answers.
4. Answer as **honestly** as you can. Please **do not talk to anyone** when you are answering**,** as we are interested only in your thoughts and feelings in this questionnaire.
5. Read each question carefully and think about your experiences in the **past four weeks** when you answer.
6. Before you answer, ask yourself: "**Does this happen to me because of problems I have had with my teeth or mouth in the past four weeks?"**
7. Please give the response that **best describes your experience** by circling the appropriate answer on the right. One answer for each question.

There is an example of how to answer the questionnaire

EXAMPLE:

Question: During the last four weeks, because of your teeth or mouth, how often have you?

Had trouble sleeping?	Never	Once or twice	Sometimes	Often

If you have had trouble sleeping because of problems with your teeth or mouth, choose the appropriate response. If it has happen for other reasons, please choose **Never**.

For example: If you have **often** had trouble sleeping in the last four weeks because of your teeth or mouth, your correct answer is **Often.** Just circle **Often** as shown above.

Lets begin

FIRST, A FEW QUESTIONS ABOUT YOUR THINKING

These questions ask about your own thinking of the health of your teeth and mouth and their effect on your life

Please circle one word that best describes what you think

1. When you think about your teeth and mouth would you say that they are…	Very good	Good	OK	Poor	
2. How much do your teeth or mouth bother you in your everyday life?	Not at all	Very little	Some	Quite a lot	Very much

These questions ask about your own thinking of the appearance of your teeth

Please circle one word that best describes what you think

3. Would you say the colour of your teeth is …	Very attractive	Quite attractive	Just ordinary	Quite unattractive	Very unattractive
4. If it were possible, would you like to change the colour of your teeth?	Definitely yes	Probably yes	Neither	Probably no	Definitely not
5. Would you say the shape of your teeth is …	Very attractive	Quite attractive	Just ordinary	Quite unattractive	Very unattractive
6. If it were possible, would you like to change the shape of your teeth?	Definitely yes	Probably yes	Neither	Probably no	Definitely not
7. Would you say your front teeth are …	Very crooked	Quite a bit crooked	A little bit crooked	Not crooked at all	
8. If it were possible, would you like treatment to straighten your teeth?	Definitely yes	Probably yes	Neither	Probably no	Definitely not
9. Would you say your front teeth are …	Very badly stained	Quite badly stained	Just slightly stained	Not at all stained	
10. Can you make your teeth look as clean as you would like?	Yes	Almost	No	Definitely not	Did not try
11. Are you satisfied with the appearance of your front teeth?	Very satisfied	Satisfied	Neither	Dissatisfied	Very dissatisfied

QUESTIONS ABOUT CONDITION OF YOUR TEETH AND MOUTH

In the past four weeks, how often have you had:

Please circle one word that best describes what you think

12. Pain in teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often
13. Sore spots in your mouth?	Never	Once or twice	Sometimes	Often	Very Often
14. Bad breath?	Never	Once or twice	Sometimes	Often	Very Often
15. Food stuck in your teeth?	Never	Once or twice	Sometimes	Often	Very Often
16. Pain in your teeth when you drink cold drinks or eat hot foods?	Never	Once or twice	Sometimes	Often	Very Often

In the <u>past four weeks,</u> because of your <u>teeth or mouth</u> how often have you …

Please circle one word that best describes what you think

17. Needed longer time than others to eat your meal?	Never	Once or twice	Sometimes	Often	Very Often
18. Had a problem sleeping at night?	Never	Once or twice	Sometimes	Often	Very Often
19. Had a hard time to bite or chew food like apples, carrots, nuts, or steak?	Never	Once or twice	Sometimes	Often	Very Often
20. Had trouble saying some words?	Never	Once or twice	Sometimes	Often	Very Often
21. Had trouble eating foods you would like to eat?	Never	Once or twice	Sometimes	Often	Very Often

QUESTIONS ABOUT YOUR FEELINGS

Have you had these feelings because of your <u>teeth or mouth</u>? If you felt this way for <u>another reason</u>, answer 'Never'.

In the <u>past four weeks</u>, because of your <u>teeth or mouth</u>, how often have you…

Please circle one word that best describes what you think

22. Been concerned about the appearance of your teeth	Never	Once or twice	Sometimes	Often	Very Often
23. Felt frustrated because of your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often
24. Been shy or embarrassed because of your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often
25. Been concerned what other people think about your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often
26. Worried that you are not as good-looking as others?	Never	Once or twice	Sometimes	Often	Very Often
27. Been upset because of your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often

QUESTIONS ABOUT YOUR SCHOOL

Have you ever had these experiences because of your teeth or mouth? If it was for another reason, answer 'Never'.

In the past four weeks, how often have you…

Please circle one word that best describes what you think

28. Missed school because of pain, appointments, or surgery?	Never	Once or twice	Sometimes	Often	Very Often
29. Had a hard time paying attention in school?	Never	Once or twice	Sometimes	Often	Very Often
30. Had a hard time doing your homework?	Never	Once or twice	Sometimes	Often	Very Often
31. Not wanted to speak or read out loud in class?	Never	Once or twice	Sometimes	Often	Very Often

QUESTIONS ABOUT YOUR SPARE-TIME ACTIVITIES AND BEING WITH OTHER PEOPLE

Have you ever had these experiences because of your teeth or mouth? If it was for another reason, answer 'Never'.

In the past four weeks, how often have you…

Please circle one word that best describes what you think

32. Avoided taking part in activities like sports, clubs, drama, music, or school trips?	Never	Once or twice	Sometimes	Often	Very Often
33. Not wanted to talk to other children because of your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often
34. Avoided smiling or laughing when around other children?	Never	Once or twice	Sometimes	Often	Very Often
35. Not wanted to be with other children because of your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often

In the past four weeks, because of your teeth or mouth, how often have…

Please circle one word that best describes what you think

36. Other children teased you or called you names because of your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often
37. Other children asked you questions about your teeth or mouth?	Never	Once or twice	Sometimes	Often	Very Often

THAT'S THE END

Thank you for your help
Please check the questionnaires again to ensure its completeness and return it in the enclosed reply-paid envelope to

ARCPOH, Dental School
The University of Adelaide SA 5005

DENTAL APPEARANCE OF SOUTH AUSTRALIAN CHILDREN
QUESTIONNAIRE FOR CHILD 11–13 YEAR-OLD

Thank you for helping us with our study.

This questionnaire is about the effects of conditions of your teeth, lips, mouth and jaws on your wellbeing and everyday life, and their effects on your family.

PLEASE REMEMBER:

1. **Please answer each question as accurately as you can.**
2. This is not a test and there are no right or wrong answers.
3. Before you answer, ask yourself: "**Does this happen to me because of problems with my teeth, lips, mouth or jaws in the last three months?"**
4. Please give the response that **best describes** your experience by **circling the appropriate answer** on the right. One answer for each question.

There is an example of how to answer the questionnaire

EXAMPLE:

Question: During the past three months, because of your teeth, lips, mouth or jaws how often have you?

Had trouble sleeping?	Never	Once or twice	Sometimes	(circled)	Very Often

If you have **often** had trouble sleeping in the last three months because of your teeth, lips, mouth or jaws your correct answer is **Often.** Just circle **Often** as shown above.

Lets begin

FIRST, A FEW QUESTIONS ABOUT YOU

Please circle one word that best describes what you think

1. Would you say the overall health of your teeth, lips, mouth and jaws is…	Excellent	Very good	Good	Fair	Poor
2. How much does the condition of your teeth, lips, mouth or jaws affect your life overall?	Not at all	Very little	Some	Quite a lot	Very much

These questions ask about your own opinion about the appearance of your teeth

Please circle one word that best describes what you think

3. Would you say the colour of your teeth are …	Very attractive	Quite attractive	Just ordinary	Quite unattractive	Very unattractive
4. If it were possible, would you like to change the colour of your teeth?	Definitely yes	Probably yes	Neither yes or no	Probably no	Definitely not
5. Would you say the shape of your teeth are …	Very attractive	Quite attractive	Just ordinary	Quite unattractive	Very unattractive
6. If it were possible, would you like to change the shape of your teeth?	Definitely yes	Probably yes	Neither yes or no	Probably no	Definitely not
7. Would you say your front teeth are …	Very crooked	Quite a bit crooked	A little bit crooked	Not crooked at all	
8. If it were possible, would you like treatment to straighten your teeth?	Definitely yes	Probably yes	Neither yes or no	Probably no	Definitely not

9. Would you say your <u>front teeth</u> are …	Very badly stained	Quite badly stained	Just slightly stained	Not at all stained	
10. Can you make your teeth look as clean as you would like?	Yes	Almost	No	Definitely not	Did not try
11. Are you satisfied with the <u>appearance</u> of your front teeth?	Very satisfied	Satisfied	Neither	Dissatisfied	Very dissatisfied

QUESTIONS ABOUT ORAL PROBLEMS

In the <u>past three months</u>, because of your <u>teeth, lips, mouth or jaws</u>, how often have you had

Please circle one word that best describes what you think

12. Pain in teeth, lips mouth or jaws?	Never	Once or twice	Sometimes	Often	Very Often
13. Bleeding gums?	Never	Once or twice	Sometimes	Often	Very Often
14. Sores in your mouth?	Never	Once or twice	Sometimes	Often	Very Often
15. Bad breath?	Never	Once or twice	Sometimes	Often	Very Often
16. Food caught in or between your teeth?	Never	Once or twice	Sometimes	Often	Very Often
17. Food caught in the top of your mouth?	Never	Once or twice	Sometimes	Often	Very Often

In the <u>past three months</u> how often have your <u>teeth, lips, mouth or jaws</u> caused you to have…

Please circle one word that best describes what you think

18. Breathed through your mouth?	Never	Once or twice	Sometimes	Often	Very Often
19. Taken longer than others to eat a meal?	Never	Once or twice	Sometimes	Often	Very Often
20. Had trouble sleeping?	Never	Once or twice	Sometimes	Often	Very Often

In the <u>past three months</u>, because of your <u>teeth, lips, mouth or jaws</u>, how often has it been…

Please circle one word that best describes what you think

21. Difficult to bite or chew food like apples, carrots, nuts, or steak?	Never	Once or twice	Sometimes	Often	Very Often
22. Difficult to open your mouth wide?	Never	Once or twice	Sometimes	Often	Very Often
23. Difficult to say any words?	Never	Once or twice	Sometimes	Often	Very Often
24. Difficult to eat foods you would like to eat?	Never	Once or twice	Sometimes	Often	Very Often
25. Difficult to drink with a straw?	Never	Once or twice	Sometimes	Often	Very Often
26. Difficult to eat hot or cold foods?	Never	Once or twice	Sometimes	Often	Very Often

QUESTIONS ABOUT FEELINGS

In the past three months, because of your teeth, lips, mouth or jaws, how often have you…

Please circle one word that best describes what you think

27. Been concerned about the appearance of your teeth, lips, mouth or jaws	Never	Once or twice	Sometimes	Often	Very Often
28. Felt irritable or frustrated?	Never	Once or twice	Sometimes	Often	Very Often
29. Felt unsure of yourself?	Never	Once or twice	Sometimes	Often	Very Often
30. Felt shy or embarrassed?	Never	Once or twice	Sometimes	Often	Very Often

In the past three months, because of your teeth, lips, mouth or jaws, how often have you…

Please circle one word that best describes what you think

31. Been concerned what other people think about your teeth, lips, mouth or jaws?	Never	Once or twice	Sometimes	Often	Very Often
32. Worried that you are not as good-looking as others?	Never	Once or twice	Sometimes	Often	Very Often
33. Been upset?	Never	Once or twice	Sometimes	Often	Very Often
34. Felt nervous or afraid?	Never	Once or twice	Sometimes	Often	Very Often
35. Worried that you are not as healthy as others?	Never	Once or twice	Sometimes	Often	Very Often
36. Worried that you are different than other people?	Never	Once or twice	Sometimes	Often	Very Often

QUESTIONS ABOUT SCHOOL

In the past three months, because of your teeth, lips, mouth or jaws, how often have you…

Please circle one word that best describes what you think

37. Missed school because of pain, appointments, or surgery?	Never	Once or twice	Sometimes	Often	Very Often
38. Had a hard time paying attention in school?	Never	Once or twice	Sometimes	Often	Very Often
39. Had difficulty doing your homework?	Never	Once or twice	Sometimes	Often	Very Often
40. Not wanted to speak or read out loud in class?	Never	Once or twice	Sometimes	Often	Very Often

QUESTIONS ABOUT YOUR SPARE-TIME ACTIVITIES AND BEING WITH OTHER PEOPLE

In the past three months, because of your teeth, lips, mouth or jaws, how often have you…

Please circle one word that best describes what you think

41. Avoided taking part in activities like sports, clubs, drama, music, school trips?	Never	Once or twice	Sometimes	Often	Very Often
42. Not wanted to talk to other children?	Never	Once or twice	Sometimes	Often	Very Often
43. Avoided smiling or laughing when around other children?	Never	Once or twice	Sometimes	Often	Very Often
44. Had difficulty playing a musical instrument such as a recorder, flute, clarinet, trumpet?	Never	Once or twice	Sometimes	Often	Very Often
45. Not wanted to spend time with other children?	Never	Once or twice	Sometimes	Often	Very Often
46. Argued with other children or your family?	Never	Once or twice	Sometimes	Often	Very Often

In the past three months, because of your teeth, lips, mouth or jaws, how often have…

Please circle one word that best describes what you think

47. Other children teased you or called you names?	Never	Once or twice	Sometimes	Often	Very Often
48. Other children made you feel left out?	Never	Once or twice	Sometimes	Often	Very Often
49. Other children asked you questions about your teeth, lips, mouth or jaws?	Never	Once or twice	Sometimes	Often	Very Often

That's the end

Thank you for your help
Please check the questionnaires again to ensure its completeness and return it in the enclosed reply-paid envelope to

ARCPOH, Dental School
The University of Adelaide SA 5005

DENTAL APPEARANCE OF SOUTH AUSTRALIAN CHILDREN
QUESTIONNAIRE FOR PARENT/GUARDIAN

Thank you for helping us with our study.

This questionnaire is about the effects of oral conditions on children's wellbeing and everyday life, and possible effects on their families. We are interested in any condition that involves your child's teeth, lips, mouth and jaws. **Please answer each question as accurately as you can.**

1. Your child means the child who participates in the Dental Appearance of South Australian Children Study.
2. To answer each question, please **circle a response that best describes your opinion about your child's experience**. If the question does not apply to your child, please answer with "Never".
3. Please **do not discuss your responses with your child,** as we are interested only in the parent's perspective in this questionnaire.

When the **Child** and the **Parent** questionnaires are completed, please return both forms in the enclosed reply-paid envelope addressed to:

Australian Research Centre for Population Oral Health
Dental School. The University of Adelaide
SA 5005

If you have any questions, please contact Professor John Spencer or Dr Loc Do on Toll-Free 1800 3333 70, or (08) 8303 3964 for Adelaide residents.

There is an example of how to answer questions.

EXAMPLE: During the last 3 months, because of his/her teeth, lips, mouth or jaws, how often has your child been …

Upset?	Never	Hardly Ever	Sometimes		Very Often	Don't Know

If your child has **often** been upset because of problems with his/her teeth, lips, mouth or jaws, choose **Often** as the appropriate response as shown above. If the child was upset for other reasons, please choose **Never**.

Lets begin

Please circle one response that best describes your opinion

1. How would you rate the overall health of your child's teeth, lips, mouth and jaws?	Excellent	Very good	Good	Fair	Poor
2. How much is your child's overall wellbeing affected by the condition of his/her teeth, lips, mouth or jaws?	Not at all	Very little	Some	Quite a lot	Very much
3. Would you say the colour of your child's teeth is…	Very attractive	Quite attractive	Just ordinary	Quite unattractive	Very unattractive
4. If it were possible, would you like treatment to change the colour of our child's teeth?	Definitely yes	Probably yes	Neutral	Probably no	Definitely not
5. Would you say the shape of your child's teeth is…	Very attractive	Quite attractive	Just ordinary	Quite unattractive	Very unattractive
6. If it were possible, would you like treatment to change the shape of your child's teeth?	Definitely yes	Probably yes	Neutral	Probably no	Definitely not
7. Would you say your child's front teeth are	Very crooked	Quite a bit crooked	A little bit crooked	Not crooked at all	
8. If it were possible, would you like treatment to straighten your child's teeth?	Definitely yes	Probably yes	Neutral	Probably no	Definitely not

9. Would you say your child's front teeth are …	Very badly stained	Quite badly stained	Just slightly stained	Not at all stained	
10. Can your child make his/her teeth look as clean as he/she would like when he/she tries hard to brush them?	Yes	Almost	No	Definitely not	Did not try
11. Are you satisfied with the appearance of your child's front teeth?	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied

The following questions ask about symptoms and discomfort that children may experience due to the condition of their teeth, lips, mouth or jaws.

During the last 3 months, how often has your child had …

Please circle one response that best describes your opinion. If it was for another reason, please answer with "Never".

12. Pain in teeth, lips, mouth or jaws?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
13. Bleeding gums?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
14. Sores in the mouth?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
15. Bad breath?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
16. Food caught in or between the teeth?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
17. Food caught in the roof of the mouth?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
18. Difficulty biting or chewing foods such as fresh apple, or firm meat?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

During the last 3 months, because of his/her teeth, lips, mouth or jaws, how often has your child …

Please circle one response that best describes your opinion. If it was for another reason, please answer with "Never".

19. Breathed through the mouth?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
20. Had trouble sleeping?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
21. Had difficulty saying words?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
22. Taken longer than others to eat a meal?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
23. Had difficulty eating hot or cold foods?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
24. Had difficulty eating foods he/she would like to eat?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
25. Had diet restricted to certain types of food (e.g. soft food)?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

The following questions ask about the effects that the condition of children's teeth, lips, mouth or jaws may have on their feelings and everyday activities.

During the last 3 months, because of his/her teeth, lips, mouth or jaws, how often has your child been?

Please circle one response that best describes your opinion. If it was for another reason, please answer with "Never".

26. Upset?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
27. Irritable or frustrated?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
28. Anxious or fearful?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
29. Missed school (e.g. pain, appointments, treatment)?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
30. Had difficulty paying attention in school?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
31. Not wanted to speak or read out loud in class?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
32. Not wanted to talk to other children?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
33. Avoided smiling or laughing when around other children?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

During the last 3 months, because of his/her teeth, lips, mouth or jaws, how often has your child …

Please circle one response that best describes your opinion. If it was for another reason, please answer with "Never".

34. Worried that he/she is not as healthy as other people?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
35. Worried that he/she is different than other people?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
36. Worried that he/she is not as good-looking as other people?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
37. Acted shy or embarrassed?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
38. Been teased or called names by other children?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
39. Been left out by other children?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
40. Not wanted or been unable to spend time with other children?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
41. Not wanted or been unable to participate in activities such as sport, clubs, drama, music, school trips?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
42. Worried that he/she has fewer friends?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
43. Been concerned about what others think about his/her teeth, lips, mouth or jaws?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
44. Been asked questions by other children about his/her teeth, lips, mouth or jaws?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

The next questions ask about effects a <u>child's oral condition</u> may have had on <u>PARENTS or OTHER FAMILY MEMBERS.</u>

During the <u>last 3 months,</u> because of your child's <u>teeth, lips, mouth or jaws</u>, how often have you or another family member …

Please circle one response that best describes your opinion. If it was for another reason, please answer with "Never".

45. Been upset?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
46. Had sleep disrupted?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
47. Felt guilty?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
48. Taken time off work *(e.g. pain, appointments, surgery)?*	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
49. Had less time for yourself or the family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
50. Worried that your child will have fewer life opportunities *(e.g. dating, getting married, having children, getting a job they like?)*	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
51. Felt uncomfortable in public places *(e.g. stores, restaurants with your child?)*	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

During the <u>last 3 months,</u> because of his/her <u>teeth, lips, mouth or jaws</u>, how often has your child …

52. Been jealous of you or others in the family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
53. Blamed you or another person in the family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
54. Argued with you or others in the family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
55. Required more attention from you or others in the family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

During the <u>last 3 months,</u> how often has the condition of your child's <u>teeth, lips, mouth or jaws</u> …

56. Interfered with family activities at home or elsewhere?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
57. Caused disagreement or conflict in your family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know
58. Caused financial difficulties for your family?	Never	Hardly Ever	Sometimes	Often	Very Often	Don't Know

And the last question

59. Questionnaire completed by …	☐ MOTHER	☐ FATHER	☐ OTHER *(please specify)* --

THANK YOU FOR YOUR PARTICIPATION. YOUR HELP IS GREATLY APPRECIATED.

The remaining questions are to be completed by your child whose name is in our letter. So that the surveys accurately reflect both the parent's view and the child's own experience, we ask that parents and children do not share their answers.

Appendix 4:

Clinical examination manual

THE DENTAL APPEARANCE STUDY

Protocol for dental team members

This protocol outlines the clinical diagnostic criteria and coding protocol to be used in the dental examination for the Fluorosis study.

SUBJECTS' SELECTION PROCEDURES

1. Age group: three age groups are selected.
    a. 8 to 9 years old (subjects born in 1993-1994)
    b. 10 to 11 years old (subjects born in 1991-1992)
    c. 12 to 13 years old (subjects born in 1989-1990)

    Subjects' age is defined as shown in the questionnaire of the Child Oral Health Study.
2. 8 to 13 years old respondents in the Child Oral Health Study from Adelaide, Bordertown, Kingscote and Mount Gambier will be selected and approached. Targeted examinations are 686. Total required to approach is 1310 subjects allowing for 60% response.
    a. Adelaide subjects will be recruited from total 6-month turnover. Up to four examination rounds will be organised. Expected examinations: 309.
    b. Bordertown and Kingscote subjects will be recruited from total 6-month turnover. One round of examination will be organised in each location. Expected examinations: 70.
    c. Mount Gambier subjects will be recruited from total 6-month turnover. Up to three examination rounds will be organised. Expected examinations: 307.
3. Subjects will be approached with a package containing:
    a. Information sheet
    b. Consent form
    c. Time sheet
    d. Reply-paid envelop
    e. Dental Perception questionnaires (parental and child's).

The list of CFS 8–13 years old subjects from Adelaide, Bordertown, Kingscote and Mt Gambier will be obtained from Carmen and Caitlin. The list has name, ID number, date of birth and contact details. This list is used to mail the primary approach package.

The primary approach package requests subjects to give agreement to participate and indicate tentative time availability. Appointment will be arranged for clinical examination based on subjects' time availability and clinics' availability. Usually examination will be done at subjects' school dental clinic. Examinations will be done during office hours. Some after hour work may be required. Date and time are subject to chair's availability at the clinic. Often, it will be during the clinic's opening day.

Subjects with given consent will be contacted by phone to arrange a time and place of examination. Details of subjects' appointment will be filled in the examination schedule for a clinic indicating date and time of appointment.

Subjects will be sent an appointment card indicating time and place of examination.

- **Exclusion criteria**

Subjects will be excluded if:

1. Refuse to participate
2. No permanent teeth present at the time of examination
3. Present permanent teeth are fully restored by crown or veneer
4. Present permanent teeth used to have fixed orthodontic band, which has already been removed.

Note: Teeth presented with orthodontic band are assessed for available surface zones for the FRI but are excluded for the TF.

EXAMINATION SCHEDULES, EQUIPMENT AND STERILIZING PROCEDURES

Examination schedule:

Examiner: Loc Do

The dental examination schedule will be made available for each examination session in duplicate. The schedules are to be taken to examination place and completed for each session. The dental examination schedule contains subjects' details (ID, name, age, sex, contact details). Any changes in contact details must be noted. Subjects will be listed in order of appointment. The outcome of dental examination must be noted in the outcome column (1=refusal; 2=to be rescheduled; 3=attended; 4=failed to attend; 5=complete) for each subject with an appointment.

Subjects who belong to categories 2 and 4 will be approached again to reschedule examination and will be recorded in the new examination schedule for that clinic.

Subjects consenting:

Written consents are to be received prior to examination arrangement.

Equipment and sterilizing procedures

Equipment used in the examination consists of a dental mirror, periodontal probe, and triplex syringe tip. Gauzes or cotton rolls can be asked from the clinic staff when necessary.

Examination procedures

Subjects will be examined for FRI first. Teeth are to be wiped with gauze before examination but no blow dry necessary. Then the examiner completes the examination for orthodontic section. TF index will be assessed last after blow-drying teeth with air from triplex syringe for 30 seconds. All scores are entered directly to laptop computer using MS Access screen.

DENTAL EXAMINATION

- Subject information

Enter the subject’s ID from the examination schedule to the data screen.

Name, address and date of birth of subject will automatically appear on the screen. Check it with the subject making sure examining the right subject.

Go to box for Clinic code, select clinic’s name from the list. Enter date of examination.

Mark if the examination is a repeat examination for reliability.

Then proceed to examination procedures

Tooth exclusion criteria

Criteria for both indices:

- ❖ Not present for any reason.
- ❖ Present but used to have orthodontic band, which has already been removed.
- ❖ Present but the labial surface is fully restored by any type of restoration such as veneer or crown.

Criteria specifically for the FRI:

- ❖ Not fully erupted tooth is assessed accordingly to the index criteria (rules for score 9)
- ❖ Currently banded tooth is assessed accordingly to the index criteria (rules for score 9)

Criteria specifically for the TF:

- ❖ Not fully erupted tooth is excluded
- ❖ Currently banded tooth is excluded
- ❖ Tooth with restoration on its labial surface is excluded
- ❖ Tooth, the labial surface of which has been fractured, is excluded.

Table 1: Procedures required in preparing teeth for each of the fluorosis indices.

Requirement	FRI index	TF index
Teeth examined	All present permanent teeth	All present permanent teeth
Tooth surface examined	• Occlusal/incisal edge (surface within 1mm from incisal edge) • Incisal one third • Middle one third • Cervical one third	Labial surface of all teeth
Cleaning	Quick wipe with gauze	Required
Drying	Not necessary	Necessary

Table 2: Differential diagnosis: milder form of dental fluorosis and enamel opacities of non-fluoride origine

Characteristics	Dental fluorosis	Enamel opacities
Area affected	The entire tooth surfaces (all surfaces) often enhanced on or near tips of cusp/incisal edge.	Usually centred in smooth surface of limited extent
Lesion shape	Resemble line shading in pencil sketch, which follow incremental lines in enamel (perikymata). Lines merging and cloudy appearance. At cusp/incisal edges formation of irregular white caps ("snow cap").	Round or oval
Demarcation	Diffuse distribution over the surface of varying intensity.	Clearly differentiated from adjacent normal enamel.
Colour	Opaque white lines or clouds; even chalky appearance. "Snow cap" at cusp/incisal edge. Some lesions may become brownish discoloured at mesio-incisal part of central upper incisors after eruption.	White opaque or creamy-yellow to dark reddish-orange at time of eruption.
Teeth affected	Always on homologous teeth. Early erupting teeth (incisors/1st molars) least affected. Premolars and second molars (and third molars) most severely affected.	Most common on labial surfaces of single or occasionally homologous teeth. Any teeth may be affected but mostly incisors.

- **Fluorosis Risk Index (Pendrys 1990)**

Protocol for FRI Examination

Prior to conducting the examination an arch, the teeth are quickly wiped with gauze to minimally dry them. Then, all permanent teeth are examined beginning with the most distal upper right molar (tooth 17), proceeding around the arch to the most distal upper left molar (tooth 27). The examination in the lower jaws begins with the most distal lower left molar (tooth 37) and proceeds to the most distal lower right molar (tooth 47). For all teeth, the four FRI surfaces zones are scored, in order: occlusal/incisal edge, incisal third, middle third, cervical third.

- *Laptop screen entry:*

  Examiner assesses the present status of each tooth and calls it out. If a tooth is not present for any reason or is excluded according to exclusion criteria, examiner calls it out and recorder records number 99 into box next to that tooth and press enter. The tap stop will automatically move to the next tooth. If tooth is present, recorder may record 0 or move straight to the first surface (Occlusal/Incisal edge) and so on. Five scores are defined for each surface zone to prevent incorrect entering.

- *Paper-based recording*:

  Five scores are pre-printed for each surface zone.

  If a tooth is excluded, the recorder puts a cross across all the fields for that tooth.

  The examiner examines a tooth surface zone and calls out a score and the clinical recorder puts a cross on an appropriate number for each zone.

Description and criteria

The Fluorosis Risk Index (FRI) scores four discrete zones of each tooth: 1) The incisal edge/occlusal table, defined as the enamel surface within one millimetre of the incisal edge of the tooth; 2) the incisal/occlusal one third of the buccal surface; 3) the middle third of the buccal surface; and the cervical third of the buccal surface.

Each surface zone is scored separately, as either negative for fluorosis, questionable for fluorosis, positive for mild-to-moderate, or positive for severe fluorosis. The specific criteria for scoring in these categories are presented in the table below.

Category	**Description**
Negative finding	
Score 0	A surface zone will receive a score of 0 when there is absolutely no indication of fluorosis being present. There must be a complete absence of any white spots or striations, and tooth surface coloration must appear normal.
Questionable finding	
Score 1	Any surface zone that is questionable as to whether there is fluorosis present (i.e. white spots, striations, or fluorotic defects cover 50% or less of the surface zone) should be score as 1
Score 7	Any surface zone that has an opacity that appears to be a non-fluoride opacity should be score as 7
Positive finding	
Score 2	A smooth surface zone will be diagnosed as being positive for enamel fluorosis if greater than 50% of the zone displays parchment-white striations

typical of enamel fluorosis. Incisal edges and occlusal tables will be scored as positive for enamel fluorosis if greater than 50% of that surface is marked by the snow-capping typical of enamel fluorosis.

Score 3 A surface zone will be diagnosed as positive for severe fluorosis if greater than 50% of the zone displays pitting, staining and deformity, indicative of severe fluorosis.

Surface zone excluded

Score 9 A surface zone is categorised as excluded (i.e. not adequately visible for a diagnosis to be made) when any of the following conditions exist:

1. Incomplete eruption

Rule 1: If a tooth is in proximal contact but the occlusal surface is not parallel with existing occlusion, the occlusal two-thirds of the tooth is scored, but the cervical one-third is recorded as excluded.

Rule 2: If a tooth is erupted, but not yet in contact, the incisal/occlusal edge is scored, but all other surfaces are recorded as excluded.

2. Orthodontic appliances and bands:

Rule 1: If there is an orthodontic band present on a tooth only the occlusal table or incisal edge should be scored.

Rule 2: If greater than 50% of the surface zones are banded, the surface should be recorded as excluded.

3. Surface crowned or restored:

Rule: Surface zones that are replaced by either a crown or restoration covering greater than 50% of the surface zone should be recorded as excluded.

4. Gross plaque and debris:

Rule: Any subject with gross deposits of plaque or debris on greater than 50% of the surface zones should be excluded from examination.

- **<u>Thylstrup and Fejerskov (TF) Index (Fejerskov et al. 1988)</u>**

Protocol for TF Fluorosis examination

Prior to examination, all teeth are dried with triplex syringe for 30 seconds. All permanent are scored for fluorosis. The examination begins with the tooth 17, proceeds along the arch to the tooth 27. On the lower arch, scoring starts at tooth 37 going along the arch to the left and finish at tooth 47. Only buccal/labial surface is scored based on the TF scoring system.

An unerupted or missing tooth and excluded tooth is scored as 99 or is crossed out appropriately. The examiner calls out a score for each present tooth and the recorder enters it into appropriate box in data screen or writes it down into appropriate box provided.

Description and criteria

Category	**Description**
TF score 0	The normal translucency of the glossy creamy white enamel remains after wiping and drying of the surface
TF score 1	Thin white opaque lines are seen running across the tooth surface. Such lines are found on all part of the surface. The lines correspond to the position of the perikymata. In some cases, a slight “snow-capping” of cusps/incisal edge may also be seen.
TF score 2	The opaque white lines are more pronounced and frequently merge to form small cloudy areas scattered over the whole surface. “Snow-capping” of the incisal edges and cusp tip is common.
TF score 3	Merging of the white lines occurs, and cloudy areas of opacity occur over many parts of the surface. In between the cloudy areas white lines can also be seen.
TF score 4	The entire surface exhibits a marked opacity, or appears chalky white. Parts of the surface exposed to attrition or wear may appear to be less affected.
TF score 5	The entire surface is opaque, and there are round pits (focal loss of the outermost enamel) that are less than 2 mm in diameter.
TF score 6	The small pits may frequently be seen merging in the opaque enamel to form bands that are less than 2 mm in vertical height. In this class are included also surfaces where the cuspal rim of facial enamel has been chipped off, and the vertical dimension of the resulting damage is less than 2 mm.
TF score 7	There is a loss of the outermost enamel in irregular areas, and less than half of the surface is so involved. The remaining intact enamel is opaque.
TF score 8	The loss of the outermost enamel involves more than half of the enamel. The remaining intact enamel is opaque.
TF score 9	The loss of major part of the outer enamel results in a change of the anatomical shape of the surface/tooth. A cervical rim of opaque enamel is often noted.

A book will accompany this manual.

- **Orthodontic examination (DAI)**

- **Missing visible teeth**: Count the number of currently not present permanent incisors, canines and premolars teeth on upper and lower arches starting at the right second upper premolar going clockwise and finish at the lower second right premolar.
  - If spaces are closed, do not count the teeth as missing. If primary teeth are in place and its successor has not yet erupted, do not count the tooth as missing. If missing teeth are replaced by a fixed prosthesis, do not count the teeth as missing.

  Age of subjects will be used during the analysis to define whether the missing teeth are unerupted or truly missing.
- **Crowding in the incisal segment of the arch**

  Examine both upper and lower incisal segments for crowding. Teeth may be rotated or displaced out of alignment in the arch.

  Record as 0, 1 or 2. 0 = no crowding; 1 = one segment crowded; 2 = two segments crowded.

  Do not mark the incisal segment as crowded if four incisors are in proper alignment but either or both canines are displaced.
- **Spacing in the incisal segment of the arch**

  Examine both upper and lower incisal segments for spacing. If one or more incisors have proximal surfaces without any interdental contact the segment is recorded as having space. The score can be 0, 1 or2. 0 = no spacing; 1 = one segment with spacing; 2 = two segments with spacing.
- **Diastema**

  A midline diastema is defined as the space measured by periodontal probe, in millimetres, between the two permanent maxillary incisors. This measurement ca be made at any level between the mesial surfaces of the central incisors and should be recorded to the nearest whole millimetre.
- **Largest anterior irregularity on the maxillary arch**

  Irregularities may be either rotation out of, or displacement from, normal alignment. Visually scan the four incisors to locate the greatest irregularities between adjacent teeth and measure it using periodontal probe. The tip of the probe is placed into contact with the labial surface of the most lingually displaced or rotated incisor while it is held parallel to the occlusal plane and at right angles to the normal arch line.
- **Largest anterior irregularity on the lower arch**

  Measurement is the same as on the upper arch except that it is made on the mandibular arch. The greatest irregularity between adjacent teeth is located and measured as described above.
- **Anterior maxillary overjet**

  Measurement of the horizontal relation of the incisors is made with the teeth in centric occlusion. Record only the largest maxillary overjet with a periodontal probe to the nearest whole millimetre from the labio-incisal edge of the most prominent upper incisor to the labial surface of the corresponding lower incisor holding the instrument parallel to the occlusal plane. This trait is not recorded if all upper incisors are missing or in lingual crossbite.

- **Anterior mandibular overjet**

  Record this trait when any lower incisor protrudes anteriorly, or labially, to the opposing upper incisor, i.e., in it crossbite, of any incisors in the lower arch to the nearest whole millimetre. Measure in the same manner as described for anterior maxillary overjet. Do not mark the tooth as a mandibular overjet if a lower incisor is rotated so that one part of the incisal edge is in crossbite but another part is not in crossbite.

- **Vertical anterior openbite**

  If there is a lack of vertical overlap between any of the opposing pairs of incisors (openbite) the amount of openbite is measured directly with a probe. Record the largest openbite to the nearest whole millimetre.

  Do not record openbite caused by not fully erupted teeth.

- **Antero-posterior relation**

  This assessment most often is based on the relation of the permanent upper and lower first molars. If the assessment cannot be based on the first molars because of one or both are absent, not fully erupted, or misshaped because of extensive decay or fillings, the relation of the permanent canines and premolares are assessed.

  The right and left sides are assessed with the teeth in occlusion and only the largest deviation from normal molar relation is recorded.

  Record 0, 1 or 2. 0 = normal; 1 = deviation of ½ cusp either mesially or distally; 2 = deviation of 1 cusp either mesially or distally.

Clinical examination form

Name: .... Clinic: .... Date: ...../...../.....

Code | | | | | | | | | | | Examiner code | | Repeat examination | |

FLUOROSIS RISK INDEX

Zones: **O**: Occlusal table, incisal edge; **I**: Incisal one third; **M**: Middle one third; **C**: Cervical one third.

Score: **0**: Normal; **1**: Questionable: **2**: Positive with no pitting; **3**: Positive with pitting; **7**: Non-fluorotic opacity; **9**: Excluded.

17	O	I	M	C	**16**	O	I	M	C	**15**	O	I	M	C	**14**	O	I	M	C	**13**	O	I	M	C	**12**	O	I	M	C	**11**	O	I	M	C
	0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
	1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1
	2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2
	3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3
	7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7
	9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9

27	O	I	M	C	**26**	O	I	M	C	**25**	O	I	M	C	**24**	O	I	M	C	**23**	O	I	M	C	**22**	O	I	M	C	**21**	O	I	M	C
	0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
	1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1
	2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2
	3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3
	7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7
	9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9

37	O	I	M	C	**36**	O	I	M	C	**35**	O	I	M	C	**34**	O	I	M	C	**33**	O	I	M	C	**32**	O	I	M	C	**31**	O	I	M	C
	0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
	1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1
	2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2
	3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3
	7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7
	9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9

47	O	I	M	C	**46**	O	I	M	C	**45**	O	I	M	C	**44**	O	I	M	C	**43**	O	I	M	C	**42**	O	I	M	C	**41**	O	I	M	C
	0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
	1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1		1	1	1	1
	2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2		2	2	2	2
	3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3		3	3	3	3
	7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7
	9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9

TF INDEX

Examine the buccal surfaces of all permanent teeth. A single score applied for each tooth.

17	16	15	14	13	12	11	21	22	23	24	25	26	27
47	46	45	44	43	42	41	31	32	33	34	35	36	37

ORTHODONTICS

Missing teeth --------------

Crowding 0 ☐ 1 ☐ 2 ☐

Spacing 0 ☐ 1 ☐ 2 ☐

Diastema --------- mm

MaxIrreg --------- mm

ManIrreg --------- mm

MaxOJ --------- mm

ManOJ --------- mm

Open bite --------- mm

Anteroposterior Relation 0 ☐ 1 ☐ 2 ☐