PREVALENCE AND PATTERNS OF CARIES, PLAQUE AND GINGIVITIS IN 4-5-YEAR-OLD JORDANIAN CHILDREN IN AMMAN AND THEIR RELATIONSHIP TO A NUMBER OF INDICATORS AND AETIOLOGICAL FACTORS

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ABSTRACT

Objectives: To investigate the association between oral health (in terms of dental caries and gingivitis), and socio-demographic factors, dental plaque, oral hygiene behaviours, infant feeding and dietary practices in 4-5-year-old Jordanian children.

Methods: Two-stage random sampling was used to select children enrolled in kindergartens in Amman, Jordan. Clinical examinations were carried out by, one calibrated examiner. Mothers completed questionnaire relating to socio-demographic factors, oral hygiene behaviours, infant feeding and dietary practices of the children.

Results: 67% of the children had caries, 31% had dmft greater than 4. 30% had caries in molars and incisors (and/or canines). 83% had 4 or more teeth with plaque and 66% had gingivitis.

Social class and oral hygiene behaviour were important risk indicators for the level of oral cleanliness and presence of gingivitis. Higher percentages of children with 4 or more sites with plaque and with gingivitis had a dmft greater than 4. Prolonged breast-feeding (>18 months), and breast-feeding on demand were significantly associated with caries. The majority of severely affected children attended kindergartens with the lowest tuition fees. Savoury snacks were consumed by 82% of the children, confectionery by 76% and teas with sugar by 42%.

Multivariate analysis showed that age, dental plaque, use of comforters had a significant effect on both caries prevalence and severity. Sleeping beside the mother, consumption of confectionery and eating food high in sugar content had a significant effect on caries prevalence. Breast-feeding on demand was significantly related to caries severity. Regarding gingivitis, plaque and kindergarten fees were the only two variables that were significantly related to gingivitis.

Conclusion: Young children in Jordan would benefit from health promotion strategies directed towards appropriate infant feeding, dietary practices and oral hygiene measures. Attention should be given particularly to children attending kindergartens with the lowest tuition fees.
DEDICATION

To the memory of my beloved son "Luai Fouad Sayegh" who left this world before getting his PhD from the Imperial College, London University
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1. INTRODUCTION

1.1. INTRODUCTION

The oral health status of children is most often measured in terms of caries and gingivitis, the two most prevalent oral diseases.

In contrast to the improvements seen in many parts of the world, epidemiological surveys suggest that caries experience of young children in Middle Eastern countries has remained high or even very high (Ghose et al., 1983; Al-Sekait and Al-Nasir, 1988; Al-Khateeb et al., 1990; Al Shammery et al., 1990; Al-Mughery et al., 1991; Magbool, 1992; Raadal et al., 1993; Murtomaan, 1995; Al-Dashti et al., 1995; Alamoudi et al., 1996; Vigild et al., 1996; Al-Esmaily et al., 1997; Ibrahim et al., 1997; Paul and Maktabi, 1997; Al-Hosani et al., 1998; Al-Malik et al., 2002).

In Jordan, despite free dental treatment in public and UNRWA schools, there is no evidence that oral disease morbidity rates are under control. Two studies performed in Amman (Hamdan and Rock, 1993; Janson and Fakhouri, 1993) showed children to have high levels of dental disease. The latter authors reported caries to be clinically visible in many children before they had reached the age of two years, and that some 25% of 2-3 year-olds had caries. Of the total sample of children aged 3 to 6 years, 72% had readily visible caries and 50% of this age group had four or more decayed teeth. It is very alarming to recognize that, at this early age, the risk group is constituted by a high percentage of children. In the other study, Hamden and Rock demonstrated that Jordanian schoolchildren have a very important unmet need, particularly with respect to the primary dentition. These authors indicate the filled component to comprise 10% of the total dmft in 6-year-olds.

Children who at an early age show manifest caries in their primary dentition are those who may later develop further caries. They therefore constitute a caries risk group (Johnsen et al, 1986 b, 1987; O'Sullivan and Tinanoff, 1993 a). Moreover, children with caries in their primary dentition are more likely to have caries in their permanent dentition (Alaluusua et al., 1987; ter Pelkwick et al., 1990; Kaste et al., 1992; Holt, 1995).

Caries prevalence gives no indication of severity and dmft(s)/DMFT(S) indices are most often expressed as population averages. These measures may be inappropriate
when population variance is high and caries is not normally distributed (Birch 1986; Douglass et al., 1994; Spencer, 1997; Lewsey et al., 2000). Different measures are required for planning purposes. For example, average caries experience indices are considered by the Danish Oral Health Care Service to provide only part of the information needed to plan and evaluate activities in the child dental health services (Schwarz and Hansen, 1979). The analysis of the caries situation is extended by means of its distribution pattern according to the caries severity zones defined by Poulsen and Horowitz (1974). The caries severity zone index stems from a belief that the more severe the caries is the more the less susceptible tooth surfaces become involved (Grainger, 1967). Other authors have identified differing patterns and suggest that these might be consequences of differences in aetiology (Johnsen et al., 1984; 1986 a; 1987; O’Sullivan and Tinanoff, 1993 a; Zammit et al., 1994; Dini et al., 1998).

Gingivitis in pre-school children has been reported to a lesser extent than caries and very few studies have reported gingival conditions in young children from the Middle East (Guile et al., 1990; Peretz et al., 1996; Al-Banyan et al., 2000).

Our understanding of the complex multifactorial nature of both caries and periodontal diseases is still incomplete. The essential roles of diet and plaque as direct causes of oral diseases have been well demonstrated, but it is ever more widely accepted that oral health status is also closely linked to socioeconomic factors - factors strongly associated with oral health knowledge, attitudes and behaviours (Dummer et al., 1987; Ng’ang’a and Vaalerhaug, 1991; O’Brien, 1994; Schou and Wight, 1994; Steel et al., 1998; Walker and Cooper, 2000). Attempts have been made to explain the variations in both caries and gingivitis through differences in oral hygiene habits and the use of fluoride by the different social classes (Konig and Navia, 1995; Burt and Eklund, 1999; Mattila et al., 2000).

Social factors may exert their influence particularly through diet. Information about sugar consumption in developing countries suggests that it is increasing and is greater in the Middle East than in other developing regions (Musaiger, 1996; Ismail et al., 1997). Studies of food habits (Musaiger, 1996), of the nutritive value of the diet (Musaiger et al., 2000) and of types of food consumption in relation to caries prevalence have been performed in Saudi Arabia (Wyne and Khan, 1995; Al-Shammery, 1999).
In the younger age groups, specific infant feeding habits have frequently been identified as important in early childhood caries (ECC) and rampant caries (severe ECC). Again, these habits have been related to social factors. It has been shown that the use of feeding bottles with added sugar is a major caries-predisposing factor in disadvantaged communities in both developing and industrialised countries (Davies, 1998). The effect of breast-feeding duration and frequency on the prevalence of ECC and severe ECC is controversial (Serwint et al., 1993; Ramos-Gomez et al., 1999; Valaitis et al., 2000). Although some authors suggest it is an important risk factor, studies investigating the effect of prolonged on-demand breast-feeding on ECC have been inconclusive, particularly when other factors such as social class and fluoride use are taken into account (Williams and Hargreaves, 1990; Weerheijm et al., 1998; Du et al., 2000).

The majority of studies on caries and gingivitis in young children in the Middle East have considered one or a relatively small number of risk factors. There is little information about the relationship between oral health and risk factors in pre-school children in Jordan.

Author’s background and stimuli prompting this study

Since 1988 the author has worked as a lecturer and clinical supervisor in the Faculty of Dentistry at the University of Jordan in Amman. A great number of patients of all ages attend daily for free treatment. The huge unmet need among poor Jordanians and the suffering of young children are among the factors that prompted this study. In this context, many questions arise concerning preventive dental care for pre-school children. For example, at what age should parents be recommended to start brushing their children’s teeth? When should they start to use toothpaste? What advice should be given to parents concerning feeding during infancy and childhood?

The author wanted to determine whether the extensive caries pattern seen at the University Hospital was also prevalent in the population at large, to find out whether other caries patterns existed, and if so, what factors and indicators played roles in the development of these patterns.
Jordan: geography and economy

The Hashemite Kingdom of Jordan, an Arab state in southwestern Asia, is a young nation that occupies an ancient land associated with the civilizations of antiquity. To the north it is bordered by Syria, to the east by Iraq and Saudi Arabia, to the south by Saudi Arabia again and the Gulf of Aqaba, and to the west by the West Bank and Israel. Jordan occupies about 89,556 km$^2$. Amman is the capital and largest city (The New Encyclopaedia Britannica, 1974). Jordan’s economy is that of an economically developing country (ESC, United Nations, 1997). It has an alarming dependency rate of 81% and an unemployment rate of 14.4% (Ministry of Health, 1999).

Demography and general health indicators

Jordan has an estimated population of 4.9 million people and has had an annual average birth rate of 3.6% since 1994. The average number of persons per family is 6. As in other countries in the region, children represent a large proportion of the population: 17% of the population is estimated to be less than 6 years old (Department of Statistic, 2000).

Life expectancy for females is 71 years and for males 69 years. The infant mortality rate per 1000 live births is 28 while the maternal mortality rate per 100,000 live births is 40.

Health Sectors

Healthcare in Jordan is covered by three sectors: the public, private, and the international and welfare sectors (Ministry of Health, 1999).

1- The public sector comprises the Ministry of Health, the Royal Medical Service, medical services in public universities, and services in ministries and governmental establishments such as the Greater Amman Municipality, the Department of Health and Safety under the Ministry of Labour, and the Department of Schools’ Health Services under the Ministry of Education.

2- The private sector comprises private hospitals and clinics and the supporting medical professions.

3- The international and welfare sector includes the UNRWA clinics for Palestinian refugees and clinics run by foreign or local charitable associations.
Oral healthcare for Jordanian children

Pre-school children are not entitled to free oral healthcare. However, school children enrolled in public schools and in UNRWA schools for Palestinian refugees are entitled to free dental treatment (Ministry of Health, 1999; Siksik, personal communication 2001). Children in private schools do not enjoy this privilege and receive dental care from private practitioners on a fee-paying basis.
2. REVIEW OF THE LITERATURE

2.1. DENTAL CARIES IN YOUNG CHILDREN

2.1.1. Introduction

Dental caries has been defined as "a pathological localized progressive loss by acid dissolution of the apatite (mineral) component of the enamel, then the dentine, or of the cementum, then the dentine" (Hume, 1993).

In caries, the early lesions of the enamel characteristically occur below its surface, with most mineral loss taking place beneath a relatively intact enamel layer (Rugg-Gunn, 1997). Distinct signs of dissolution of the individual crystal peripheries leading to an uniform enlargement of the inter-crystalline spaces (Thylstrup and Fejerskov, 1986). With an increase in subsurface porosity, the lesion becomes clinically visible as a white spot, which may be made more obvious by air-drying.

2.1.2. The carious process

This white spot indicates that the underlying enamel has become demineralised. Although at this stage the surface remains intact, progression of the disease results in the loss of surface integrity. If unchecked, caries may progress through the enamel to involve the dentine and pulp. At least in its early stages, caries is understood to be the outcome of a two-way process of demineralisation and remineralisation occurring at the tooth surface. Only when the process of demineralisation outweighs that of remineralisation, caries does progress (O’Mullane, 1994).

2.1.3. Caries in primary teeth

It has been suggested that in primary teeth the enamel is less highly mineralised and is more permeable to ions (Silverstone, 1990). It is certainly thinner (0.5-1mm - about half the thickness of permanent teeth) and the pulp chambers are relatively much larger (van Beek, 1983). Consequently, lesion progress may appear more rapid in primary than in permanent enamel. In absolute terms, the process needs to advance a shorter distance to reach the pulp in a primary molar than in an equivalent permanent tooth (Silverstone, 1990).
As in permanent teeth, caries most often affects pits and fissures, followed by the proximal and then smooth tooth surfaces. However, the pattern of attack may be influenced by the pattern of eruption, particularly when the dentition is incomplete, and by the nature of the factors promoting the disease. Further, the disease actually recorded may be affected by the diagnostic methods used. Primary teeth tend to have more marked areas of contact than do permanent teeth, and lesions in the deciduous dentition may therefore be more difficult to detect by clinical means. In primary teeth, 68% of proximal lesions can only be seen by radiography and are not detectable by clinical means (Murray and Majid, 1978). In their review of the available literature on deciduous dentition, Kidd and Pitts (1990) indicated that radiographs consistently revealed a higher percentage of lesions than clinical inspection (range 40-469%) irrespective of age or diagnostic threshold.

2.1.4. Caries throughout history

Dental caries has been with mankind throughout history but has varied in prevalence, becoming particularly common (practically affecting the whole population) over the last century with increased industrialisation.

There are, however, few studies that provide much insight into the changes in dental caries prevalence since the 1930s. Lady Mellonby et al. (1957) showed an improvement in prevalence between the mid 1930s and 1950. A deterioration then occurred during the 1950s (James and Parfitt, 1957) - a trend confirmed by studies undertaken by the Department of Health during the same period (Department of Education and Science, 1975). The latter studies also demonstrated a slight recovery among five year-old children during the early 1960s. This pattern is very similar to that recorded over the same period in Finland (Rytoma et al., 1980). Since the 1960s and 1970s there has been a marked reduction in both prevalence and severity of the disease in most “Westernised” countries (Bratthal et al., 1996).

A 1993 national survey of children’s dental health (OPCS, 1994) provided encouraging evidence of a further marked decline in caries throughout the United Kingdom compared to earlier surveys of 1973 and 1983 (Todd, 1975; Todd and Dodd, 1985). Over 20 years, total decay experience (dft, DMFT) in England and Wales fell by 52% in deciduous teeth in 5-year-olds, 82% in the permanent teeth of 8-year-olds, 75%
in 12-year-olds, and 74% in 14-year-olds. In 1973, only 7% of 12-year-olds had no experience of permanent tooth decay (DMFT=0). By 1993, 50% were caries-free (Downer, 1994 a).

Caries is a disease in which many factors play a direct or indirect role in both initiation and progress. The reasons for its decline in developed countries are not yet fully understood, but the widespread use of fluoridated toothpaste is thought to have played a major role. To a lesser extent, a reduction in sugar consumption may also be involved (Downer, 1996).

In developing countries, however, both the prevalence and severity of caries are believed to be on the increase (Barms, 1982). This might be linked to the adoption of more Westernised diets, wider access to cariogenic foods and drinks, and the increased availability of sugar-containing snacks (Rugg-Gunn, 1997).

Caries may affect people of any age but, with the exception of root surface caries, it is primarily a disease of children, in whom it may affect both primary and permanent teeth. Caries does not affect teeth in a random fashion but shows a predilection for certain sites, particularly those where plaque may accumulate and remain undisturbed for periods of time. The most common sites for caries are the pits and fissures of occlusal surfaces, followed by the proximal surfaces beneath the contact area. The labial/buccal and palatal/lingual tooth surfaces are the least susceptible to attack. Where these are affected, caries is most likely to occur at or near the gingival margin where plaque accumulation may more readily occur and where it can quickly reach moderate thickness (Hume, 1993).
2.2. AETIOLOGY OF CARIES

2.2.1. Introduction

In 1962, Keyes published a now well-known diagram illustrating the multifactorial nature of the caries process in which three circles representing host susceptibility microflora and substrate overlap. For caries to occur, these three factors must be present and interact over a period of time.

For the past several decades it was believed that of these primary factors the microflora was the major aetiological agent - and thus the major risk factor (Johnson, 1991). This was supported by evidence from well-known germ-free animal studies (Orland et al., 1954). Bratthai (1996) upholds this view and asserts that bacterial plaque is the only immediate factor causing caries, with diet and host susceptibility determining the level of bacterial activity. In this context, the term ‘bacteria’ is understood to include the type and amount of bacteria, bacterial adhesion, plaque formation rate, acid producing capacity, and all other factors that make dental plaque more or less cariogenic. Similarly, diet describes all factors making diet more or less suitable for bacterial growth and acid formation. This includes the fermentable carbohydrate content and frequency of food consumption, as well as the possible antibacterial components of food. Host susceptibility includes all disease resistance factors such as the mineralisation of teeth, fluoride, the secretion of saliva and its buffering capacity, salivary antibodies, and all other salivary or “host” components affecting demineralisation and remineralisation (Bratthai, 1996).

2.2.2. Host susceptibility

For a period of time following eruption, newly exposed enamel surfaces undergo the final stages of post-eruptive maturation and hardening when ions such as fluoride are incorporated (Fejerskov and Clarkson, 1966). Epidemiological studies suggest that this period, immediately following eruption and prior to final maturation, is when the tooth is most susceptible to caries (Carlos and Gittelsohn, 1965). Thus, in many infants, a combination of recently erupted immature enamel in an environment of cariogenic flora with frequent ingestion of fermentable carbohydrates would render teeth particularly susceptible to caries (Seow, 1998).
In addition to immaturity, developmental structural defects in the enamel may increase the risk of caries. Surface irregularities such as pits and grooves can increase plaque retention (Svanberg and Loesche, 1977) and foment colonisation by mutans streptococci (Li et al., 1994). Matee et al. (1992a), in their study on Tanzanian preschool children, reported that carious lesions occurred on the labial surfaces of incisors between the neonatal line and gingival margin. This finding confirms that hypoplasia may predispose children to caries.

The cariostatic effect of fluoride is well recognised. Data from the British Fluoridation Society (1995) show that the five districts with the lowest prevalence of caries among 5-year-olds all have fluoridated water supplies. In contrast, the five with the highest prevalence have little or no fluoride in their water. The effect of water fluoridation was further investigated in relation to rampant caries. Reported prevalence was between 13% in a fluoridated community compared to 18% in a non-fluoridated community in California (Louie et al., 1990). In another study (Williams and Hargreaves, 1990), bottle-feeding in fluoridated Edmonton was not associated with caries experience unless milk was sweetened.

Until recently, the major caries-inhibiting effect of fluoride was thought to be its incorporation into tooth mineral during the development of the tooth prior to eruption. There is now overwhelming evidence, however, that the primary preventive mechanisms are post-eruptive and due to topical effects in both children and adults (Featherstone, 1999).

It is well known that saliva has a major role in controlling plaque pH, and that the stimulation of saliva flow by foods is an important factor in determining their acidogenic potential (Edgar and O'Mullan, 1990). Saliva flow rate might be expected to influence the initial concentration of fermentable carbohydrate in the mouth and its clearance rate, as well as the removal of fermentation acids from plaque (Pearce, 1991). Buffering capacity is another important factor. In un-stimulated saliva, bicarbonate levels are low, but at higher flow rates this concentration rises, along with the buffering power (Sreebny et al., 1992). In a longitudinal study (Holbrook, 1993), the association of caries with salivary parameters was investigated in 5- and 6-year-old Icelandic children. The results showed a slight trend towards a higher caries score with lower salivary flow. Significantly fewer children with a stimulated salivary flow of < 1ml/min were caries-free
at 6 years of age. Similarly, those children with saliva below pH 7.5 had more caries and were less likely to be caries-free at the same age. With respect to buffering capacity, no significant differences were seen in caries scores between children with high or low buffering capacity, although there was a trend towards more caries and fewer caries-free individuals among those with the lowest buffering capacity.

Bacterial inhibition has a more direct effect on acid production. The antibacterial effect of the salivary enzyme lysozyme has been investigated in relation to caries pattern in an animal study (Mundorff-Shrestha et al., 1994), and it was found that lysozyme correlated negatively only with sulcal caries. It may be that the antibacterial effects of lysozyme are more effective in the stagnant areas of the sulci than on the smooth tooth surfaces where enzyme concentrations may not become sufficiently high to inhibit bacteria.

2.2.3. Micro-flora

The concept of the microbiology of dental caries changed after the observation that hamsters and rats failed to develop dental caries when fed a sugar-rich diet unless they were infected with certain streptococci (Fitzgerald and Keyes, 1960). A later study tested the cariogenicity of human plaque lactobacilli in gnotobiotic rats showed that a wide variety of lactobacilli may be cariogenic under favourable conditions (Fitzgerald et al., 1981).

In Man, certain genera and species of bacteria are generally accepted as being associated with different stages of the development of caries. Streptococcus mutans and lactobacilli are those most strongly associated with the development of caries while a role for actinomyces is less certain (Bowden, 1991).

2.2.3.1. Mutans streptococci

Streptococcus mutans, S. rattus, S. crecitus, S. sobrinus, S. ferus, S. macacae and S. downae form a group of oral streptococci (mutans streptococci) found in Man and animals (Whiley et al., 1988). DNA homology analysis shows they are distinct species. Several serovars of all these species exist. The two species most commonly associated
with Man are *S. mutans* and *S. sobrinus* (Bowden, 1991). The remaining species are found in animals, although they too are occasionally isolated from Man (Loesche, 1986).

There is considerable information on the pathogenicity, biochemistry, physiology and ecology of *S. mutans* (Loesche, 1986) but relatively little is known of the biology of *S. sobrinus* (Gibbons, 1986; Loesche, 1986). Differences have been recorded, however, in their physiological properties (Loesche, 1986; de Soet et al., 1989, 1991), in their ability to adhere to teeth (Gibbons et al., 1986), and in their cariogenic potential in animals (de Soet et al., 1991). They vary in the amount of acid they produce (Kral and Daneo-Moore, 1981; de Soet et al., 1989) and in glucan synthesis (Hamada et al., 1989).

Numerous studies on different populations show that *S. mutans* can be isolated more often than *S. sobrinus* from teeth (Loesche, 1986; Bratthall, 1991) and from individual tooth surfaces (Lindquist and Emilson, 1991). Higher numbers of mutans streptococci bacteria have been found in the saliva of individuals who harbour both *S. mutans* and *S. sobrinus* compared to those who only harbour *S. mutans* (Köhler and Bjarnason, 1987; Emilson and Thorselius, 1988). *Streptococcus mutans* is also more bacteriocinogenic than *S. sobrinus* (Lindquist and Emilson, 1991) and the growth of the latter species can be suppressed by bacteriocins production by *S. mutans* (Ikeda et al., 1988). Hirose et al. (1993) showed that children with both *S. mutans* and *S. sobrinus* in their saliva had significantly higher levels of past caries experience than those with either *S. mutans* or *S. sobrinus* alone.

Some studies (de Stoppelaar et al., 1970; Scheie et al., 1984) show that a positive correlation exists between the sugar content of the diet and the level of mutans streptococci in dental plaque. Both *S. mutans* and *S. sobrinus* react in the same way to sugar restriction, the decrease in their numbers being more pronounced on the buccal than on the proximal surfaces (Wennnerholm et al., 1995).

*Streptococcus mutans* and *S. sobrinus* preferentially colonise the most caries-prone sites apical to the contact area (Ahmady et al., 1993).

*Streptococcus mutans* is considered the major causative bacterium of dental caries in Man (Tenovuo et al., 1990) and its numbers in the buccal cavity can be a good indication of caries risk (Köhler et al., 1988). There are, however, some inconsistencies.
Some people heavily colonised by *S. mutans* and *S. sobrinus* seem to have low levels of caries experience (Carlsson et al., 1987).

### 2.2.3.1.1. Colonisation by *mutans* streptococci

At birth the oral cavity is sterile, but within 6-10 hours an aerobic flora develops. Streptococci are among the first to appear (Zinner and Jablon, 1969). The colonising organisms come from many sources in the environment: from the air, from personnel involved in immediate postnatal care, and from close contact with the mother (Harris, 1991). The main source of infection is either directly via maternal saliva (Köhler and Bratthall, 1978; Masuda et al., 1985) or by the use of domestic items such as spoons contaminated with saliva (Svanberg, 1978). The bacterial count of the mother’s saliva is strongly related to that of her infant. Mothers with the highest *S. mutans* counts have infants with similarly high *S. mutans* counts (Köhler and Bratthall, 1978).

*Streptococcus mutans* is rarely detected in the mouth of predentate babies since it has a preference for tooth surfaces (Carlsson et al., 1975; Masuda et al., 1979). However, the species establishes itself in ecological niches on the epithelial surfaces of the mouth and in saliva. Once the teeth erupt, many of these bacterial reservoirs participate in the formation of plaque (Harris, 1991). The initial establishment of *S. mutans* frequently occurs within the first 1-4 years of life (Alaluusua and Renkonen, 1983; Köhler et al., 1988). A gradual increase in the detection of mutans streptococci is then observed, isolation frequency reaching its highest when the deciduous dentition is complete and the proximal contacts between deciduous molars are present (Catalanotto et al., 1975). However, colonisation remains relatively low key in infants and toddlers, and only a small number of children harbour high levels of salivary mutans streptococci (Grindfjord et al., 1991, 1993; Hallonsten et al., 1995). The earlier the colonisation by *S. mutans*, the more prone are children to dental caries (Alaluusua and Renkonen, 1983; Köhler et al., 1988).
2.2.3.1.2. *Mutans streptococci and the prevalence and pattern of caries*

Studies of caries prevalence and incidence in young children have shown a significant relationship between counts of mutans streptococci on mitis salivarius bacitracin agar and caries scores (Köhler et al., 1981; 1988).

The factors responsible for regulating the distribution of *S. mutans* and *S. sobrinus* are poorly understood. It has been indicated that both are more numerous in plaque collected from proximal tooth surfaces (Lindquist and Emilson, 1991). The location of *S. mutans* and *S. sobrinus* below the contact area might be related to stagnation in this location (Ahmady et al., 1993). Children harbouring high levels of mutans streptococci show a significantly higher prevalence of not only maxillary anterior caries but also pit/fissure caries than do children with few (or no) salivary mutans streptococci (Thibodeau et al., 1993; O'Sullivan and Tinanoff, 1993). The prevalence of *S. sobrinus* is more closely associated with an increase in smooth caries than is *S. mutans* (Hirose et al., 1993). The frequency of mutans streptococci decreases towards the anterior teeth, with *S. sobrinus* predominating over *S. mutans* (Wennerholm and Emilson, 1995). The implantation of *S. sobrinus* is favoured by high sucrose consumption (Köhler and Bjarnason, 1987). This is consistent with the observation of an enhanced attachment of *S. sobrinus* to the tooth surface in the presence of sucrose where it accumulates through glucan (Gibbons et al., 1986). In a later study (Wennerholm and Emilson, 1995), the greater retention rate of sucrose in the anterior upper region did not appear to favour the growth of *S. sobrinus*.

It has been indicated that sucrose is not uniformly distributed around the mouth. Its clearance is less rapid from the maxillary sites than from the rest of the dentition (Macpherson and Dawes, 1994). Further, maxillary sites show lower pH values and a slower return to resting values than mandibular sites after sucrose rinsing (Fejerskov et al., 1992). This might help explain the site specificity of smooth surface caries (Macpherson and Dawes, 1994).

In animal studies it has been demonstrated that strains of *S. sobrinus* have high cariogenic potential (Ooshima et al., 1981; de Soet et al., 1991) and induce pit and fissure caries as well as smooth-surface caries in rats (Madison et al., 1991).
In another animal study (Mundorff-Shrestha et al., 1994), the *S. sobrinus* count correlated with the number of buccolingual caries, but did not correlate well with sulcal caries. It was concluded that in view of the specialized ability of *S. sobrinus* to colonise smooth surfaces, the first finding was not surprising. However, with respect to the second, it is likely that in the stagnant areas of the sulci only a continuous threshold level of *S. sobrinus* is necessary to initiate and cause caries progression. The initial colonisation of the smooth surfaces by *S. sobrinus* most likely enhances secondary colonisation by lactobacilli and other non-mutans organisms associated with the promotion of smooth surface and sulcal caries.

Microbiological studies of rampant caries (early childhood caries – ECC) have demonstrated heavy colonisation of the affected teeth by mutans streptococci and lactobacilli (Milnes and Bowden, 1985). In breast-fed children with nursing (rampant) caries, the mean counts of mutans streptococci and lactobacilli in plaque were 100-fold higher than in caries-free children (Matee et al., 1992a). Children with rampant caries were not only heavily infected with mutans streptococci but also often colonised by more than one clonal type. Frequent sugar consumption may have an important role in the acquisition of such clones (Alaluusua et al., 1996).

Breast-feeding allows the colonisation and proliferation of mutans streptococci and lactobacilli on the teeth of young children, and rampant caries can occur in breast-fed children in the presence of an aciduric plaque microflora (Matee et al., 1992a). However, a high prevalence of mutans streptococci and lactobacilli is also observed in caries-free children, which implies that microbial distribution only partially explains the occurrence of rampant caries in the population studied by Matee et al. (1992a).

2.2.3.2. *Lactobacillus* species

The idea that lactobacilli play a major role in the cariogenic process dominated dental literature for more than 35 years. Lactobacilli are aciduric in addition to being acidogenic, and can therefore multiply well in plaque of low pH and in carious lesions. *Lactobacillus casei* is possibly the most damaging of the lactobacilli, although *L. acidophilus* has received extensive attention (Rosen et al., 1968).

Lactobacilli are strongly associated with Man (Hardie et al., 1977). Before children reach the age of 2 years, however, they are recovered in low numbers and very
often they seem to be present only transiently (Carlsson et al., 1975). Heavy colonisation of the upper anterior teeth by *S. mutans* and Lactobacilli occurs in children with nursing (rampant) caries. The same pattern of colonisation is present in white spot lesions, caries lesions and on intact enamel surfaces (Milnes and Bowden, 1985).

2.2.3.3. *Actinomyces*

This is the third genus considered potentially odontopathic, a belief based mostly on the ability of *Actinomyces viscosus* and *A. naeslundii* to produce caries in animals (Jordan et al., 1972).

2.2.4. Diet

Diet can be defined as the types and amounts of food eaten daily by an individual. This is distinct from nutrition, which is the sum of processes by which an individual takes in and utilises foods (Midda and König, 1994). In the present context, nutrition refers to the systemic effects of nutrients on the development, regeneration and repair of tissues. Teeth are unusual in that nutritional influences are exerted solely during their formation. Diet refers to the local action of foods on oral tissues and encompasses the composition of the food and the pattern and frequency of eating (Speirs and Beely, 1992).

On present evidence, the post-eruptive local effect of the diet would seem to be very important, with sugar the most important factor (Rugg-Gunn and Hackett, 1989).

Diet acts locally by:

1. Reacting with the enamel surface
2. Serving as a substrate for cariogenic microorganisms

2.2.4.1. Diet during infancy

2.2.4.1.1. *Milk*

Milk is one of the main sources of sugar in the human diet. For babies it is the only source. Its importance declines after weaning (Rugg-Gunn, 1993). In general, milk is not regarded as a cause of dental caries. Although lactose alone can be moderately
cariogenic, milk contains other factors, which protect against dental caries. Milk without added sugars may be considered virtually non-cariogenic (Department of Health, 1989).

Animal studies have shown that milk is non-cariogenic when fed to desalivated rats (Bowen et al., 1991). Bowen and Pearson (1993) went on to show that milk is not cariostatic when sucrose and milk are administered separately. However, it does have a minimal cariostatic effect when these are taken simultaneously.

Milk contains the antibacterial substances lysozyme, peroxidase and lactoferrin (Kosikowski, 1970), which theoretically, at least, could affect the microbial flora of the buccal cavity. It also contains a range of other substances, many of which are adsorbed onto hydroxyapatite (Reynolds and Wong, 1983; Vacca-Smith and Bowen, 1993: Vacca-Smith et al., 1994).

The effect of milk and some of its constituents on plaque bacteria has been studied. Milk and milk glycoprotein x-casein not only reduce the adherence of streptococci to a modified salivary pellicle and to saliva-coated hydroxyapatite (Guggenheim et al., 1994), but also reduce the glucan-forming activity of glucosyl transferase enzyme which can modulate the formation of plaque (Vacca-Smith and Bowen, 1995).

In an in vitro study, McDougall (1977) reported milk to remineralise enamel.

2.2.4.1.1.1. Human milk

Breast-feeding is strongly encouraged for full-term infants. Human milk is recommended as their sole food for the first 4 to 6 months of life given its compatibility and nutritive value. Biochemical, immunochemical and cellular components of human milk appear to be uniquely beneficial to the infant. Human milk contains a lower protein content than the milk of other mammals and consists largely of whey, which is easily digestible. Whey proteins include carriers of minerals and vitamins (Barness, 1994).

Contraindications to breast-feeding include galactosaemia, phenylketonuria, urea cycle defects and a few other rare errors of infant metabolism. With respect to maternal health and behaviour, contraindications include tuberculosis, hepatitis, AIDS or other infectious diseases, the taking of certain drugs (including illicit drugs), alkylating medications for the treatment of malignancies, radioactive preparations, sulphonamides and probably antithyroid agents (Barness, 1994).
2.2.4.1.1.2. Infant formulae

Breast milk substitutes have been developed for mothers who should not or cannot nurse their child. At first, these were the milks of other animals modified slightly by the addition of water and carbohydrate. These were relatively inexpensive and supported the growth of many infants, but morbidity was appreciable. Formulae more closely approximating the composition of human milk were therefore developed.

When diluted according to instructions, presently available cow’s milk-based standard infant formulae are made to provide 67 to 70 kcal/dl, and to have a protein content of 1.5g/dl (approaching that of human milk which is approximately 1.0g/dl). In some formulae the protein is mainly whey; in others it is largely casein. In their manufacture, cow’s milk is reduced and, in some products, the overall proportion of casein is lowered. Casein-dominant milks are based on whole cow’s milk protein and have a casein-whey ratio of approximately 4:1. Whey-dominant milks are modified so that the cow’s milk protein has a casein-whey ratio of approximately 2:3 - similar to human milk. The carbohydrate most commonly used is lactose; also allowed are maltodextrin and glucose syrup (Department of Health, 1994). The fat they contain is a mixture of vegetable oils, which are more easily absorbed by infants than is the butterfat of cow’s milk. As in human milk, the fat content is approximately 3.5g/dl and supplies 45% of the calories. Vitamins and minerals are added in amounts sufficient to meet daily requirements (Barness, 1994). Infant formulae offer a satisfactory sole source of nutrition until the age of 4-6 months (Department of Health, 1994).

2.2.4.1.1.2.1. Special formulae

Soya infant formulae:

These are based on soy protein isolate and may be used from birth to beyond the first year if indicated. They were developed for infants who are not breast-fed and who are intolerant of cow’s milk protein. Soya formulae are suitable for infants who require a vegetarian diet, for those with galactosaemia, and for those with lactase deficiency.
(Barness, 1994). Lactose is replaced by other sugars such as glucose, sucrose or maltose (Department of Health, 1994), which unfortunately renders them potentially cariogenic (Holt and Moynihan, 1996).

Children who have severe milk or soy protein intolerance usually benefit from formulae in which the protein is supplied as amino acids or peptides. Most of these formulae are made by hydrolysis of cow’s milk protein (Barness, 1994).

2.2.4.1.1.2.2. Cariogenicity of formula milk

Controversy exists over the cariogenicity of milk used in the manufacture of formulae as well as over the different types of carbohydrate sources used.

An in vivo/in vitro combination was developed to investigate the plaque pH changes associated with nursing with eight different infant formulae belonging to four categories (formulae with iron, with low iron, soy-based, protein hydrolysate). All reduced the pH significantly below pre-rinse values. Further, the soy-based and protein hydrolysate formulae produced pH falls significantly beyond the two milk-based formulae. If casein is predigested in these two formulae, an important anticariogenic mechanism (Dreizen et al., 1961) may be removed. This suggests that infant formulae are acidogenic and may therefore play a significant role in the development of baby bottle tooth decay (rampant caries) (Sheikh and Erickson, 1996).

2.2.4.1.1.3. Milk and rampant caries (incisor caries/early childhood caries [ECC])

This has been linked to a variety of inappropriate infant dietary habits. Reports reviewed by Reisine and Douglass (1998) suggested that putting a child to bed with a bottle is a widespread behaviour, ranging from 18% (Kaste and Gift, 1995) to 85% (Serwint et al., 1993). This practice, however, is prevalent among children with and without caries. In one study (Schwartz et al., 1993), although more than one half of the children were put to bed with a bottle, only 37% developed maxillary anterior caries. In another study (O’Sullivan and Tinanoff, 1993 b), 69% of children who did not develop maxillary anterior caries were reported to have taken a bottle to bed, and 14% who did were not given a bottle to take to bed. This finding refutes the belief that inappropriate use of the bottle is correlated strongly with the disease. This is in agreement with the
findings of Wendt and Birkhed (1995), who report that giving a child a bottle containing formula at bedtime or during the night has no influence on caries prevalence in 3-year-olds.

Feeding methods have been investigated in relation to rampant caries in a number of studies. Holt et al., (1988) reported no statistically significant relationship between numbers of children with rampant caries and feeding methods. The prevalence of this pattern of caries in bottle-fed, breast-fed and mixed-fed infants was 9%, 2% and 7% respectively. However, in another study (Al Dashti et al., 1995), the prevalence of rampant caries in breast-fed children was much lower (17%) than in bottle-fed children (53%).

Winter et al. (1971 a) suggest that children with caries discarded the bottle 4-7 months later than those without. Holt et al., (1996) reported that 19% of the children who continue having a bottle after two years of age had rampant caries compared to 6% for those who stopped before two years. Prolonged bottle-feeding was further assessed in relation to dmfs values for anterior teeth (Al Dashti et al., 1995). Children who were bottle fed for less than one year had a dmfs value of 2.6 compared to 4.7 among those who had been fed for at least 12 months.

Prolonged breast-feeding has been suggested to cause rampant caries. Children not yet weaned at 18-months of age were found to have nearly twice the prevalence of caries (21.3%) than those already weaned (12.4%) (Tsubouchi et al., 1994). A Turkish study (Eronat and Eden, 1992) showed that most children with rampant caries were breast-fed for either less than 6 months or longer than 12 months. In another study (Wendt and Birkhed, 1995), significantly more children with than without caries at the age of three had been breast-fed either for a period of 2 months or less, or for a period of longer than 12 months. Similarly, Holt et al. (1996) reported that when breast-feeding was stopped within the first 12 weeks, the prevalence of rampant caries was 9% compared to 13% among those who continued longer than 36 weeks. The lowest prevalence (2%) was reported among those who stopped between 12 and 36 weeks.

Feeding on demand has also been implicated in rampant caries. A study in Kuwait (Al Dashti et al., 1995) showed the prevalence of rampant caries in children breast-fed “at-will” for more than 6 months was 26% compared to 5% in those not breast-fed on demand.
Breast-feeding with high frequency may predispose to caries. Matee et al. (1992b) report that all six infants with rampant caries in the 1-1.5 age group in their study were still breast-fed with a mean frequency of 14 times a day.

In infants, prolonged bottle-feeding and bottle and breast-feeding on demand may keep the plaque pH close to critical (the pH below which dental enamel begins to dissolve because the environment is no longer saturated with enamel minerals) for comparatively long periods of time. The balance would consequently be tipped towards demineralisation, and the opportunity for a carious lesion to develop would be great.

In a Swedish study, prolonged breast-feeding was associated with other potentially cariogenic dietary habits (Hallonsten et al., 1995).

In contrast to the findings of the above studies, a case control study in South Africa (Roberts et al., 1994) demonstrated that rampant caries was unrelated to the length or type of feeding (breast or bottle).

2.2.4.1.2. Foods and Drinks other than milk and water

Fruit drinks, squashes and diluted fruit syrups are given to nearly all young children, and they constitute a major source of non-milk extrinsic (NME) sugars.

Durward (1991) found that the sugars added to baby foods were sucrose, glucose, fructose, lactose, maltose, glucose syrup, invert syrup, caramel and maltodextrine. Maltodextrine, an intermediate between starches and sugars, is used to sweeten as well as to thicken baby foods. Many foods also contain their own sugars. Consequently, even foods with no added sugars may have very high sugar contents (Durward, 1991). Curzon et al. (1988) analysed 15 baby and infant fruit drinks on sale in and around Leeds (UK) for sugars (glucose, sucrose and fructose) using Boehringer-Mannheim kits. All those tested contained substantial quantities. The proportions of different sugars varied and the sucrose content was sometimes low. However, total sugar content was as high as 4.1 equivalent teaspoons of sugar (sucrose) in a volume normally taken by a baby. The authors pointed out that having no added sugar does not make these fruit drinks any less dangerous to the teeth, especially when they are used frequently throughout the day.
Fruit juices termed "pure fruit juices for babies", and intended for consumption by infants, have become popular in place of the high sugar fruit cordial drinks, which are implicated in caries in infants. However, the acidic nature of these "baby fruit juices" may be reflected in an erosive effect on enamel after prolonged exposure. Smith and Shaw (1987) investigated five samples each of Cow and Gate's apple and pear and Robinson's apple and orange flavours of the baby pure fruit juices. Even when diluted 10-fold they gave rise to an acidic pH below that critical for the dissolution of enamel. The in vitro incubation of teeth in these juices led to significant demineralisation of enamel in a short time.

In a later study (Duggal and Curzon, 1989), nine fruit drinks and Gripe water were investigated with respect to their inherent pH and titratable acidity. The drinks were diluted (if recommended) according to the manufactures' instructions. The cariogenic potential (CPI) was assessed by testing the ability of each fruit drink to depress plaque pH in vivo in a group of subjects selected for the acidogenic potential of their plaque. All the tested drinks, whether marked as 'no added sugar' or 'free from added sugar' were known to contain substantial quantities of sugars (Curzon et al., 1988), and all except Gripe water had a low inherent pH, ranging from 3.2 to 3.79. On dilution, the pH of these drinks did not rise significantly. All the drinks depressed the plaque pH below 5.5 within 5 minutes of drinking, and all showed CPIs equal to or greater than the standard 10% sucrose solution.

Assessment of the plaque pH produced by drinks can indicate their relative cariogenic potential (Duke et al., 1988). The Cariogenic Potential Index (CPI) is calculated using the area enclosed by the sucrose curve as the baseline (with a score of 1.0). Drinks which score above 1.0 have a high cariogenic potential. In Duggal and Curzon study (1989), apple/cherry, apple/black current, summer fruit, pear/peach were all classified as highly cariogenic. It is evident from the results of this study, that the absence or presence of sucrose (as opposed to 'natural sugars' such as glucose or fructose) makes no difference to the cariogenicity of fruit drinks.

Six commonly used herbal baby drinks were analysed for their inherent pH and titratable acidity in vitro and their acidogenic potential assessed by measuring their ability to depress plaque pH in human volunteers (Duggal et al., 1996). Three of the six test drinks had a low pH though most had a low titratable acidity. All drink, except herbal
tea, on rinsing led to a significant drop in the plaque pH to near critical pH value of 5.5. Most drinks tested contained dextrose (glucose) or maltodextrin as the principal carbohydrate. Maltodextrin was shown to produce a fall in plaque pH not significantly different from that caused by a 10% sucrose solution. Glucose (which is naturally present in fruit drinks), was investigated in an earlier study (Duggal and Curzon, 1989), and was already found to have a profound acidogenic potential. Thus, some herbal drinks, especially those with a fruit component, have acidogenic and maybe erosive potential. The authors of the study warn that the assumption that these drinks are 'safe' may be unfounded. Safer drinks are herbal tea and milk.

2.2.4.1.3. Weaning and the weaning diet

Weaning, which forms an integral part of nutritional development in infancy, has been defined as ‘the process of expanding the diet to include foods and drinks other than breast milk or infant formula’ (Department of Health, 1994).

During weaning, infants are introduced to a wide variety of food flavours and textures. The early diet may include manufactured foods prepared especially for infants, but ‘family foods’ such as biscuits may also be included (Mills and Tyler, 1992). Non-milk extrinsic sugars may be present in any of the foods and drinks given at weaning. The COMA Working Group recommends that, for dental health, NME sugars should be limited to about 10% of total dietary energy intake (Department of Health, 1994). Weaning, and the foods and drinks used at weaning, may affect the development of caries either directly or indirectly. The eruption of the primary dentition usually starts during or just after weaning. Weaning has an indirect effect on caries because it is thought to be the time at which dietary habits are established (Holt and Moynihan, 1996).

2.2.4.2. Diet in early childhood

2.2.4.2.1. Dietary sugars

Sugar - particularly sucrose - is thought to be the most cariogenic food in the normal human diet (Rugg-Gunn and Hackett, 1989).
The catabolism of carbohydrates by microorganisms and the production of organic acids have long been regarded as the mechanisms by which enamel is demineralised (Miller, 1890). According to Stephan (1940), acidity in plaque increases immediately after the consumption of sugar, taking about 40 minutes to return to the original pH of near neutrality. As the quantity of acid increases, so the pH within the plaque falls, very often to levels close to critical pH (Jenkins, 1978). The pH values of food or drink, the type of acid formed from sugars, and plaque thickness, all influence the speed of the pH fall and the degree by which it falls (Jenkins, 1981).

Demineralisation depends on the extent of drop below the critical pH and the time required for the pH to recover. Remineralisation depends on the length of time the plaque pH remains near neutrality.

Significant factors influencing the development of caries caused by refined carbohydrate consumption include the consistency, frequency of intake and type of sugar.

2.2.4.2.1. Consistency

The Vipeholm study (Gustafsson et al., 1954) clearly demonstrated that the consistency of sugar-containing food is very important in the aetiology of caries. Sticky or adhesive foods that maintain high sugar levels in the mouth for a long period of time are much more cariogenic than those which are rapidly cleared.

2.2.4.2.1.2. Frequency

The same study (Vipeholm) further highlighted the importance of intake frequency. Intake frequency has been further investigated in animal studies (Kö nig et al., 1968) and in plaque pH studies. Plaque pH changes in subjects taking frequent between-meals snacks strongly suggest that increased frequency of eating favours caries. The pH may fall below the critical level on many or all occasions in which sugary foods are taken, thus increasing the frequency at which demineralisation may occur (Jenkins, 1981). If acid attacks are of too long a duration in relation to periods of remineralisation, the final outcome will be a carious lesion (Midda and König, 1994).
Two comprehensive longitudinal studies in England and the USA (Rugg-Gunn et al., 1984; Burt et al., 1988) found that caries increment in children was more strongly associated with total consumption of sugars than with frequency of ingestion, though both associations were weak.

In an earlier study, Sreebny (1982) reviewed the relationship between sugars and dental caries and concluded that total consumption as well as frequency of intake contributed to the formation of dental caries.

2.2.4.2.1.3. Types of dietary sugars

The Committee on Medical Aspects of Food Policy (Department of Health, 1989) classified sugars as intrinsic or extrinsic on the basis of their availability for metabolism. Intrinsic sugars are those that are naturally integrated into the cellular structure of a food. They are mainly found in whole fruits and vegetables. Extrinsic sugars are those that are free in the food or added to it (i.e., not located within the cellular structure of a food). These include milk sugars (almost entirely lactose) as a special subgroup as well as non-milk extrinsic sugars (mainly fructose, glucose, sucrose added during manufacture, recipe sugars and table sugars).

The report added that the physical location of sugars affects their availability for bacterial consumption. It was recommended that the consumption of NME sugars should be reduced and replaced by an increase in consumption of starches and fruits in order to reduce dental caries. The validity of the COMA’s classification and recommendations has been questioned and critically reviewed (Edgar, 1993).

Hussein et al. (1996) investigated the effects of some intrinsic and NME sugars on plaque pH. Three fruits (apple, orange and banana) in three different physical forms (whole, homogenised and juice) were tested on ten adult volunteers. Data were compared with plaque pH changes resulting from rinsing with 10% sucrose solution (positive control). Values reached after a one minute rinse with 10% sucrose were not significantly different from scores obtained with apple juice, orange juice, whole banana or homogenised banana. There were no significant differences between the minimum plaque pH values for whole apple and homogenized apple, or for whole banana and homogenised banana. The only significant difference was between whole orange and orange juice. The latter was not significantly different to a homogenised orange. These
results show that homogenisation of fruits has little effect on acidogenicity even though the intrinsic sugars are converted by this process to extrinsic sugars. Therefore, it is concluded, there is no significant difference in the acidogenic potential between intrinsic sugars and extrinsic sugars derived from fruits.

2.2.4.2.1.4. Cariogenicity of dietary sugars

All dietary sugars can be metabolised by plaque bacteria, and cooked and processed starches may be similarly utilised after enzymatic degradation by salivary amylase to low molecular weight carbohydrates (Midda and König, 1994). The most common dietary sugars are sucrose, glucose, fructose, maltose and lactose. Sucrose, fructose and maltose have rather similar cariogenic potentials (Koulourides et al., 1976) since they give similar Stephan curves (Imfeld, 1983). Fructose is highly cariogenic and can induce smooth surface caries in animals fed a cariogenic diet (Bowen et al., 1990; Bowen and Pearson, 1993). Lactose is less cariogenic than sucrose, fructose or maltose. The little data available on galactose indicate a cariogenicity similar to that of lactose (Imfeld, 1983)

Of these sugars, sucrose is the most common in infants’ food, drinks and snacks. It is also used to sweeten milk, fruit juices and squashes, in making jams, and is found with fructose and glucose in honey.

Fruit juices contain fructose. The sweetest of all sugars, it is added to soft drinks along with glucose and sucrose.

Maltose is a component of numerous infant formulae in which partial hydroxylates of starches are included (Nizel and Papas, 1989).

Lactose is the main sugar in milk. Human milk contains more lactose than cow’s milk [7g/100ml versus 4.8g/100 ml] (Rugg-Gunn, 1993). This sugar has repeatedly been reported to stand out among the major dietary sugars as being of markedly lower cariogenicity (Rugg-Gunn, 1993). It should be remembered, however, that this conclusion is based on laboratory rather than epidemiological studies.

Lactose is the major source of carbohydrate calories for breast-fed and most formula-fed infants (Saavedra and Perman, 1989). It has been indicated that, in children
who are breast-fed over a period of a year or longer, the lactose in milk can be highly
cariogenic when taken frequently (Storey, 1982; Matee et al., 1992 a). The reason for
the high cariogenicity of milk in this situation may be the habit of *ad libitum* feeding.
Williams and Hargreaves (1990) indicate that continued use of the feeding bottle was
not, *per se*, associated with caries experience, but that caries is more likely to occur if
sugar, honey or cereal is added to the drink.

In an earlier study, Winter et al. (1966) noted the dietary habits of 200 children
with rampant caries and came to the conclusion that there was a direct cause-effect
relationship between the sugar-sweetened contents of the nursing bottle and extensive
carious damage to the teeth.

As far as young children are concerned, the relationship between dietary sucrose
and caries approximates an S-shaped curve, rising steeply when sucrose-containing food
is eaten frequently, when newly erupted teeth are at risk, and when the immune response
is immature (Newbrun, 1982).

Sugars in sweetened comforters have been implicated in rampant caries. This was
confirmed by Winter et al. (1971 a) who noticed that 83% of parents of children with
rampant caries admitted to pacifying their offspring with sweetened comforters. This has
been further substantiated by Holt et al. (1988) who found that 11% of children with
rampant caries were given a sweetened comforter; those who were given none made up
only 3% of the study population. Holt et al. (1996), also report that the use of
comforters contributes to the risk of caries, but their findings failed to reach statistical
significance in multivariate analysis.

The sugar-caries relationship appears to be complicated by different facets of sugar
consumption, such as the total amount consumed, frequency of ingestion, between-meal
versus within meal consumption, the varying sugar content of foods, possible sugar-
starch interactions, and the physical form of the sugar-containing food (Szpunar et al.,
1995).

2.2.4.2.2. Dietary starches

Starches cannot directly serve as substrates for bacterial fermentation. They can,
however, be readily metabolised after their hydrolysis to maltose, maltotriose, dextrins
and minute amounts of glucose. These diffuse into plaque much more easily than large intact starch molecules (Jacobsen et al., 1972). A profound fall in plaque pH after starch consumption has been demonstrated by different investigators (Mörmann and Mühlemann, 1981; Lingström et al., 1989), even approaching those obtained with sucrose (Jensen and Schachtele, 1983). This has been further demonstrated by another study where plaque pH values produced by different starch products were found to be similar to that induced by a 10% sucrose solution (Pollard et al., 1996). Mörmann and Mühlemann (1981) found that the pH drop in plaque in vivo is a result of both the extent of starch hydrolysis in saliva and of the fermentation of low molecular weight dextrins by plaque bacteria. This has been further demonstrated in that after chewing crackers or potato chips etc., glucose clearance is prolonged due to the intermediate starch degradation products maltotriose and maltose. During oral clearance, different types of starches give rise to various amounts of maltotriose, maltose and glucose. Foods containing cooked starch can be considered as retentive or ‘sticky’ since glucose arising from their intra-oral degradation contributes to prolonged acid production (Linke et al., 1993).

Starchy foods should not be considered, however, as one homogeneous group. Lingström et al. (1993) studied the effect of different starch-containing food items on pH changes in dental plaque. These authors indicate that all starch products could be fermented in the oral cavity. However, the fall in the pH they occasioned differed greatly, depending on the processing conditions used to make the food. Sweetened bread gave a more attenuated pH fall than did unsweetened bread.

Sucrose added to a starch-containing diet is known to increase its cariogenic potential (Lingström et al., 1989). The probable explanation for this is that starch prolongs the sugar’s retention time in the mouth. There are also some indications that starch may increase acid production from sucrose when present at the same time (Glor et al., 1988).

The acidogenicity of starches has been further demonstrated by a large number of animal experiments (Imfeld, 1983). There is now no doubt that starches are acidogenic in the mouth. Cooked starch cannot be considered a non-cariogenic dietary component.
2.2.4.2.3. Snacks

Snacks are foods eaten between meals, usually while the consumer is engaged in some other activity, and contribute little to the total daily caloric intake (Rugg-Gunn, 1993). Snacks allow ample opportunity for acid attack in the susceptible child if cariogenic items are consumed often (Holt, 1991).

2.2.4.2.3.1. Fresh fruits and vegetables

Fresh fruits, when consumed infrequently in a normal varied diet, do not contribute detectably to caries activity (Edgar, 1993). However, they do have a cariogenic potential which may become manifest if they are consumed frequently (Grobler and Blignaut, 1989). Though little is actually known of the cariogenic potential of fresh vegetables, they may contain considerable concentrations of intrinsic sugars. Plaque pH data indicate they have appreciable cariogenic potential (Edgar, 1993).

2.2.4.2.3.2. Sugared snacks

Many snack foods have high sucrose contents. Sugar-containing products are introduced very early to infants, often before the age of 6 months, and consumption rises during early childhood (Rossov et al., 1990). Manufactured sugar-containing products represent a major source of sugar intake by children and, perhaps, other age groups, in developing as well developed societies (Birkhed et al., 1989; Marthaler, 1990; Petersen et al., 1990). Such snacks may therefore have a direct impact on the prevalence of caries.

2.2.4.2.3.3. Soft drinks

Soft drinks can be divided into three main classes: natural or reconstituted pure fruit juice - generally drunk undiluted and containing natural sugars; squashes, fruit ‘drinks’ and cordials - concentrates requiring dilution before being drunk; and carbonated drinks under pressure with fruit or other flavours e.g., cola. Squashes and carbonated drinks can be sweetened with either sugars or low-calorie substitutes (Grenby et al., 1989).

Research into the effect of soft drinks on dental caries is relatively limited.

2.2.4.2.3.3.1. Cariogenicity of fruit juices

The National Diet and Nutrition Survey (Hinds and Gregory, 1995) compared the average daily frequency of fruit juice consumption in children with and without
caries experience. Trends were not consistent across all age groups. Among 2½ - 3½ year-olds the mean average daily intake of fruit juices was 34.7 g for children with caries and 35.8 g for children without. Among 3½ - 4½ year-olds, the average daily intake for children without caries experience was 43.4 g - significantly higher than the intake of children with caries (15.0gm) (p<0.01). It is worth noting that fruit juice consumption was far more common among children from non-manual backgrounds than among those from households with a manual family head (Gregory et al., 1995). These findings may indicate that fruit juices are non-cariogenic but other factors could have confounded the results. Significantly lower proportion of children from non-manual backgrounds had experience of dental decay than from the manual background (Hinds and Gregory, 1995).

2.2.4.2.3.2. Acidity, sugar content and demineralising power of soft drinks

Soft drinks might cause not only erosion of the enamel but also dental caries (Grenby et al., 1989). These authors tested eight soft drinks (a pure orange juice, a pineapple juice, a lemon juice ‘health drink’, an orange drink, a low sugar orange drink, a black current cordial, a carbonated cola, and a low calorie carbonated lemonade) and found wide variation between their acidity, sugar content and demineralising power.

With respect to acidity, they ranged from pH 2.5 - 3.8. The two drinks with the highest pH values were the pure orange and pineapple juices; the two most acidic were the lemon juice and cola drinks. The concentrations of sucrose, glucose and fructose (either found in the drinks or provided by the manufacturer) were combined to give a total sugar content. The overall concentration was highest in the blackcurrant cordial, cola and the two pure fruit juices (orange juice and pineapple juice), was very low in the lemon juice drink and the low-sugar orange drink, and undetectable in the low-calorie lemonade. It is worth noting that fruit juices contain an appreciable amount of total sugar, so they offer no advantages with regard to dental health in this respect. With regard to calcium, phosphorus and protein contents, all were very low in the latter, apart from the two pure fruit juices (orange juice and pineapple juice). These two were also relatively high in calcium and phosphorus. One noticeable feature was the high level of phosphorus in cola, which despite having the lowest pH caused far less demineralisation than any of the other drinks. The two pure citrus juices caused the greatest
demineralisation, the amount of calcium dissolving in the presence of the lemon juice being particularly high. The connection between the acidity and the demineralisation findings suggests that demineralisation, as measured by both calcium and phosphorus dissolution, is at its lowest when the pH of the drinks is in the region of 3.2-3.3, rising when the pH is either above or below this.

2.2.4.2.3.4. Pattern of snack consumption

The types of snacks taken and their frequency of intake differ not only between countries but also within the same country. A large study of 2139 4-year-olds in Norwich, UK (Holt, 1991) indicated that the vast majority took snacks and/or drinks between meals. Almost two thirds ate or drank something on three or four of the occasions investigated (mid-morning, mid-afternoon, throughout the evening, and at bedtime). Sweet biscuits were eaten more often than any other snack item. Fruits were also common. Among drink choices, diluted fruit squash and milk were the most common. In another British study, 21% of 1½-4 ½-year-olds were reported to eat biscuits more than once a day, and 14 – 16% consumed blackcurrant drinks. Fruit juices were consumed more than once a day by 21%, 11% and 9% of children aged 1½ - 2 ½, 2 ½ - 3 ½, and 3 ½ - 4 ½ respectively (Hinds and Gregory, 1995). A Romanian study (Petersen et al., 1995) describing the health behaviour of grade-1 school children reported that milk with sugar was consumed either twice or more by 12% of children, biscuits by 11%, jam by 10% and sweets/chocolate bars by 12%. Sugary breakfast cereals were consumed once a day by 30%.

Burt (1993) reported the high consumption (1.4 cans/person/day) of soft drinks in the USA in 1991, 70% of which were sweetened with HFCS (a mixture of fructose, glucose and other oligosaccharides) and 30% of which were sweetened with aspartame or saccharine.

A study in Kuwait reported that 44% of first grade children drank soft drinks and 70% drank tea with sugar ‘several times a day’ (Petersen et al., 1990).

In Iraq, where sweetened tea forms a major part of daily sugar intake, individuals from urban locations have a much greater preference for sweetness than their rural counterparts, consuming more sugar. Within the urban population, those who have lived
in the city longer and who are from families with lower educational qualifications prefer the highest levels of sugar (Jamel et al., 1996).

Some studies have demonstrated that immigrant children have higher sugar consumption than non-immigrants (Widström and Suksis-Jansson, 1985; Grindefjord et al., 1993; Wendt and Birkhed, 1995). On the other hand, Neiderud et al. (1991) found no differences in dietary habits between Greek immigrant children and Swedish children.

Social class has also been investigated in relation to dietary habits. Children from manual backgrounds are more likely to consume sugar confectionery and carbonated drinks most days of the week, and more often than those from non-manual backgrounds. For example, Hinds and Gregory (1995) showed that 41% of 1 ½ - 2 ½ year-olds from manual backgrounds ate sugar confectionery with this frequency, the proportion rising to 56% among those aged 2 ½ - 3 ½ years, compared to only 24 % and 36% respectively for the same two age groups from non-manual background. In an earlier study (Blinkhorn, 1982), mothers in deprived areas of Edinburgh were more likely to give their children sweets after nursery school than were their counterparts from non-deprived areas. Holt (1991) argues that although there was a difference in caries prevalence between social classes, there was little evidence that this trend was related in a meaningful way either to consumption of snacks or drinks as a whole or to consumption of sweet items.

2.2.4.2.3.5. Factors implicated in the cariogenicity of snacks

As with other foods, the relative cariogenicity of snack foods is dependent not only on sucrose content but also on their composition, texture, solubility, retentiveness and ability to stimulate saliva flow (Morrisey et al., 1984).

The inherent retentiveness of snack foods within the oral cavity may affect the time that carbohydrates are available for bacterial metabolism (Pollard et al., 1996). Retention of food depends on its own properties such as adhesiveness, cohesiveness and fracturability (Caldwell, 1962). In children under the age of 15 years, food was found to be retained in the mouth for longer periods. Accordingly, starchy foods are potentially more dangerous in children, whose oral clearance pattern is less efficient than that of adults (Crossner et al., 1991).
Although retentiveness is higher in children than in adults, their plaque pH response is significantly less acidic. Not only the pH drop and its duration is less, the area under the curve below the resting pH is smaller. For example, the cariogenic potential of a blackcurrant drink was twice as high in adult than in child volunteers (Tahmassebi and Duggal, 1996). These authors advised carrying out acidogenic studies of children's foods and drinks in children rather than in adults. When investigating the cariogenicity of foods, it is best to assess the length of time they are retained in the oral cavity in addition to measurements of acidogenicity and demineralisation (Pollard et al., 1996).

2.2.4.2.4. Diet and the prevalence of dental caries

Diet has long been suspected to be involved in the caries process, but direct proof has been difficult to establish. In a mixed human diet the part played by one factor is complex and the cariogenicity of one food is difficult to predict. Nevertheless, a pattern has emerged which implicates sugar, particularly sucrose (Rugg-Gunn and Hackett, 1989). Sugar is consumed in different forms and at different times. A higher proportion is eaten in snacks. Almost two thirds (63%) of the total sugar intake of English adolescents is consumed in snacks rather than at mealtimes (Hackett et al., 1984). From a review, Bibby (1975) concluded that snack foods share the same importance as sucrose alone in the aetiology of dental caries.

Evidence relating the consumption of sugar to the occurrence of dental caries is derived from many sources including epidemiological evidence, cross-sectional and longitudinal correlation studies, clinical trials, animal experiments, plaque pH experiments, enamel slab experiments and incubation experiments.

2.2.4.2.4.1. Epidemiological evidence

Our knowledge of sugar-eating habits and their relationship with caries is based on epidemiological surveys (basically observational studies). Many have investigated the prevalence of caries in isolated communities or in the populations of developing countries before and after exposure to Western style diets (with their high-sugar content), and many report a positive correlation. The deterioration in the dental health of the islanders of Tristan Da Cunha is an interesting example. This community enjoyed exceptionally low levels of dental caries in 1937 when it was isolated from the world and
lived on locally available food. From 1940 onwards, however, the islanders had access to increasingly greater quantities of imported manufactured food and this was paralleled by a considerable increase in the prevalence of caries (Fisher, 1968).

Studies on groups of people with restricted sugar intakes have shown them to have few caries. Children living in a home (Hopewood House) in New South Wales from soon after birth to 12 years of age and who were fed a lacto-vegetarian diet with low levels of sugar and white flour had a caries prevalence of only 54% compared to 99% in children in the same district’s state schools (Harris, 1963).

Patients with hereditary fructose intolerance cannot eat foods containing fructose or sucrose due to a deficiency in a liver enzyme. Newbrun et al. (1980) indicate that 17 such patients had a mean DMFS of 3.3 compared to 36.1 for a matched control group of 14 normal people. The mean daily sugar intake of the test group was 2.5 g compared to 48.2 g for the controls. On the other hand, young children taking long-term syrup medicine (Roberts and Roberts, 1979), and workers in a Danish chocolate factory (Petersen, 1983), were seen to have high caries experience. Further, Winter et al. (1974) in a study on phenylketouric children (who consume a sucrose-rich diet from birth until eight years of age) had no higher caries experience than a control group of normal children.

Caries experience has been positively correlated with the availability of sugar (Marthaler, 1978; Sreebny, 1982). Sreebny correlated dental caries experience in the primary dentition (dmft) of 5-6-year-olds with sugar availability in 23 countries, and the dental caries experience (DMFT) of 12-year-olds with sugar availability in 47 countries. Caries decline during wartime in Europe and Japan has also been related to sugar restriction (Sognnaes, 1948; Takeuchi, 1961).

It should be remembered that the last two types of epidemiological comparison are imperfect, as sugar availability figures do not refer specifically to 5 or 12-year-olds. The per capita consumption of sucrose is a crude measure estimated by dividing sugar supplies by the population size. This yields a value that exceeds the true amount consumed by individuals. ‘Consumption data’ actually represent the ‘disappearance’ of sugar, a great amount of which is used in the fermentation industry or is lost as wastage.
2.2.4.2.4.2. Cross-sectional correlation studies

The interpretation of the many cross-sectional studies, which compare caries levels in people with reportedly high and low sugar intakes presents difficulties. These mainly arise because of the multifactorial aetiology of the disease and because of the discrepancy between the time period during which the teeth are exposed to the diet and the actual period over which the diet is reported (at the most the previous 3-7 days) (Rugg-Gunn, 1993). Several studies have been reviewed by Rugg-Gunn (1993). Those on young children (5-year-olds and younger) show a significant correlation between caries experience and sugar consumption. However this correlation was observed less frequently in children over 9 years of age and in adults. Rugg-Gunn points out that the correlation in pre-school children may be explained by the fact that their teeth have only recently erupted. Further, their sugar-eating habits may not have changed appreciably since eruption. Winter (1988) suggests that the pre-school population is the best in which to assess the relationship of dietary factors to caries risk.

That there are more or less fixed dietary habits during early childhood has been substantiated by a Norwegian study (Rossov et al., 1990) in which the patterns of sugar consumption in early childhood were investigated. The consumption of soft drinks and sweets at the age of 10 months, 18 months and 2 years is relatively consistent, which is probably maintained in early childhood. These findings seem to indicate not only a consistency in consumption of sweets and soft drinks over time, but also indicate the satisfactory reliability and validity of the sugar variable.

Some studies have correlated caries experience with previous dietary habits. A Swedish study (Persson et al., 1985) compared dietary habits of children at 12 months of age with their caries status at the age of 3 years and found that the consumption of sugar-rich foods at 12 months was positively related to the presence of caries at the older age. In a British study (Silver, 1987), infant feeding practices, dietary habits and caries status were obtained at the age of 3 years and at 8-10 years, and a positive relationship was found between poor infant feeding practices and caries experience at both ages.

Several studies on young children in different countries have attempted to determine whether a significant relationship exists between sugar consumption and dental caries. Dietary information collected in a variety of ways showed a significant correlation between sugar comforters and rampant caries (Holt et al., 1982, 1988; Silver, 1987),
frequency of sugar intake and caries experience (Holbrook et al., 1989; Holt, 1991), and the total weight of sugar consumed and caries experience (Kleemola-Kujala and Rasanen, 1979). Household expenditure on chocolate and sweets, frequency and the high average intake of sugar confectionery and soft drinks and caries experience (Hinds and Gregory, 1995).

Some studies have compared the sugar-eating habits of children at the two extremes of the caries experience distribution. A United Kingdom study of 444 5-year-olds (Tee, 1987) compared 66 who were caries-free with 378 with active caries (≥ 6 dmft). Although significantly higher sugar consumption was found in the caries-active group, the sample of caries-free children was small compared to that of the caries-active children. A Finnish study of 112 5-year-olds (Kleemola-Kujala and Rasanen, 1979) compared 58 low-caries children (dmfs 0-10) with 54 high-caries children (dmfs18-60). The authors arbitrarily divided children into tertiles by dmfs values (the 33rd and 67th percentile points of dmfs). Those in the first tertile were taken as the low-caries group and those in the third tertile as the high-caries group. The intake of sugar and sugar-containing products was found to be higher in the high-caries group.

Holt (1991) examined the between-meal snacks and drinks of 4-year-old children in the United Kingdom. It was found that levels of disease rose with an increase in frequency of snack or drink consumption even with a relatively crude classification of 'sweet' and 'non sweet' items.

In a study by Kalsbeek and Verrips (1994), linear regression and logistic regression analyses indicated that 5-year-olds with a reported frequency of sweet consumption of more than 5 times/day appeared to have significantly higher caries scores than those whose consumption was between 1-5 times/day.

Stecksen-Blicks and Holm (1995) showed an association between snacking and caries experience of pre-school children that was not negated by the frequent use of fluoride toothpaste.

The caries inhibiting effect of avoiding between-meal eating and snacks containing high sucrose component have been shown by a Swedish study of 4-year-old children (Granath et al., 1978).
Although many cross-sectional studies report a positive correlation between sugar consumption and the development of dental caries, the validity of the human diet-caries relationships based on dietary recall data have been questioned (Newbrun, 1989). Longitudinal measurements of caries increments combined with multiple dietary histories are needed to clarify the association between caries and sugar-eating habits (Newbrun, 1982).

2.2.4.2.4.3. Longitudinal correlation studies

Few studies have assessed sugar-eating habits over a period of time and related these to caries development over the same period. Longitudinal studies, where sugar intake and caries increments are recorded in the same individual, are revealing. Grindfjord et al. (1996), following infants from one year through to 3.5 years of age, showed that the consumption of “candies” and sugar containing beverages were significant risk factors for the development of caries. However, these univariate associations may oversimplify a more complex inter-relationship of several influences.

Thompson et al. (1983) had re-examined subjects from an initial sample of 343 Canadian children who had received a clinical examination and underwent nutritional evaluation. Although a significant correlation was seen between sugar consumption between meals and caries, the authors were able to examine only 73 children and dietary information was only obtained at baseline and at 3 years.

Roeters et al. (1995) examined 252 children (average age 2.3 years) in a longitudinal study. At the age of five years, 193 children were still in the study. In the three-year observation period, the children were examined at 6-month intervals until the age of five years. At the same time, the dietary habits of the children were recorded using a 24 h recall methodology. A seven-day dietary record was kept at baseline. The number of times foods were ingested per day was recorded, and a special note made of those containing fermentable carbohydrates (including beverages). When the interval between food ingestion was less than 20 minutes, these intakes were scored as a single intake. A low correlation was found between the daily number of food intakes and sugar-containing food intakes (according to the twenty-hour recall method) and early dentine caries scores. The authors concluded that this might be partially explained by the low
validity of the diet recall method. A low correlation may also be seen when caries prevalence is low and differences in dietary habits are small (Newbrun, 1989).

In New Zealand, 355 preschool children under 5 years of age (93 with a minimum dmft of 4 and 262 caries-free children) were studied in relation to their dietary habits (McMahon et al., 1993). Two methods of dietary assessment were used. For each child, three 24 h quantitative food recalls were recorded over a one-year period (Beaton et al., 1979). A food frequency questionnaire developed from the food frequency grid described by Baghurst (1981), which included some foods and beverages frequently consumed by preschoolers, was also administered. No single food or group of foods (including sweet beverages, confectionery, jams and snack foods), was consumed more by the children with dental decay than by the caries-free children (as determined by the Student’s paired t-test). Children with dental decay did not report eating or drinking more frequently than caries-free children. The authors explained the lack of any association on the basis of the protective effect of the fluoridated water supply.

Holbrook et al. (1989) examined a group of 4-year-olds to investigate several factors known to relate to dental caries. The baseline investigation included a dietary questionnaire completed by interviewing the parents or guardians and recording the frequency of consumption of sugar-containing foods, sweets and drinks over a one-week period. The use of fluoride-containing compounds and the consumption of sugar-containing paediatric medicines was also recorded. These children were then followed for two years and the progression of caries recorded at 5 and 6 years of age with particular reference to the aetiological factors measured (Holbrook, 1993). The earlier dietary study gave a sugar frequency value for each subject, and a marked ‘threshold effect’ was noted with respect to sugar consumption and caries score (Holbrook, 1989). As a further refinement, children were designated as ‘misusing sugar’ if they had a sugar index of greater than 30 times per week, if the intake of sweets was not limited to 2 days per week, or if sugar-containing foods or drinks were consumed after brushing the teeth at night. Children in the misuse group had significantly higher caries scores. This group also contained lower number of caries-free children at 4, 5 and 6 years of age compared to the limited sugar intake group.
Holbrook continued his first study to obtain data on a longitudinal basis in order to reinforce his original conclusion that the misuse of sugar was one of the strongest factors in determining which children who would develop most caries by 6 years.

Wendt and Birkhed (1995) tried to describe the dietary habits of infants and toddlers in Sweden with special reference to caries prevalence at 2 and 3 years of age and immigrant status. Parents of one-and two-year-olds were interviewed at the time of the clinical examination. They were asked about the children's dietary habits (feeding method, regular meals, frequency of intake of caries risk products such as soft drinks, fruit soup, sweets, ice cream, biscuits) during the past year. With regard to the intake frequency of caries risk products, there were significant differences between children who had developed caries at the age of 2 or 3 years and those who had not. Children with caries by these ages, when compared with children who remained caries-free at the age of three, had consumed caries risk products when they were one year old, and had been given nocturnal meals and sweetened liquids in their feeding bottles.

2.2.4.2.4. Clinical trials

Controlled clinical trials would clearly provide the strongest evidence of the effect of sugar consumption on dental caries, but these are difficult to justify ethically. The only major study of this nature was the Vipeholm study (Gustafsson et al., 1954), conducted shortly after the Second World War in an adult mental institution before more stringent ethical codes were developed. The results showed a marked increase in caries increments with frequent between-meal intakes, but limited increments when sugar was eaten only 3-4 times a day with meals. More retentive foods were also found to be more cariogenic.

A rapid experimental caries model was developed by Von der Fehr et al. (1970) in which young adult volunteers rinsed nine times a day with 10ml of a 50% sucrose solution while abstaining from oral hygiene. After three weeks they showed a greater number of early carious lesions than a control group. A period of daily rinsing with a fluoride solution reversed the temporary damage inflicted.
2.2.4.2.4.5. Animal experiments

Due to the complex nature of human diets and the difficulties in controlling these over long periods of time, experimental animals have been used in caries research. Caries in rats shows many similarities to that in Man. Nevertheless, differences in the nature of their dentition and the composition of their saliva means findings cannot be directly extrapolated (Bedi et al. 1999).

König et al. (1968) studied the relationship between caries scores and the frequency with which animals ate a cariogenic diet. A positive correlation was seen between frequency of cariogenic diet and caries severity.

The interval between meals (Firestone et al., 1984) also affects the development of caries experience in animals. This was greater in those whose meals were spread out during the day compared to those whose meals were bunched close together.

Many experiments have shown that diets containing some sugar (for example about 10% of the total diet) produce more dental caries in rats than diets with no sugar (Rugg-Gunn, 1993). Further increases in dental caries have not always been observed when the sugar content is raised above 10%. The differences were probably due to the type of diet and to whether the rats were superinfected with cariogenic organisms.

The composition of the non-carbohydrate part of the diet is very important in determining how cariogenic a given amount of sugar will be. Huxley (1977) investigated two strains of rat (Spague-Dawley and Long-Evans, both maintained in closed breeding colonies for several generations) on two basic diets ('2000' or 'DD' - the DD diet contained icing sugar, corn starch, casein, salt mixture, vitamin mixture and corn oil; the '2000' diet contained sucrose, starch, skim milk powder, flour, casein, yeast extract, liver powder, and sodium chloride) with up to five levels of sugar concentration fed either ad libitum or 17 times per day. Caries increased linearly with dietary sugar concentrations (0, 15, 30 and 56% sugar) in Sprague-Dawley rats receiving the '2000' basic diet. On the other hand, those receiving the 'DD' basic diet showed no linear increase in dental caries for sugar concentrations above 15%.

Sugar types have also been investigated in experiments with rats. The addition of 25% glucose, fructose, lactose or maltose to basic starch did not produce significantly more dental caries than starch, while sucrose was more cariogenic (Guggenheim et al.,
1966). The animals used in these experiments, however, were inoculated with a dextran-producing *Streptococcus*. This probably exaggerated the differences between the cariogenicity of sucrose and other sugars.

Animal studies have been also performed to investigate the cariogenic potential of some popular snacks as well as to investigate the inherent properties they have that might modify this potential. Mundorff et al., (1990) reported on the major ingredients and on the cariogenic potential indices CPIs (with respect to sucrose) of 22 test foods representative of common human snacks. These (CPIs) were determined in six intubated rat caries experiments and calculated for each food from the sulcal and buccolingual caries (taking into account both their number and severity). Values differed depending on which of four classes of caries (number and severity of sulcal and buccolingual lesions) was used in calculations. When the mean of the CPIs was calculated for all four classes of caries scores, certain foods consistently fell into one of two arbitrary groupings ($\leq 0.4$ or $>0.4$). This is consistent with the indications of the 1985 Scientific Consensus Conference on Methods for Assessment of the Cariogenic Potential of Foods (Bowen, 1986) which cites a CPI ranking of 0.4 as indicative of foods with low cariogenic potential. Foods with mean CPIs $\leq 0.4$ were gelatine dessert, corn chips, peanuts, bologna and yoghurt. Those with mean CPIs $>0.4$ were pretzels, potato chips, saltines, natural snack mix, cornstarch, rye crackers, fried cake, milk chocolate, graham crackers, sponge cake with filling, bread, sucrose, granola cereal, French fries, bananas, cupcakes and raisins. It is worth noting that snacks with high CPIs (potato chips, bananas, raisins, saltine crackers, white bread, cakes) were among the foods that cleared slowly in humans and resulted in moderate to high caries in rats (Bibby and Mundorff, 1975). This supports the idea that food retention is important in determining caries-producing potential.

Significant positive correlations were found between total food consumed and the number and severity of sulcal caries. The authors gave two possible interpretations for this association. High food consumption may, in itself, result in increased sulcal caries, or the rats, due to a taste preference, may have consumed more of the foods that encouraged sulcal caries.

High recoveries of *S. sobrinus* were observed in rats fed on sucrose, cupcakes and fried cake, while the bacterium failed to colonise rats fed on food of low cariogenic
potential. These observations suggest that the test foods’ effect on caries production may be, in part, related to their effect on colonisation by cariogenic bacteria.

All the foods tested produced caries. The properties that modified their cariogenic potential included retention in the mouth, the physical form of the food, acidogenic properties, the protective effect of food ingredients, effects on bacterial colonisation and the quantity and type of carbohydrate composition.

Mundorff-Shrestha et al. (1994) carried out a series of rat experiments to test relative cariogenic potentials and to identify the major cariogenic elements of 22 popular snack foods (potato chips, dry roasted unsalted peanuts, yellow cake with white sugar icing, cornstarch, saltine crackers, graham crackers, pretzels, corn chips, white bread, doughnuts, granola cereal, unsalted French fries, vanilla yoghurt, cherry-flavoured gelatine dessert, bananas, bologna, sponge cake with marshmallow filling, raisins, rye crackers, nuts and dried fruit mix, milk chocolate, and powdered sucrose). In each experiment, sucrose was used as the high caries-producing control and milk chocolate as the moderate caries producing control. Parameters measured included: rat caries, number of cariogenic bacteria in plaque, salivary parameters including flow rate, buffering capacity, total protein, lysozyme and amylase contents, and the composition of the test foods including protein, fat, phosphorus, calcium, fluoride, galactose, glucose, total reducing sugar, sucrose and starch contents.

Six rat caries experiments were performed. In each, six groups of 12 SpragueDawley rats were used. Each group was fed 17 daily meals of one test food for 5 weeks using a programmable feeder. The foods that ranked highest in cariogenic potential were cupcakes, bananas, raisins, and French fries. Cupcakes, bananas and raisins contained concentrations of 1% or more of each of glucose, sucrose and total reducing sugars, suggesting that combinations of mono- and disaccharides are more cariogenic than individual sugars. Galactose was related to sulcal but not to buccolingual caries. This may be due to the fact that this type of sugar is not broken down as rapidly as the others by oral bacteria. In the sulci, galactose likely remains for a longer period of time, facilitating its breakdown into acidic end products that decalcify enamel - hence the positive correlation with sulcal caries.
All of the foods with cariogenic potential greater than or equivalent to sucrose (CPI ≥1.0), with the exception of bananas, had approximately 1% or more hydrolysable starch in combination with sucrose. This suggests that sucrose and starch combinations can be more cariogenic than sucrose alone (Mundorff et al., 1990)

Individual food components which were associated with low caries activity were protein, fat, calcium, phosphorous and fluoride. Protein, fat and phosphorus in foods were all associated with the inhibition of both sulcal and bucco-lingual (smooth-surface) caries. Fluoride was associated with the inhibition of bucco-lingual caries, whereas calcium was related to inhibition of sulcal caries.

The authors concluded that foods should be considered not only for their caries-causing potential but also for their anticariogenic potential since many contain components with cariostatic properties. Further, the relationship of a specific parameter with caries depends upon the type of caries being compared: a factor associated with the inhibition of sulcal caries may or may not have an effect on smooth surface caries etc.

2.2.4.2.4.6. Enamel slab experiments

Intra-oral appliances can hold slabs of enamel in the mouth for 1-6 weeks. This experimental system is extremely flexible so that by using either sound or partially demineralised enamel, the cariogenic or the remineralising effect of the diet can be assessed (Rugg-Gunn, 1993). Enamel slab experiments have some advantages over in vitro incubation and demineralisation experiments, and in vivo plaque pH experiments. Nevertheless, few experiments using slabs have been reported.

2.2.4.2.4.7. Plaque pH studies

If the acidogenic theory of caries aetiology is accepted, the effect of eating foods upon the pH of dental plaque is likely to be a reasonable guide to their cariogenicity

If measurements of plaque pH are made under standardized conditions, the acidogenicity – and therefore potential cariogenicity - of various foods, drinks and meal patterns can be compared. It is emphasised that what is measured is acidogenicity not cariogenicity, but it might be expected that the two are strongly correlated. Only the possible presence of ‘protective factors’ which may defend the enamel from dissolution
even at low pH, or ‘chelators’ which might cause loss of calcium at neutral pH, could confound the relationship (Rugg-Gunn, 1993).

Rugg-Gunn et al. (1978) ranked 22 snack foods by using the plaque sampling method involving 5 human subjects. Of the snack foods tested boiled sweets, sugared coffee and tea, and toffee produced the greatest fall in plaque pH, while sugarless chewing gum, salted peanuts, potato crisps, bread and butter, ‘ice-lolly’ and un-sugared coffee produced no fall, or only slight fall in plaque pH

2.2.4.2.4.8. Incubation experiments

These are simple laboratory tests that examine the ability of plaque microorganisms to metabolise test foods to acid. Saliva, which contains microorganisms, or pure cultures of oral microorganisms are substituted for plaque. Rapid acid production is taken to indicate that the food under test is potentially cariogenic. A slow rate of acid formation is likely to be of little clinical significance (Rugg-Gunn, 1993).

Grenby et al. (1989, 1990) investigated the potential cariogenicity of baby foods and drinks and other soft drinks by estimating the amount of calcium and phosphorous released when the test products were incubated with hydroxyapatite and plaque organisms. Sugar content was an important determinant of the amount of mineral dissolved, but other factors, such as the pH and buffering potential of the drink, were also relevant.

2.2.4.2.5. Dietary sugars and the pattern of dental caries

It is believed that in an age of generally declining dental caries, high sugar consumption is still a risk factor for children susceptible to proximal and smooth surface caries (Rugg-Gunn et al., 1984; Burt et al., 1988)

Sucrose may play a more dominant role in the development of smooth surface caries than in fissure caries because its metabolic by-products include extracellular polysaccharides - substances that greatly increase the adherence of cariogenic mutans streptococci to smooth enamel surfaces (Newbrun, 1982; Rølla et al., 1983). In fissure caries, where plaque can become packed into fissures, the adherence factor is not so critical (Burt, 1993).
Burt (1993) examined the impact on the development of caries, especially on the proximal and free smooth surfaces that followed a reduction in sucrose consumption and an increase in monosaccharide consumption. Comparing data on sugar consumption and the distribution of caries increments suggested that British 11-13-year-olds consumed more sucrose than their American counterparts and experienced more carious lesions on proximal and free smooth surfaces.
2.3. PREVALENCE OF CARIES IN YOUNG CHILDREN

2.3.1. Introduction

In epidemiology, the most important tool for measuring disease is the rate. There are two kinds of prevalence rates, point and period. When the term ‘prevalence’ is used without further specification, it generally refers to “point prevalence”.

Prevalence measures the number of people in a population who have a given disease at a certain time divided by the population at risk at that point in time (Last, 1983). Dental caries, however, usually requires to be measured by intensity and not simply by prevalence, since the latter cannot discriminate between degrees of severity. Such differences can usually be determined only by the use of an index such as DMFT(S)/dmft(s).

Some information on caries in primary teeth has often been drawn from studies of 5-year-old or older children. Studies on the prevalence of dental caries in pre-school children are fewer. In part, this may be a consequence of the practical difficulties of carrying out studies on representative samples of children who do not attend school (Holm, 1990). Information is available from many parts of the world but often from small studies with varying criteria, making comparisons difficult.

Risk factors make a functional biological contribution to the causation of disease, while risk indicators may be associated with disease but play no biological or functional role in causality (Manji et al., 1991). Although risk indicators are helpful in identifying groups at risk, they give little information about the causes of differences in caries experience (Verrips et al., 1992). Nonetheless, a number of risk indicators for caries have been identified. Socio-economic status has been considered one such factor in risk assessment studies (Hunter, 1988; Disney et al., 1992), as has low family income. The latter can affect food selection and nutrient intake in mothers and infants during the tooth development period, level of education, health values, lifestyle and access to health care information. As a consequence, it can be an indirect factor for susceptibility to caries (Li et al., 1996).

The flow of immigrants to industrialised countries has introduced ethnicity as a new risk indicator (Bedi and Elton, 1991; Verrips et al., 1992).
Studies on caries prevalence have been more frequent in developed countries, and changes over time have been demonstrated. Those from developing countries are less numerous, but reports are available from Africa, South East Asia and the Middle East.

2.3.2. Caries prevalence in developed countries

The 1995 ORCA symposium (Marthaler et al., 1996) presented data on caries prevalence from recent studies (1991-1995) in all European countries, and indicated there to be wide variation. Despite the continuous reduction noted in most "Westernised countries", an increase in some was reported. For example, in Albania the dmft of 6-year-olds increased from 3.4 in 1989 to 8.5 in 1994. In several countries (Switzerland, Netherlands, England and Wales, Finland, Norway, Denmark and Ireland-[Eastern Health Board]) where the second-last average dmft was below 2.0, new averages remained stable or decreased slightly, the latest ranging between 1.3 and 1.6 dmft. However, Irish Eastern Health Board data showed the average dmft of Irish 5-year-olds to have decreased from 1.3 in 1984 to 0.9 in 1993 (Marthaler et al., 1996).

Some studies have not only recorded a decline in caries prevalence but have also offered data on when this decline began to slow down. In England and Wales, the trend in caries experience for 5-year-olds recorded in successive OPCS (Office of Population Censuses and Surveys) and BASCD (British Association for the Study of Community Dentistry) surveys between 1973 and 1983 showed a dramatic decline (4.0dmft - 1.8dmft). Thereafter there was little further reduction; a slight upswing from 1.7dmft to 1.8dmft was even recorded between 1991/92 and 1993 (Downer, 1994b). However, the proportion of 5-year-olds free of caries increased slightly from 51 % to 55 % (Downer 1994a), a change compatible with the hypothesis of increasing polarisation in caries experience (Downer, 1994b).

This fluctuation was further illustrated in three studies of 2-4-year-old children in Camden, an inner city district of London, over a period of 20 years (Holt, 1990). Caries prevalence declined during the 1970s but has not continued to do so during the 1980s. In 3-year-olds the percentage of caries-free children increased from 64 % in 1966-68 to 78 % in 1980-81, and then decreased again to 72 % in 1986.
In the Nordic countries (Von der Fehr, 1994), 60-70% of 5-year-olds were reported at national level to be caries-free in 1991-92. The average dmft was 1.4-1.5. Large regional differences, however, were observed in Denmark, Finland, Norway and Sweden. The Danish material which included individual dmf components, demonstrated that a decline in caries prevalence (3.2-1.5dmft) took place in the period from 1978 to 1989, a reduction primarily due to an increase from 27% to 63% in the proportion of caries-free children. However, as in the UK, caries decline halted or even reversed after 1989. Similar trends were also observed in Norway (Haugejorden, 1994).

In Canada, Burt (1994) presented unpublished data from the Ontario Ministry of Health for def scores and caries prevalence in 5-year-olds between 1974 and 1990. Although the data showed evidence of decline since 1974, there was reason to believe that this had stopped, with 1990 levels little different to those of 1986.

Two earlier surveys from the United States - the National Dental Caries Prevalence Survey 1979/1980 (1981) and the National Survey of Dental Caries in US School Children 1986/1987 (1989) - also demonstrated a decline. However, trends since that time have been difficult to estimate as there have been no national surveys of oral health: small studies which reflect regional variations make it difficult to draw inferences about national trends. Nonetheless, one local study (Heller et al., 1994) in three Michigan communities in 1986 and 1993 showed that caries experience in primary dentition had not changed over those seven years.

Burt (1994) concluded that, in North America, the apparent levelling out of caries experience in the primary dentition began around 1986/1987.

Lately, some improvement has been reported in England. In the last BASCD survey (Pitts et al., 2001) the data showed a slight decrease in caries prevalence after a long plateau. Yet significant groups remain within the population of 5-year-olds who have dental disease and who are in need of dental care. The authors believe there is a continuing need for more effective preventive and treatment services for the under-fives.
2.3.2.1. Caries prevalence and socio-economic status

It has long been recognised that there are a number of health inequalities related to social class. It is not only in death that inequalities exist between social classes, but also in patterns of morbidity (Beal, 1989).

The literature is rich with evidence of social factors influencing oral diseases and illness. There is no consensus, however, as to how social class actually affects oral health.

Although economics has a role to play in physical health, the rich and the poor have different lifestyles and are separated by more than money (Petersen, 1997). Poverty creates an environment with numerous obstacles to dental care, of which the lack of funds is only one (Pinkham et al., 1988). This has been illustrated by the fact that children from lower social classes have higher caries prevalence even when there is access to free dental care (Hausen et al., 1982) and when preventive treatment is received at school (Poulsen, 1987).

There are numerous ways of dividing the population into social classes according to standard criteria based on one of the following: occupation, education, housing characteristics, ownership of consumer durables or other indicators of life circumstances. A large number of occupational classifications have also been developed, the earliest and most widely used in the United Kingdom being the Registrar General’s Social Class Classification introduced in 1911 (Reid, 1981). Its aim was to allocate occupations to hierarchically ranked groups on the basis of the degree of skill involved and the social position implied:

Social class I: Professional (e.g., accountant, doctor, lawyer)
Social class II: Intermediate (e.g., manager, nurse, school teacher)
Social class III NM: Skilled non-manual (e.g., clerical worker, secretary, shop assistant)
Social class III M: Skilled manual (e.g., bus driver, butcher, carpenter, coalface worker)
Social class IV: Partly skilled (e.g., agricultural worker, bus conductor, postman)
Social class V: Unskilled (e.g., cleaner, dock worker, labourer)
This system, however, has several disadvantages. One is that the relationships between occupations change with time. Thus, the income of some individuals classified as Class III manual may now exceed that of individuals in Class I. Further, the system may not be sensitive to structure within an occupation. For example, a small shopkeeper may be assigned the same class as the owner of a large retail firm. Neither does the system include the unemployed, single parents or women in paid employment who contribute to the material well-being of the family.

Another main limitation of this system is that about half the population falls into social class III, making an uneven balance in numbers in large random samples. To overcome this difficulty, various combinations of classifications have been used. These have included dividing the population into non-manual or middle classes (classes I-IIIN) and manual or working classes (classes IIIM-V) (Holt et al., 1982, 1988; Jones and Nunn, 1995), and combining classes I and II and classes IV and V but retaining class III either alone (Carmichael et al., 1984,1989) or subdividing it into manual and non-manual groups (Silver, 1982,1987; Dummer et al., 1987,1990). In the national surveys of child dental health carried out in the United Kingdom, groups were combined to give three categories. The first comprised classes I, II and III NM, the second comprised class III M, and the third was made up of classes IV and V (Todd and Dodd, 1985).

Several studies have investigated the relationship between the five different social classes and dental caries (Winter et al., 1971a and b; Shaw and Murray, 1980).

These systems have all made it possible to identify broad patterns and trends in relation to dental caries.

Many studies have demonstrated a positive correlation between social class and dental caries, with more children in the lower classes experiencing caries (Winter et al., 1971a; Carmichael et al., 1980, 1984; French et al., 1984; Todd and Dodd, 1985; Mansbridge and Brown, 1985, 1986; Tee, 1987; Dummer et al., 1987, 1990; Holt et al., 1988; Slade et al., 1996b).

In a study carried out in Camden in the late 1960s, Winter et al. (1971a) found an association between social class and dental caries. In the same area in 1986, Holt et al. (1988) investigated caries experience in 565 1-5-year-old pre-school children, and also reported a highly significant relationship between social class and the number of children
with or without caries. Children from social class IIIM-V and those who were unclassified (mainly single parent families and those from families in which the father was unemployed) had higher caries experience (22% and 18% respectively) than those in social classes I-IIIN (8%). This relationship was further confirmed in a more recent study in Camden during 1993/1994 (Holt et al., 1996). A higher proportion of children in the lower social classes experienced caries: 23% and 14% for children in the IIIM-V and unclassified groups respectively compared to 14% in those of classes I-IIIN. There was a trend for children in the non-manual classes to experience a higher prevalence of caries than in 1986, and for the children who could not be classified to have less disease. These findings were not entirely straightforward, since in multivariate analysis social class failed to contribute significantly to the risk of having caries.

The first national study of child dental health in England and Wales in 1973 (Todd, 1975) showed that children from social classes IV and V were more likely to have caries experience. A similar trend existed in the 1983 UK survey (Todd and Dodd, 1985). Five year-olds from social classes IV and V had twice as many teeth with decay experience as children from professional households.

In England, a national survey of children aged 1½ - 4½ showed that caries was strongly linked to social factors, with higher levels of disease in children with families who received state benefit. Among 3½ - 4½ year-olds, 40% of children from the manual social class group had some decay experience compared to 16% of those from households with a non-manual head (Hinds and Gregory, 1995).

In Hong Kong (Wei et al., 1993), dental caries in 5-year-olds was presented in terms of four social classes: higher positions in society; upper middle class; lower middle class; and workers, farmers, and fishermen. A significant, positive correlation was found not only between the father’s profession and child’s caries status, but also between the latter and parental income.

Markers other than occupation have also been used to study the relationship between dental caries and social classes.

Education has been studied as a marker by a number of investigators (Holan et al., 1991; Thomas and Startup, 1992; Verrips et al., 1992) and an association between the parents' education level and their child’s caries experience has been noted. For example,
Verrips et al. (1992) showed that the 3-4-year-olds of parents with no school education were especially at risk; their mean dmfs score was 4.7 times higher than that of a reference group. Further, a study of Latvian nursery school children reported a non-significant tendency towards lower caries levels when parents were more highly educated (Bjarnason et al., 1995). Similar findings have also been reported in the former Soviet Union (Honkala et al., 1992).

A study in Wales (Thomas and Startup, 1992) showed that lower dmft values in 5-year-olds were positively associated with households possessing a telephone, a car and with higher maternal educational achievement.

In Scotland (Schou and Uitenbroek, 1995), socio-economic status was significantly related to caries experience in 5-year-olds. Children with low socio-economic status were less likely to be caries-free no matter which way that status was measured (mother’s education, the mother’s or her partner’s occupation, which newspaper they read, how many cars they had or simply by postal codes).

Studies to assess the impact of water fluoridation on the caries x social class interaction have also been undertaken. Differences between fluoridated Newcastle and non-fluoridated Northumberland were observed in all social class groupings. The respective figures for caries prevalence (and mean dmft) in 5-year-olds in the three social groupings: I+II; III; and IV+V; were 23% (0.59), 39% (1.21), and 31% (1.17) in the fluoridated area, and 38% (1.46), 47% (2.04), and 62% (2.74) in the non-fluoridated area. The greatest difference in the percentage of children with decay experience and severity in the fluoridated (31% and 1.71dmft) and non-fluoridated (62% and 2.74 dmft) areas occurred in social groups IV+V (Evans et al., 1996). These authors then compared their findings with data gathered over the previous 18 years and concluded that there had been a fall in caries in both the fluoridated and non-fluoridated areas since 1987, although this reduction was not enough to obviate the disadvantage of social background.

A study in Australia aimed to evaluate inequalities in children’s dental caries experience with respect to socio-economic status groups, and to investigate the effect of exposure to fluoride in water on those inequalities. Children from low socio-economic status (categorised by household income and parental education) had higher mean dmfs than children from high socio-economic groups. The independent effects of income and
education remained significant even after controlling for exposure to fluoride in drinking water (Slade et al., 1996b).

The effect of water fluoridation on the caries experience of young children at high and low levels of material deprivation (measured by the Townsend Index) was undertaken in County Durham. The mean dmft values and the number of children with caries were 0.8 and 30% in the fluoridated low deprivation group, 1.2 and 34% in the non-fluoridated low deprivation group, 1.2 and 40% in the fluoridated high deprivation group, and 2.1 and 55% in the non-fluoridated high deprivation group. Most caries was within the high deprivation group. In the fluoridated areas there were lower caries experiences within each group compared to the non-fluoridated wards. Reductions in caries experience with fluoridation were larger for the more deprived, higher caries group. This clearly demonstrates that fluoridation reduced - but did not eradicate - the dental inequalities associated with material deprivation (Provart and Carmichael, 1995).

2.3.2.2. Caries prevalence and ethnic minorities

Over the last three decades, dental health has improved significantly in developed countries. This improvement, however, has not been experienced equally across the population. Inequalities in health continue to be an area of concern.

Bedi and Elton (1991) argue that dental health professionals are acutely aware of important differences in dental disease, some of which are not racially based but merely associated with social deprivation, poor housing and the inability to speak English. New immigrants present unique problems to health providers because of different backgrounds, food preferences, unhealthy conditions and a seemingly endless array of special needs (Waldman, 1995). The process of migration itself can be destabilising to health and well-being. For example, exposure to new social and physical conditions in a new country can be a major threat to health. Marginalisation, poor communication and unfamiliarity with official systems can exacerbate these difficulties (Karmi, 1996). Besides the stress of migration and moving to typically crowded living conditions in deprived inner city areas, some minority groups retain - or acquire - beliefs, attitudes and behavioural characteristics that are quite distinct from those of the host community (O'Mullane et al., 1996). These authors further argue that genetically transmitted
characteristics should not be disregarded and that caries prevalence in immigrants should take into account the relative contributions of genetics and environment.

Despite the improvement in caries prevalence in developed countries, it remains a problem in many immigrant groups. Immigrants have varying caries prevalence, which might be attributed to their diverse background (Marthaler et al., 1996). In a study on trends in coronal caries prevalence in north-western Europe (Holm, 1996), the primary dentition of immigrants presented more severe caries situations than that of older children with permanent dentition. In England, Asian pre-school children have more dental caries than White children (Prendergast et al., 1989; Bedi and Elton, 1991). The latter authors compared the dental caries experience of Asian and White Caucasian children aged 5 and 6 years attending multiracial schools in Trafford and Glasgow, and demonstrated that Asians had 4.18 and 4.49 dmft compared to 3.02 and 3.29 dmft for White Caucasians in the two areas respectively. The Asian population was further divided according to religion and to the English language ability of the mother. Non-Muslim children of English speaking mothers had similar caries levels in both areas (Trafford 2.28 dmft and Glasgow 2.32dmft) and better dental health than the rest of the Asian population.

In Greece, a sample of 195 pre-school immigrant children in a northwestern area of Athens was examined. Although of Greek origin, the children were born either in the USSR or in Athens and their parents were recent immigrants. The proportion of children that had experienced carious attacks was 68.7% and the mean deft index was 4.38. Compared to the results of a similarly conducted study of Greek children in the Athens area (Artemi et al., 1992), the mean deft value of immigrant children was found to be almost four times higher (Lygidakis et al., 1996). However, any comparison between the two studies should not disregard the fact that they were carried out four years apart.

In the Netherlands (Verrips et al., 1992), 5-year-olds from Morocco and Turkey were found to have dmft values approximately twice as high as Dutch and Surinamese children (8.1 and 8.2 versus 3.6 and 3.4 respectively). The authors attributed the lower caries prevalence in Surinamese children to their parents' good knowledge of the Dutch language, and therefore the disappearance of certain barriers to obtaining care. In a later study (Verrips et al., 1993), the dental health of 5-year-olds born in 1982 was assessed. The sample was stratified not only by ethnicity but also by the level of maternal
education, resulting in six different strata: three Dutch (high, low and unknown level of education) and three Turkish/Moroccan (high, low and unknown level of education). The difference in the mean dmfs scores was statistically significant: children in the Turkish/Moroccan groups had higher mean dmfs scores than their Dutch peers in similar educational strata. Within both ethnic groups, children in the low or unknown education groups had higher mean dmfs scores than children in the high education groups. The results clearly show that ethnicity and maternal education are independent indicators of caries risk in primary dentition. It is interesting to note that, between 1987 and 1993, caries prevalence in 5-year-olds of Turkish or Moroccan origin decreased significantly, and that the difference between Dutch and Moroccan or Turkish groups became much smaller. It is hypothesised (Kalsbeek et al., 1996) that immigrant parents participating for longer in Dutch society adopt the dental health habits of the host population.

In Finland, when caries prevalence in the primary dentition of Tanzanian immigrants and Finish 3-7-year-olds was compared (Kerosuo and Honkala, 1991), the results indicated that high socio-economic status decreased the risk of caries in Finnish children but was not associated significantly with the risk of Tanzanian children developing caries. It would seem that ethnicity could be a stronger determining factor than socio-economic status.

In the United States, differences in caries experience have been found among race and racial-ethnic subpopulations. In general, Mexican-American children were less likely to be caries-free in their primary dentition. In the 2-4 age group, the percentage of caries-free Mexican-American children was 67.7 % compared to 78 % in non-Hispanic Blacks and 87 % in non-Hispanic Whites (Kaste et al., 1996).

A weak effect of socio-economic status was also reported in a study of 36-72-month-old Asian children residing in a fluoridated city in Canada (Williams and Hargreaves, 1990). No significant differences were seen in the presence or extent of caries in relation to maternal education (years spent in full time education) or the employment status (self-employed, unemployed or manual or non-manual worker) of the head of the household (usually the father). It is interesting to consider whether, and to what extent, fluoridation may have contributed to an elimination of these differences. These findings are contrary to those reported for Asians in unfluoridated parts of the United Kingdom on Asian ethnic minorities (Bedi, 1989).
2.3.3. Caries prevalence in developing countries

The pattern of caries in developing countries is following a similar pattern to that observed in Europe during the 18th and 19th centuries, i.e., an increase in prevalence and severity initially in the upper income groups, then in the urbanised populations, and finally in the rural groups (Sheiham, 1983). This is explained by the fact that cariogenic foods normally became available sooner to the more wealthy people. In the developed countries, effective preventive behaviours were later adopted by the affluent and dental caries became a disease of the deprived (O’Mullane et al., 1996) - a pattern that is likely to be repeated in the developing world.

Developing countries are often discussed as though they formed one coherent group of populations with similar trends of health and disease. But this is not justified. In reality, differences in race, religion, culture, economy, diet, hygiene practices, attitudes and behaviour can be huge, and are likely to have a major impact on oral health (Holm, 1990).

Studies performed in developing countries indicate there to be large variations in caries experience, not only between different countries where caries experience is either low (Noah, 1984; Mosha and Robison, 1989) or high (Amaratunge et al., 1986; Irigoyen et al., 1986; Petersen and Steengard, 1988; McNulty and Fos, 1989; Wright et al., 1989) but also in the same country (Songpaisan and Davies, 1989). In some developing countries there is an indication of an increase in caries. Studies in the Sudan and Nigeria (Emslief, 1966; Ibrahim et al., 1986; Olojugba and Lennon, 1987) performed several years apart in pre-school children have shown an increase in dmft values. It is suggested that there has been a rapid accumulation of risk factors in developing countries over the last two decades, effectively increasing the likelihood of caries developing (Manji et al., 1991). Several attempts have been made to identify the nature of these factors (Enwonwu, 1981; Sreebny, 1982; Manji, 1986).

Few studies have been carried out in developing countries on the impact of social class. In some, social classes have been assigned according to the type of schools attended by children: those at private schools classified as having high socio-economic status, and those attending public school as having low socio-economic background. In
Brazil (Freire et al., 1996), it was reported that 4- and 5-year-olds in private nurseries had (1.19 and 2.03dmft respectively) less caries than children in public nurseries (2.48 and 3.5dmft respectively). The percentage of children who were caries-free at 4 and 5 years of age was 67.3% and 58.3% respectively for private nurseries compared to 43.9% and 29.8% respectively for public nurseries.

It is apparent that the higher social classes have a significantly lower caries experience than those in the lower social classes, as in developed countries.

2.3.3.1. Caries prevalence in the Middle East and the Arab countries of Africa

Data on the dental health of pre-school children in the Middle East are sparse. Caries experience varies not only between different countries but also within the same country due to differences in geographical location, fluoride level, lifestyles, sample size and age groups. Further, some studies have sampled specific age groups while others have investigated wide age ranges.

2.3.3.1.1. Caries experience and age

In a cross sectional survey conducted in Al-Khobar, 1665 6-17-year-old pupils were studied. The mean dmft score of 6-7-year-olds was 5.11 (Magbool, 1992). This contrasts with the 2.7dmft recorded for 7-year-old children in Ashkelon (Zusman and Crawford, 1995). The latter figure is even lower than that (3.8dmft) recorded in 7-year-old Kuwaiti children of high socio-economic class (Murtomaa et al., 1995). A study from Saudi Arabia (Alamoudi et al., 1996) reported a much higher figure (5.61dmft) for 7-year-old children in Jeddah.

More reports have provided data on dmft in 6-year-old children. In Saudi Arabia 7040 school children aged 6-15-years in the Riyadh District were studied (Al Sekait and Al Naser, 1988). The number of decayed and filled primary teeth recorded for 6-year-old children was 0.8dft. This is surprisingly low compared to the results of other Saudi Arabian studies. Al Shammery et al., (1990) recorded 4.14 dmft in boys and 3.43 in girls in Riyadh, while in the same year Al Khateeb et al. (1990) reported mean dmft figures of 4.6, 2.1 and 2.7 for 6-year-olds in Jeddah, Rabagh and Mecca respectively. A few years
later, a higher figure (5.54dmft) was reported (Alamoudi et al., 1996) for 6-year-old children in Jeddah.

Six-year-old Kuwaiti children have been reported (Vigild et al., 1996) to have a mean dmft of 6.2 compared to 4.6 for Omani children (Al-Ismaily et al., 1997). These figures are much higher than those recorded in Jordan where a dmft of 2.15 has been reported for children in Amman (Hamdan and Rock, 1993).

Fewer reports have examined pre-school children. One from Saudi Arabia recorded a mean of 7.12dmft for a sample of 103 5-year-olds attending two nurseries in Al-Kharj near Riyadh (Paul and Maktab, 1997). Two reports from Abu Dhabi recorded different means. One (Al Mughery et al., 1991) reported mean dmft figures of 5.14, 5.02 and 3.06 for 1210 5-year-old children in city, rural and private schools respectively, with a mean of 4.63dmft for the whole sample. The other (Al Hosani and Rugg-Gunn, 1998), a study of 640 2, 4 and 5-year-old children, reported mean dmft figures of 8.4, 8.6 and 5.7 for 5-year-olds in Abu Dhabi, Al-Ain and the Western Region.

Holan et al. (1991) examined 210 5-year-olds from an Arab village in Israel and recorded scores as high (8.04dmft) as those reported from Abu Dhabi and Al-Ain. A much lower figure (2.9dmft) for this age group was reported in Kuwait (Murtomaa et al., 1995). The authors indicate that the low caries experience of the whole sample of 3-7-year-olds, which was also 2.9dmft, should be considered an underestimation of the situation in the whole country since the studied population most likely represented a higher socio-economic status than the average.

Scores for 4-year-olds in two studies from Kuwait were 1.4dmft (Murtomaa et al., 1995) and 4.6dmft (Vigild et al., 1996).

In Abu Dhabi (Al Hosani and Rugg-Gunn, 1998), higher figures for 4-year-olds were recorded in the three areas studied: Abu Dhabi (6.2dmft), Al Ain (5.2dmft) and the Western Region (5.1dmft).

In a study on Iraqi children (Ghose et al., 1983), 43-48-month-olds were found to have a score of 4.4deft. The average deft for the whole study sample including all age groups (13-48-months) was 2.3deft. This figure may be considered comparable to a Kuwaiti study (Al Dashti et al., 1995) where 2.4dmft was reported for the total sample of 227 18-48-month-old children. One should not ignore that the two studies were
carried out in two different countries and with a time difference of 12 years.

Studies that include **different age groups** within their samples agree that caries is age related, with caries experience increasing up to a certain age and then declining. This increase with age, starts when children are just two years old. In Riyadh, Saudi Arabia (Al Mohammadi et al., 1997), where two social classes (high and low) and a rural population were studied, an increase in caries prevalence was demonstrated in all three groups, starting at 0.4, 1.7 and 0.2dmft, with a prevalence of 17%, 30% and 6% respectively by the age of two, rising to 3.7, 5.0 and 2.9 dmft with a prevalence of 62%, 89% and 61% respectively by the age of six.

A study in Abu Dhabi (Al Hosani and Rugg-Gunn, 1998) investigated caries prevalence in three different areas (Abu Dhabi, Al Ain and the Western region). The scores were different in the three studied areas but an increase with age was demonstrated in all. For example, in Abu Dhabi a score of 1.7dmft and a prevalence of 35.5% was recorded at the age of two, rising to 6.2 and 8.4dmft with corresponding prevalence figures of 85.7% and 93.8% respectively, by the ages of four and five.

A Jordanian study (Janson and Fakhouri, 1993) of 255 6-month-6-year-olds in a suburb of Amman showed that caries was clinically visible in the second year of life and recorded a prevalence of caries of 25% in those 2-3 years of age, rising to 72% in the 3-6 year age range.

Other authors have not only reported an increase in prevalence and severity with age but also the age at which decline occurred. In one study from Saudi Arabia (Al Sekait and Al Naser, 1988), scores increased from 0.8dft at the age of six to 1.2dft at the age of eight, and then declined to 0.8dft by the age of nine. In Al Khobar (same country) the decline was evident by 8-9 years of age, where a score of 4.7dmft was recorded compared to 5.1dmft at 6-7 years of age (Magbool, 1992). A third study from Saudi Arabia (Alamoudi et al., 1996) demonstrated that in a sample of 522 6-9-year-olds living in Jeddah (a cosmopolitan city with a mixed population of Saudi and non-Saudi children), scores were 5.54dmft at the age of six, 5.61dmft at seven, declining to 4.41dmft and 2.93dmft by the age of 8 and 9 respectively.

This pattern has been further demonstrated in a Kuwaiti study (Murtomaa et al., 1995) where a random sample of 450 3-7-year-olds was examined. Caries experience
increased with age, reaching its maximum (4.1dmft) by the age of six and declining to 3.8dmft by the age of seven.

The exfoliation of incisors in the older age groups might explain why the index of 7-year-olds was lower than that of 6-year-olds. The latter may still have had carious incisors, while the incisors of the 7-year-olds had probably exfoliated (Murtomaa et al., 1995).

2.3.3.1.2. Caries experience and gender

With respect to gender, results have been controversial. In some studies, a lack of a consistent difference in caries experience between genders is reported (Ghose et al., 1983; Al Mughery et al., 1991; Murtomaa et al., 1995; Al Dashti et al., 1995; Paul and Maktabi, 1997; Al Hosani and Rugg-Gunn, 1998). Al Hosani and Rugg-Gunn (1998) studied three different areas of Abu Dhabi and found no gender-related differences in two (Abu Dhabi and Al Ain). However, in the third (the Western Region), higher dmft scores were recorded in boys in three age groups (2, 4, and 5 years) (3.2, 7.5 and 7.2 in boys compared to 2.3, 3.5 and 4.5 in girls). In agreement, others authors have reported that caries experience is higher in boys (Al-Khateeb et al., 1990; Al Shammery et al., 1990; Janson and Fakhouri, 1993; Hamdan and Rock, 1993). On the other hand, some authors have reported the opposite (Al Sekait and Al Naser, 1988; Vigild et al., 1996). The latter authors suggested that the earlier eruption of the teeth in girls was a likely explanation for their higher caries experience.

2.3.3.1.3. Caries experience and regions

In Oman (Al Ismaily et al., 1997), data was collected for 3114 Grade 1 (6-year-old) children from 11 administrative regions. Examinations were carried out according to the protocol of the British Association for the Study of Community Dentistry (BASCD), using the criteria defined by Palmer et al. (1984). Examination was confined to canines and molars. Large variation between the administrative regions was observed with regard to caries severity and percentage of caries-free children. Percentages of caries-free children and dmft scores ranged between 30.8 % and 3.04dmft in Al-Woustah to 4.4% and 6.56dmft in Dhahira. Similarly, in Abu Dhabi (Al Hosani and Rugg-Gunn, 1998),
different figures were reported for Abu Dhabi, Al Ain and the Western region in 2, 4 and 5-year-old children. For example, in 2-year-olds the dmft scores for the three regions were 1.7, 3.2 and 2.8dmft respectively. The authors noted that the reason for this difference was not obvious.

2.3.3.1.4. Caries experience and fluoride concentration

Fluoride in drinking water may have a role to play in the difference in caries experience between regions. Al-Khateeb et al. (1990) investigated the caries experience of 1440 6, 12 and 15-year-olds from three cities in Saudi Arabia with varying concentrations of fluoride (Jeddah <0.3ppm; Rabagh 0.8ppm; and Mecca 2.5ppm). For 480 6-year-olds (160 in each area) the figures were 4.6, 2.1 and 2.7dmft respectively. The lowest (2.1dmft) was recorded in optimally fluoridated Rabagh.

A Sudanese study (Ibrahim et al., 1997) examined 124 6-16-year-old children in two areas with contrasting fluoride content in their drinking water (Treit el Biga 0.25ppm and Abu Groon 2.5ppm). Marked differences in caries experience in the primary dentition were noticed. The percentage with caries and the dmft scores in Treit el Biga were 72 % and 2.2 compared to 23 % and 0.5 in Abu Groon. This was not the case in the permanent dentition. The severity of dental fluorosis was not related to caries experience when all the children were included in the analysis. It is worth noting that the sample of this study was heterogeneous in age and gender, in addition to being relatively small.

2.3.3.1.5. Caries experience and rural areas

The situation in rural areas has also been investigated and compared to that of either urban areas or the different socio-economic classes in urban areas. Al Hosani and Rugg-Gunn (1998) found that children 4- and 5-years-old from rural areas of Abu Dhabi tended to have more caries than children of urban areas (6.0 and 8.4 dmft for rural versus 5.2 and 7.1 dmft for urban).

In a study from Saudi Arabia (Al Mohammadi et al., 1997), data of 2, 4 and 6-year-old children from rural areas were compared to those of high and low socio-economic classes in the Riyadh region, and provided conflicting results. The dmft scores
were lowest in the rural area for children aged 2 and 6 years of age (0.2 and 2.9dmft respectively compared to 0.4 and 3.7dmft for the high socio-economic class). For four year-olds, the lowest score recorded was for children from the high socio-economic class (mean dmft 0.7 compared to 2.1and 3.0 for the rural and the low socio-economic class respectively). For the three age groups, mean dmft values were highest in the urban low socio-economic group, although only in children aged 6 years did the difference between the low and high socio-economic groups reach statistical significance.

Al Mughery et al. (1991) examined all 5-year-olds attending city and rural schools within the Abu Dhabi administrative area, as well as those of three private schools. Caries experience in the city (5.14dmft) and rural (4.39dmft) school children was greater than those attending the private schools (3.06dmft).

2.3.3.1.6. *Caries experience and socio-economic status*

Socio-economic status was investigated in a few reports where it was defined in a number of ways. One report from Saudi Arabia (Al-Khateeb et al., 1990) considered children at private schools as of high socio-economic status and children at public schools as of low socio-economic status. Three cities were studied (Jeddah, Rabag and Mecca). In the three age groups examined (6, 12 and 15-year-olds), caries experience was greater among public school pupils than those of private schools. Differences were particularly marked amongst residents of Jeddah, where the level of fluoride in drinking water is less than 0.3ppm. Six-year-old children attending public schools in this city experienced considerably higher levels of caries than their counterparts in private schools. The difference was 54 % (a mean dmft of 6.3 for public schools compared to 2.9 for private schools).

Another report from Jordan (Hamdan and Rock, 1993) classified children into three socio-economic groups according to the method of Al Titi (1990). Children of private schools were considered to be of high socio-economic class, children of public schools as of middle class, and children of schools in the deprived areas and refugee camps of low socio-economic class. High social class children had significantly lower caries experience (1.6dmft) than did middle (2.7dmft) and low socio-economic (2.3dmft) class children.
Parental education is believed to play a role in the oral health of children. A study of 210 kindergarten children aged 5 in an Arab village in Israel (Holan et al., 1991) was conducted not only to determine caries experience but also to examine the effect on this of the parents' education level. Each parent's education level was scored as follows: level 1 = completed 5 school years or less; level 2 = completed 6-9 school years; level 3 = completed 10-12 school years without a high school diploma; level 4 = completed 12 years with a high school diploma; level 5 = university or college but without an academic degree; level 6 = university studies with at least a first degree.

Caries experience in the children of mothers with lower levels of education (levels 1, 2 and 3), were significantly higher than in children whose mothers had higher education (levels 4, 5, 6).

With respect to paternal education, dmft values were significantly lower (6.04) only in the children of fathers with an academic degree (level 6).

Income has been investigated in a number of studies. Al Sekait and Al Naser (1988) studied a sample of Saudi children aged 6-15 and reported that dental caries was more prevalent in the middle and upper income groups. Similarly, in Oman (Al-Ismaiely et al., 1997) it was found that the percentage of caries-free children in Batina North (7.1%), an affluent region, was relatively low.

A study in Kuwait (Al Dashti et al., 1995) investigated socio-economic status according to the father's employment as well as maternal education level. Paternal employment was classified as social classes I, II and III (social class I = professional and technical, social class II = skilled and semiskilled, and social class III = manual). Maternal education was classified as 'no schooling', up to 'primary', 'middle' or 'secondary' school, or higher education when mothers had a college degree. Analysis of the social class structure of the sample indicated that 33% came from social class I, and 60% from social class II. Only 7% came from social class III. Most mothers had either a college degree (48%) or had finished middle or secondary school (44%). Differences in caries experience between classes were significant in terms of paternal occupation and maternal level of education. The dmft values and percentage of caries-free children in social classes I and II were 1.2 and 58% in class I compared to 3.0 and 42% in class II.
Similarly, 55% of children whose mothers had a college degree were caries-free compared to 39% of those whose mothers had finished middle or secondary school.

On the other hand, in a suburb of Amman (Janson and Fakhouri, 1993) dental decay was related to neither maternal education nor paternal profession. This was further confirmed in a study of south Jerusalem (Sgan-Cohen et al., 1997).

In a study from Abu Dhabi (Al Hosani and Rugg-Gunn, 1998), the effect of education together with income was studied. With respect to parental education, each child was categorised as either: low = primary school only; middle = achieving high school level; high = university or college education. The three income groups were: low = less than 3000 Dirham per month; middle = 3000-7000 Dirham per month; high = more than 7000 Dirham per month. Four and five year-old children of parents of high educational status tended to have less dental caries (2.6dmft and 5.6dmft respectively) than those of low education level (7.0dmft and 8.6dmft respectively). The relationship between parental income and dental caries experience was less apparent. Using data from all 640 children, logistic regression analysis revealed that educational status and income were significantly related to caries prevalence. Examination of the odds ratio revealed that, as parental educational attainment increased from low to middle and from middle to high, caries risk decreased markedly. Conversely, as parental income increased from low to middle and from middle to high, caries risk increased. Mean dmft was 6.9 in the high income/low education group compared to 2.7 in the low income/high education group. The authors comment that the opposing effects of education and income are intriguing and have not been reported previously. It was suggested that the combination of high income and poor parental education is a new risk factor which needs further investigation.

A Sudanese study (Radaal et al., 1993) reported a tendency for dental caries to be more prevalent in the highest socio-economic group, but this trend was not statistically significant. The authors used two variables to classify children into three different socio-economic groups: the level of maternal education (primary school, secondary school and university) and family total income per month. The authors attributed the failure to reach significance to a weakness in the criteria for classifying the children into socio-economic categories, especially in an economically fluctuating country like Sudan. Another reason given was the rationing of sugar in Sudan for a number of years prior to the study.
2.3.3.1.7. Caries prevalence: change over time

A limited number of studies have investigated change of caries prevalence over time.

Data from a 1993 survey carried out in Kuwait (Vigild et al., 1996) was compared to results from the First National Oral Health Survey of 1982 (Glass, 1983). The percentage of caries-free 6-year-olds (dmft=0) decreased from 21 % in 1982 to 9 % in 1993. This was partly associated with an increase in the filling component.

Contrary to the findings from Kuwait, two reports from Israel mentioned a decline over time. Zusman and Crawford (1995) examined 602 7-year-olds recruited in three surveys (235 in 1980, 176 in 1982, and 191 in 1994) in Ashkelon. Between 1980 and 1994 the percentage of children free from caries rose from 21 % to 29 % and the dmft dropped from 3.5 to 2.7. Improvement was mainly due to a fall in disease prevalence. The decayed (dt) component was almost halved from 2.6 in 1980 to 1.7 in the same period. Similarly, Sgan-Cohen et al. (1997) investigated 6-and 9-year-old children in south Jerusalem. A reduction of 42 % in dmfs (13.95-8.09) in 6-year-olds between 1983 and 1992, and 48 % (13.87 - 7.22) in 9-year-olds between 1986 and 1992, was reported.

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It is worth remembering that studies in the Middle East – as in other developing countries - have their limitations. Strict comparisons of the results of different studies conducted at different times in the same country, or the results of studies conducted over approximately the same period but from different countries is inevitably difficult. The studies mentioned here were conducted for a variety of reasons, with different aims and objectives, and only a few were designed with the specific intention of obtaining national estimates. Consequently, the extent to which inferences from the data can be made is restricted to the sections of the population from which samples were drawn, and may not necessarily reflect national trends. Different diagnostic methods may also affect the results obtained, although in most Middle Eastern studies WHO methodology (1985, 1987) has been used to collect caries data. Other factors such as the geographical location and the different lifestyles together with certain unknown factors may further complicate comparison.
2.4. PATTERN OF CARIES IN YOUNG CHILDREN

2.4.1. Introduction

Despite its wide use, prevalence has certain limitations. Its measurement depends not only on the existing cases of disease but also on the sample size. Prevalence data report nothing about the severity of the condition, but only about how many people have it. Accordingly, its range covers different severity levels, from a case with one lesion to a case where the whole dentition/surfaces is/are affected. However, dmft(s)/DMFT(S) indices can discriminate between degrees of severity.

DMF and def indices for teeth or surfaces are used universally for the examination of caries experience. Although these measures have proved useful for a number of decades, they also have their limitations. They are a broadly encompassing measure that looks at entire populations without focusing on individuals or caries patterns (O’Sullivan et al., 1994). High population variance and non-normal distribution of caries make them less useful and appropriate (Douglass et al., 1994). They also have the drawback of being quantitative, recognising both early and extensive caries as having the same value (Chosack, 1986). In attempts to make them more appropriate, several investigators have reported on the use of different diagnostic levels (Marthaler 1966; Radke 1972). A Caries Severity Index for the primary dentition based on clinical examination has been proposed in addition to def figures (Chosack, 1986). Mount and Hume (1997) suggested a revised classification of carious lesions, taking into consideration not only their extent but also their location.

A further limitation of these indices is that they equally treat decayed, missing and filled teeth. From the point of view of dental care, equal DMF (dmf) index scores can be associated with quite different patterns of untreated disease, satisfactorily filled teeth and surfaces or extracted teeth (Spencer, 1997). Investigators have examined ways to modify these indices so that they better reflect dental health outcomes. Two such modifications were proposed to reflect different concepts of dental health rather than dental disease: Functioning Teeth and Tissue Health (Sheiham et al., 1987).

Other studies have explored the use of child-oriented caries measures as a supplement to traditional tooth-oriented caries measures, so that the prevalence of specific patterns can be determined from caries experiences (Johnsen et al., 1984; 1987).
Child-oriented caries measure is based on the classification of the individual according to which teeth and surfaces show evidence of dental caries.

The pattern of caries in primary dentition has been described in a number of ways. Simply, in terms of teeth and/or surfaces affected. Others defined patterns by groupings of tooth types; this system is termed the tooth type caries pattern. In many studies, interest has been confined to the pattern of caries affecting incisor teeth, especially their smooth surfaces (often termed "rampant caries"). The disease has also been expressed in more complex terms, e.g., the severity zone system based on which surfaces and tooth types are affected and arranged according to severity in a hierarchical manner. Similarly, one group of researchers suggested a series of specific patterns, each having a different aetiology.

2.4.2. Teeth and surfaces affected

Different teeth and tooth surfaces are affected differently by dental caries. It is believed that there is a hierarchy of caries susceptibility of each tooth type and tooth surface (Marthaler, 1968).

The primary teeth and surfaces affected by caries have been described in detail in a number of studies (Parfitt, 1955; Hennon et al., 1969; Todd, 1988: Trubman et al., 1989; Li et al., 1993; Petersen et al., 1994; Holt, 1995). In all of these, caries was found to be most common in the second primary molars and, with the exception of incisors, mandibular teeth were found to be affected more often than their maxillary counterparts. In a survey of 100 geographic sectors of the United Kingdom it was reported that caries most commonly affected primary molars. Some 13% of 1.5-4.5 year-olds had decayed molars, 8% had caries in incisors, and only 1% had caries experience in canines. When the age groups 1.5-2.5, 2.5-3.5, 3.5-4.5 years were investigated separately, this pattern of disease was found to be age related. Up to 2.5 years, caries in the incisors and molars was equally prevalent, and it was only in the older children (3.5-4.5 years) that it became more noticeable in the molars (especially in the lower molars) (Hinds and Gregory, 1995). A study in 3.5-5.9-year-old Australian aboriginal children in non-fluoridated Brisbane also showed mandibular molars to have the highest dmft (Seow et al., 1996). Trubman et al. (1989) not only found that the second molar was the most frequently
affected but also that caries in the second molar increases with age from 25.7% in 3-year-olds to 65.7% in 6-year-olds. It was also reported that at the age of seven, caries is concentrated in primary molars and, in particular, mandibular molars. Maxillary incisors were also affected (Petersen et al., 1994). When the pattern of caries was studied in a group of 5-year-old children, and again in the same cohort at 9 years of age, the second molar showed the highest levels of caries attack in both cases (Holt, 1995). In a comparable epidemiological study of kindergarten 4-5-year-olds in Salzgitter (FRG) and Oslo (Norway), not only were the mean dmfs of individual teeth compared between the two cities but also the filled component. The mean dmfs values of individual teeth were higher for all teeth in Salzgitter. There was no significant difference between mean dmfs values for the first and second primary molars in either city. In both cities, only deciduous molars were filled. A higher level of untreated caries was seen in Salzgitter. It is postulated that the differences between the two cities are due to different levels of fluoride exposure, nutritional habits and dental treatment provision (Clasen et al., 1992).

In pre-school children it was found that the occlusal surfaces of the primary molars are the first site of attack, and that occlusal lesions are more common than interproximal lesions (Parfitt, 1955). This may be explained by the fact that posterior contacts may not close until the age of three. Once they do, the prevalence of interproximal lesions increases (Curzon et al., 1996). The later eruption of the canine and primate spaces may explain the low level of caries on the mesial surfaces of the canines and the distal surface of the laterals (Douglass et al., 1995).

In the upper arch, however, the incisors were reported to be carious almost as often as the occlusal surfaces of posterior teeth (Parfitt, 1955). A similar pattern of disease was seen in a study of Scottish children (Todd, 1988). Incisor caries was less prevalent in a more recent investigation of children with low caries experience in Norwich than in previous studies, but with this exception, the pattern of disease in affected children was very similar to that seen previously (Holt, 1995). Again, most disease occurred on occlusal surfaces in primary molar teeth, especially the second primary molars. Mandibular molars were affected more often than maxillary molars. This is to be expected because of the deeper and the more numerous pits and fissures of the second primary molar compared to the first primary molar (Finn, 1973). However, the
occlusal surfaces of the first molars are frequently affected, which may be explained by the early eruption of these teeth (Douglass et al., 1995).

The predilection of caries for the occlusal surfaces of molars in the permanent dentition of children is mirrored in their primary teeth; at least up to the age of 5 years. The morphological similarity of second primary molars and first and second permanent molars seems to be a major reason for the resemblance in pattern of disease (Holt, 1995).

Similar findings have been reported from the Middle East. In Saudi Arabia, a study was conducted to measure the levels of oral health in three cities with varying levels of naturally occurring fluoride (Jeddah <0.3ppm, Rabagh 0.8ppm and Mecca 2.5ppm). In the three age groups investigated (6, 12 and 15), occlusal caries made the greatest contribution with one exception: in 6-year-olds of Jeddah the proximal surfaces made a greater contribution than the occlusal surfaces (46% vs. 32%). Free smooth surfaces in 6-year-olds contributed approximately one fifth of the total caries experience in the three cities (Al Khateeb et al., 1990). In Khartoum, Sudan, two age groups (4-5 and 7-8-year-olds) were investigated. Although occlusal caries was most prevalent among 4-5-year-olds, proximal caries was just as frequent. In 7-8-year-olds, the percentage of dmfs of proximal caries exceeded that of occlusal caries (28% vs. 23%) (Raadal et al., 1993). One report on 5-15-year-old children enrolled with the South Australian School Service showed that caries experience in 5-year-olds was distributed predominantly between pit/fissure (45.4%) and mesiodistal surfaces (38.3%), with 16.2% of caries observed on the free smooth surfaces (Slade et al. 1996a). In a Romanian study of 7-year-old children it was found that the proximal surfaces had higher caries scores (4.9dfs) than the occlusal (3.6dfs) and facial/lingual (3dfs) surfaces. This might be due to the older age of the children since the prevalence of dental caries was 67% for 6-year-olds, rising to 86% in the 7-year-olds (Petersen et al., 1994).

Caries on surfaces has been studied in relation to age and ethnic groups in the United States. Although differences by surface types were not observed in 2-4-year-olds, in 5-9-years-olds, occlusal and mesiodistal scores (1.6dfs and 1.4dfs respectively) were greater than buccolingual scores (1.0dfs). The difference between surfaces was not tested for statistical significance. Mean dfs scores for occlusal, buccolingual and mesiodistal surfaces for the non-Hispanic White and non-Hispanic Black subpopulations appeared to be lower than those observed for Mexican-Americans of all ages (Kaste et al., 1996).
Most studies on the pattern of disease have been cross-sectional, but in two, children were re-examined after an interval (Todd, 1988; Holt, 1995). In a study in Scotland, new disease was found particularly in those 8-year-olds who had moderate or poor dental health at 5 years of age. Some 41% of the 5-year-olds in the study were classified as having poor dental health on the basis of having some disease of the incisors or canines or some missing canines or molars (Todd, 1988). In the Norwich study, new disease in primary teeth in children between 5 and 9 years was largely confined to those who had some caries at 5 years. However, children with lower caries experience, (defined as having a dmfs value between 1 and 5), showed an increase at least as great as that seen in those with greater destruction (having a dmfs of 6 or more). The author argues that with the lower levels of caries now seen in children, all those with caries experience at the age of five should be regarded as being at high risk. This was emphasised by sensitivity, specificity and predictive values, which showed that the presence/absence of disease at 5 years was probably of greater value in predicting disease than incisor caries (Holt, 1995). A similar finding was reported in a study (Kaste et al., 1992) conducted in Head Start children to investigate the relationship of prior nursing caries, obtained by using different nursing caries classification schemes, to high caries level determined in the same children approximately 10 years later. The relative risk for children with \( \geq 5 \text{dmft} \) was 2.4 compared to 1.6 and 1.4 for caries defined as 2 or more or 3 or more decayed maxillary anterior teeth. Caries on buccal or lingual surfaces of the maxillary incisors showed no increased risk of \( \geq 5 \text{DMFT} \) at the age of 15 (Kaste et al., 1992).

A study from the USA investigated changes in surface attack with time in both permanent and primary teeth. Data was drawn from two cross-sectional national surveys, the first in 1979/1980 and the second seven years later in 1986/1987 (Li et al., 1993). The results provided little evidence of any preferential decline on different surfaces or teeth in the primary dentition with declining caries. Neither absolute nor percentage changes varied between smooth and occlusal surfaces. The relative pattern of disease was therefore very similar in both surveys. This was in contrast to findings in permanent teeth, where changes in prevalence differed between surfaces and teeth.

In Japan, changes in teeth affected with time have been investigated. Trends in caries experience in 2-5-year-old children were studied from 1972-1992. The percentage
of deft in all types of teeth showed a marked reduction until 1977. After this date, the percentage of deft in all types of teeth either remained the same or continued to decrease slowly (either steadily or with some fluctuation). An exception to this was the percentage of dft in the primary maxillary and mandibular second molars in 2-3-year-olds, which showed a slight increase until 1992. The apparent decline till 1977 might have been due to a combination of dental health education and reduced sugar consumption. Poor food habits and a decline in oral hygiene may have contributed to an increase in caries experience of the second molar with its deep and retentive fissures (Mayanagi et al., 1995).

To investigate the effect of fluoridation on tooth type affected by caries, a study was carried out among 3-6-year-old children in areas of contrasting fluoridation history in Brazil. In terms of tooth prevalence, all primary teeth showed less caries in those children living in areas where fluoridation had been continued for longer. The difference in percentage prevalence was greatest in upper incisors in 3-4-year-olds and in primary first molars in 5-6-year-olds. Second primary molars were the most frequently affected in the two age groups studied (3-4, 5-6-year-olds), with a lower prevalence of caries experience in areas fluoridated since 1963 (20.6% and 46.1%) than in recently fluoridated areas (33.3% and 77.1%).

2.4.3. Tooth Type Caries Pattern

2.4.3.1. Rampant caries (Maxillary-Incisor caries)

Rampant caries (Winter et al., 1966; Holt, 1990; Yiu and Wei 1992) was defined by Winter et al. (1966) as caries affecting labial or palatal surfaces of two or more maxillary incisors. But there is no universally accepted definition of this disease. Rampant caries has been defined as occurring when lesions affect one (Kamp, 1991), at least two (Barnes et al., 1992; Matee et al., 1992b; Weinstein et al., 1992), or even three (Kelly and Bruerd, 1987) maxillary incisors. This form of caries - or one with a similar pattern - has also been given a number of other names including ‘nursing bottle caries’ (Benitez et al., 1994; Veerkamp and Weerheijm, 1995), ‘baby tooth decay’ (Lee et al., 1994), ‘baby bottle tooth decay’ (Weinstein et al., 1992; Domoto et al., 1994; Tsubouchi et al., 1994), ‘nursing bottle syndrome’ (Muller, 1996), and ‘nursing caries’ (Ripa, 1988).
These definitions carry assumptions about aetiology, assumptions that are avoided in the term ‘rampant caries’. The term ‘maxillary anterior caries’ (O’Sullivan and Tinanoff, 1993a) fails to differentiate the pattern where smooth surfaces are attacked. Although ‘rampant caries’ is most often described in young children, the term ‘early childhood caries (Duperon, 1995, Tinanoff, 1998) and ‘infant caries’ (Ramos-Gomez et al., 1996) may be restrictive in terms of age group.

The exact location of lesions has been critical in some definitions. In his review, Milnes (1996) defines nursing caries as affecting one, at least two, or three maxillary incisors. He also defined it as caries of maxillary incisors and primary molars. This definition includes all studies that diagnosed caries as involving labial/palatal surfaces (e.g., Winter et al. [1966, 1971a] and Holt et al. [1982, 1988] etc.). Other studies included in this definition are those in which caries involves one or more, or two or more labial surfaces of the maxillary incisors (Cleaton-Jones et al., 1978 a, b; Aldy et al., 1979; Richardson et al., 1981), and a third in which rampant caries is diagnosed as generally affecting one or two maxillary incisors (without limiting the lesion to labial/palatal surfaces) (e.g., Kelly and Bruerd, 1987; Broderick et al., 1989; Kamp, 1991; Barnes et al., 1992; Matee et al., 1992b; Weinstein et al., 1992).

To avoid confusion, the term “rampant caries" is used to describe all these slightly differing forms of severe disease typically affecting smooth surfaces of maxillary incisor teeth in young children.

The involvement of maxillary incisor teeth in rampant caries relates partly to the timing of tooth eruption. These teeth are amongst the first to erupt and are therefore exposed to the cariogenic environment for the longest period of time. Other teeth, with the exception of the mandibular incisors, are affected as caries progresses, with a pattern of attack reflecting their order of eruption. Mandibular incisors are thought to be protected from the cariogenic environment by the tongue, and by their proximity to the ducts of the sublingual and submandibular gland (Milnes, 1996).

As well as the disease carrying significant morbidity and being difficult and expensive to treat, the clinical importance of rampant caries lies in the fact that, in affected children, the likelihood of further caries is thought to be increased (Johnsen et al., 1987; Sclavos et al., 1988; O’Sullivan and Tinanoff, 1993a). The factors that cause maxillary anterior caries may also contribute to the high prevalence of dental caries in
posterior primary teeth (O’Sullivan and Tinanoff, 1993a). Furthermore, children who have had highly cariogenic practices, such as using sweetened comforters during infancy and early childhood, are also those in whom caries-promoting habits and poor dental health practices continue in later life. This association has been shown in at least one study (Silver, 1987).

2.4.3.1.1. Prevalence of Rampant caries

Milnes (1996) reviewed numerous studies from Europe (mainly England) Africa, Asia, the Middle East, and North America. Using different classification schemes for rampant caries in the same population yields different prevalence rates (Ramos-Gomez et al., 1996). Discrepancies between studies may be due to the application of different definitions. No suitable epidemiological index for this specific pattern of caries has been developed.

Investigations in England, Sweden, and Finland have reported the prevalence of rampant caries to vary from 1%-12% in England (Silver, 1982; Winter et al., 1966), to 7.7% in Sweden (Wendt et al., 1991), and 6% in Finland (Paunio et al., 1993). Pre-school children who attended maternal and child welfare clinics in the London borough of Camden were examined for rampant caries in 1966-1968 (Winter et al., 1971a), 1980-81 (Holt et al., 1982) and 1986 (Holt et al., 1988). Similarly, three studies were carried out in Bishop’s Stortford in 1973 (Silver, 1974) 1981 (Silver, 1982) and 1989 (Silver, 1992). A decline in prevalence was seen from 8.0 % in 1971 to 3 % in 1982 in Camden, and from 8.0 % in 1973 to 1.0 in 1981 in Bishop’s Stortford. However, the third study showed an increase in prevalence in both groups (to 7.0 % and 4.0 % respectively). The use of sweetened pacifiers was found to be a major aetiological factor.

In the United States, the recorded prevalence of rampant varies, affecting from 1.0 % in a sample in Los Angeles child patients examined at the Dental School, (Children’s Hospital of Los Angeles), public health service clinics and private dental offices (Powell, 1976), to 72 % in Navajo children enrolled in Head Start programmes (Broderick et al., 1989). It is worth noting that most United States studies refer to Native Americans and children from low socio-economic backgrounds, which may partly explain the high prevalence rates often found. In contrast, the Third National Health and Nutrition
Examination Survey (Kaste et al., 1996) estimated the prevalence of rampant caries in 12-23-month-old American children as a whole to be 0.8%. It was argued that due to the limitation of the “Lift-the-lip” examination for rampant caries used in this survey, data pertaining to unclassified individuals (not sure whether stained or carious) might be combined with the 0.8% - resulting in a prevalence of 2%. These figures, which probably are rather conservative, are consistent with the lower boundary of Ripa’s estimation of 1-5% (Ripa, 1988).

In the Middle East, few studies have reported on rampant caries. One found a prevalence of 11.5% among 5473 4-5-year-old Kuwaiti children screened in kindergartens (Soparkar et al., 1986), while another, more recent, including 227 18-48-month-old patients at a hospital and health centre in Kuwait, showed a higher prevalence (19%) (Al Dashti et al., 1995). Yagot et al. (1990) reported a prevalence of 15.6% among 2389 12-53-month-old Iraqi children enrolled in nursery schools in Baghdad. Similarly, in an earlier study in the same city (Ghose et al., 1983) a prevalence of 12.1% among 964 13-48-month-olds was reported.

In several studies, it has been shown that prevalence of rampant caries increases with age (Winter et al., 1971a; Ghose et al., 1983; Holt et al., 1988; Holt et al., 1996). Estimates for groups of varying age ranges may not be directly comparable.

A number of studies have investigated the prevalence of rampant caries in ethnic and immigrant populations as well as in relation to socio-economic status. A study of rampant caries in Native American Head Start children in Alaska and Oklahoma demonstrated a wide range (17-85%) of prevalence with a mean of 53% (Kelly and Bruerd, 1987). In a later study, Tsubouchi et al. (1995) reported a prevalence of 26.1% in children as young as 12-18-months of age. Investigations of the dental health of a group of Australian Aboriginal children in Brisbane (Seow et al., 1996) showed that maxillary anterior labial decay of at least one tooth affected 23% of children.

Immigrants are vulnerable to rampant caries. In the Yakima Valley, 125 Mexican immigrant children under 4 years of age were investigated (Weinstien et al., 1992) for rampant caries. Some 29.6% were affected. The authors related this high prevalence to the multiple post-immigration stresses associated with acculturation that Mexican-American farm workers face. The results of this study also showed that when mothers received more help, and when someone other than the mother or father fed the children
in the evening, the latter had less rampant caries. Although rearing practices are culturally determined, they are often modified during this stressful period.

In Sweden, it was reported that 22.2% of two-year-old immigrant children had caries compared to 4.5% of non-immigrants (Wendt et al., 1991), and in England, Holt et al. (1988) reported that Asian children had a higher prevalence (14%) compared to Europeans (6%). Africans and Afro-Caribbeans had a similar prevalence (5%). This trend was seen again in a more recent study (Holt et al., 1996) in which more children of Asian origin had rampant caries (18%) than those of other ethnic groups (8%). The higher disease level in Asian children has also been reported from the North of England. In a study in Dewsbury, West Yorkshire, 13% of children of Pakistani origin, and 21% of Indian origin, showed rampant caries compared to 5% of an equivalent group of Caucasian children (Pendergast et al., 1989). Children with immigrant backgrounds have been found to have significantly higher sugar consumption than non-immigrants (Ekman, 1990), which might explain some of these findings. Immigrant families often belong to the lower socio-economic strata (Grindfjord et al., 1993).

Studies in the United States have been conducted among children enrolled in programmes for low-income families (Louie et al., 1990). These authors reported a relatively high prevalence (28% with a range from 22% to 36%) in 3-5-year-old Head Start children.

The prevalence of rampant caries has also been studied in relation to social class. In England, many recent investigations of pre-school children have been confined to city or inner city areas. Inner city areas often have populations covering a wide social spectrum, making it easier to draw samples that include children from a variety of social classes (Holt, 1990). Three studies were carried out in Camden over a 20-year period (Winter et al., 1971a; Holt et al., 1982, 1988). Comparison of the results of 1986 with those of 1980 (Holt et al., 1988) shows a trend for higher levels of rampant caries in 1986 in classes III M-V and amongst those not classified, although this difference was not statistically significant. A small difference was noted between the two studies among children from classes I-IIIN. In the third study (Holt et al., 1996), a higher proportion of children in the lower classes had rampant caries. However, in multivariate analysis social class failed to contribute significantly to the variation seen.
2.4.3.2. Anterior (Incisors and/or Cuspids); Posterior (Molars); Both (Entire dentition)

In an attempt to evaluate the effect of "maxillary anterior caries pattern" on caries rates and patterns in other areas of the child's mouth, a study in 3-4-year-old Head Start children was undertaken (O'Sullivan and Tinanoff, 1993b). Of the 481 examined, 210 (44%) had caries. These children also were categorised as having maxillary anterior caries only, posterior caries only, or both. Maxillary anterior caries was found in 78 children (16%). Of the children with the maxillary anterior pattern, 87% also had posterior caries. Among the latter (having both anterior and posterior caries), mean dmfs was 14.4 - or more than double the combined mean dmfs of the children with only one caries pattern. This indicates that dmfs of individual patterns are not simply additive and that children with multiple disease patterns have far worse caries. All children except one with maxillary anterior caries had recoverable mutans streptococci, which indicates that maxillary anterior caries, when accompanied with infection, may be an initiating factor for posterior caries.

In 1993 the dental health in of 631 Latvian 3-4-year-old nursery school children was assessed (Bjarnason et al., 1995). Molar decay (2.1dmft) accounted for 66% of total caries experience (3.2 dmft). This type of decay was dominant in both age groups with a mean annual increase of 73% in dmft between three and four years of age. Decay in the incisors and cuspids (1.1dmft) accounted for 34% of total caries experience.

A similar categorisation including the group 'caries-free' was investigated (Dini et al., 1998) in 1066 3-6-year-old Brazilian children. The aim of the study was to define the pattern of caries in areas of contrasting fluoridation history (fluoridated for more than 10 years versus recently fluoridated). In both areas, the majority of 3-4-year-olds had disease confined to molars (18% and 24% respectively). In the areas fluoridated for more than 10 years, 5-6-year-old children also had the disease confined to primary molars (36%). However, in the more recently fluoridated area, the proportion of children with caries in their primary molars alone was similar to that of children with caries in both primary molars and incisors (40% and 44% respectively). A smaller proportion of 3-4-year-olds showed caries experience confined to primary anterior teeth - with a lower prevalence in the area fluoridated for more than 10 years. The difference in the
prevalence of this pattern between areas was statistically significant. Further, amongst 3-4-year-olds, more children in the areas fluoridated since 1963 were caries free (67% compared to 42% in recently fluoridated areas). Amongst 5-6-year-olds, fewer children were caries-free: 11% of those in the recently fluoridated area compared to 43% in areas fluoridated since 1965.

2.4.4. Severity Zone System

The susceptibility to caries of different teeth and tooth sites varies, and attacks on less susceptible surfaces have been thought to imply greater severity of disease (Poulsen and Horowitz, 1974). Grainger (1967) was the first to suggest a hierarchical system of caries patterns to describe severity in the permanent dentition based on a classification according to which teeth and surfaces show evidence of disease (see Table 1). This procedure was developed to reduce the time needed to examine and record dental caries in epidemiological studies. It can be used to directly measure susceptibility to dental caries and does not necessitate conversion to DMFT.

Table 1: Criteria for Classification of Individuals According to Severity Zone of Dental Caries (Grainger, 1967).

<table>
<thead>
<tr>
<th>Severity Zone</th>
<th>Definition (surfaces involved)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Proximal surfaces of mandibular anterior teeth (excluding distal surfaces of cusps).</td>
</tr>
<tr>
<td>4</td>
<td>Labial surfaces of maxillary and mandibular incisors and cuspids.</td>
</tr>
<tr>
<td>3</td>
<td>Proximal surfaces of maxillary anterior teeth (excluding distal surfaces of cusps).</td>
</tr>
<tr>
<td>2</td>
<td>Proximal surfaces of molars and premolars (including distal surfaces of cusps).</td>
</tr>
<tr>
<td>1</td>
<td>Pit and fissure surfaces of posterior teeth</td>
</tr>
<tr>
<td>0</td>
<td>None of the above</td>
</tr>
</tbody>
</table>

It should be noted that most of the buccal and lingual surfaces of posterior teeth (those without developmental pits) and the lingual surfaces of the anterior teeth are not included in the examination.

An assumption underlying the use of this index is that, after the severity zone for an individual has been determined, it can be assumed that he/she also belongs to any lower severity zone (excluding severity zone 0). Thus, the zones in the system are mutually exclusive (Wong et al, 1997).
Poulsen and Horowitz (1974) examined whether the assumption of cumulative zone membership was appropriate. The data used for their report were derived from three different sources (Hawaii, Brazil and Seagrove) in which the permanent dentition of relatively young adults was considered. The Hawaiian data comprised the controls of a clinical trial on the caries-reducing effect of acidulated phosphate fluoride toothpaste, Brazilian data was for children who participated in a clinical trial of supervised toothbrushing with acidulated phosphate fluoride toothpaste, and the Seagrove data came from children who had had continuous exposure to fluoridated water. Of the 198 13-15-year-old Hawaiian individuals investigated, 21 were classified as belonging to severity zone 5 since they had caries on the proximal surfaces of their mandibular anterior teeth. Six (29%) of these individuals classified as belonging to severity zone 5 could also be classified into severity zone 4 since they had decay on the labial surfaces of the anterior teeth, and 18 (86%) could also be classified into severity zone 3 since they had caries on the proximal surfaces of maxillary anterior teeth. The assumption was only fulfilled with respect to zones 1 and 2: 21 persons could be classified as belonging to both. For Grainger's Method to be most useful, there should be a strong assurance that a child assigned to a specific severity zone also has all lesser severity levels of decay.

In an attempt to improve the fit of the model, Poulsen and Horowitz (1974) combined severity zones 5 and 4. This did improve the pattern for each data set: at least 85% of the children assigned to severity zone 4-5 also qualified for all lesser zones, while 29% of the children assigned to zone 3 did not qualify for zones 2 and 1. Almost perfect agreement was achieved after zones 3 and 2 were also combined. The worst remaining disagreement was that 11% of the children in the Brazilian subset classified in zones 4-5 failed to qualify for classification into zone 2-3. The revised criteria suggested by Poulsen and Horowitz (1974) are shown in Table 2.
Table 2: Revised Criteria for Classification of Individuals According to Severity Zone of Dental Caries (Poulsen & Horowitz, 1974).

<table>
<thead>
<tr>
<th>Severity Zone</th>
<th>Definition (surfaces involved)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (Formerly 5 and 4)</td>
<td>Proximal surfaces of mandibular anterior teeth (excluding distal surfaces of cuspids) or labial surfaces of maxillary or mandibular incisors and cuspids.</td>
</tr>
<tr>
<td>2 (Formerly 3 and 2)</td>
<td>Proximal surfaces of all maxillary teeth or proximal surfaces of mandibular teeth posterior to and including distal surfaces of cuspids.</td>
</tr>
<tr>
<td>1</td>
<td>Pit and fissure surfaces of posterior teeth.</td>
</tr>
<tr>
<td>0</td>
<td>None of the above.</td>
</tr>
</tbody>
</table>

Poulsen and Horowitz (1974) advise that Grainger’s Method should be subjected to these minor modifications in order to fulfil its basic assumption of hierarchical zone membership. It can then be used for descriptive purposes in epidemiological studies since only limited time is needed for examination and recording. The method proved sensitive enough to detect the already established caries-reducing effect of fluoridation of school water supplies as shown by the Seagrove children. The biggest preventive effect is obtained in severity zone 2-3, since these comprise all proximal surfaces (excluding proximal surfaces of mandibular anterior teeth). This finding is consistent with present knowledge on the effect of water fluoridation.

Wong et al. (1997) tested the fit of Grainger’s Method on primary dentition. Dental caries data were collected from 452 3-5-year-old Chinese pre-school children in Conghua, southern China. Since a morphological peculiarity was seen in a considerable number of the children’s maxillary cuspids, (a developmental pit in the middle of the labial surface – a predilection for the development of caries), the criterion for this surface was changed from zone 4 (caries on labial surfaces of maxillary cuspids) to zone 1 (pit and fissure caries). The fit of the model was assessed, by calculating the percentage of children who were correctly classified according to severity zone criteria. The percentage of correct classifications was calculated by dividing the total number of correctly classified children by the total number of children. Some 274 (61%) children were classified correctly according to the assumption of the hierarchical system.
It is interesting to note that the mean dmfs score for those children assigned to severity zone 0 was 0.3 rather than zero. This discrepancy could be explained by the fact that, according to the criteria, most buccal and lingual surfaces of posterior teeth (those without developmental pits) and the lingual surfaces of the anterior teeth were excluded when assigning severity zones. However, caries was naturally counted in the dmfs scores, which comprised all surfaces. A statistically significant correlation coefficient ($r_s = 0.75; P<0.001$) was found between dmfs and severity zone. This suggests a direct but unspecified relationship between severity zone and dmfs, and supports the logic of the hierarchical system.

In order to improve the fit of the original model, 12 possible alternative models have been assessed even though they are not all reasonable from a cariological point of view. The newly proposed model that gives the most useful additional information corresponds to that chosen by Poulsen and Horowitz (1974). This correctly classified 83% of the study population instead of 61% when using the original criteria.

Wong et al. (1997) argue that this modification of the system provides us with clinically meaningful information, adding considerably to that gained from dmfs values. The findings of this study support the suggestion of Poulsen and Horowitz (1974) that the hierarchical severity system, as originally proposed, must be modified in order to fulfil the basic assumption underlying the method. Nonetheless, even with the most favourable grouping, 17% of children were not correctly assigned.

A slightly modified model with four caries severity zones, was adopted by the Danish Oral Health Care Service for Children (Schwarz and Hansen, 1979). A law on dental care for children was passed in 1971 after the provision of dental services for children was recognised as a public responsibility. One of the important elements of the law was the establishment of a nationwide epidemiological database and recording system. It was found that average caries experience indices only provided part of the information necessary to plan and evaluate child dental health service activities. The analysis of the caries situation was extended by means of the distribution pattern according to Poulsen and Horowitz's severity zones with slight modifications (see Table 3). The present criteria included the smooth surfaces that were ignored in the previous classification.
Table 3: Criteria for Classification of Individuals according to Severity Zones (Schwarz & Hansen, 1979).

<table>
<thead>
<tr>
<th>Severity Zone</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>No tooth surfaces have caries experience.</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Caries experience in fissures and pits in premolars and/or molars.</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Proximal caries in canines and/or premolars and/or molars.</td>
</tr>
<tr>
<td>Zone 4</td>
<td>Caries experience in incisors and/or on smooth surfaces.</td>
</tr>
</tbody>
</table>

Children classified as belonging to one zone usually belong to lower zones as well.

Data for the primary dentition of 159,035 2-7-year-old were analysed and the distribution according to the percentage of children at each age (2-7) who belonged to severity zones 1, 2, 3, or 4 were compared to their distribution according to the total number of defs. As total caries experience increased with age, a decreasing proportion of children remained caries-free and an increasing proportion of children developed caries of a more severe type (as illustrated by the decreasing percentage in zone 1 from 77% at age 2 to 14% at age 7; and the increasing percentage of children in zone 4 from 9% at age 2 to 27% at age 7) and moved simultaneously into groups with more tooth surfaces involved. Based on these findings, the success of the preventive and therapeutic efforts of dental services may depend not only on a general reduction in defs but also on pushing the children towards less severe caries zones.

To evaluate the achievement of the Danish Oral Health Care Service for Children, cross-sectional analyses of those in grades 1, 5 and 9 (approximate ages 9, 12, and 16) were carried out in 1977 and 1981. Children in each grade were distributed according to the four severity groups. For grade 1, it was obvious that distribution in caries severity was much more favourable in 1981, amounting to about 60% caries-free children compared to 43% in 1977. The size of the group with occlusal caries was reduced by about 15% and the two most severely affected groups were reduced by 1-2%. In grade 5, development over time was less favourable, while at grade 9 the differences between 1977 and 1981 were negligible. Looking at the different age groups in the same year, it
was obvious that there were still problems in preventing children from developing an ever more severe kind of caries, although the problem was less in 1981 than in 1977 (Schwarz, 1983).

In Romania, a survey was conducted to describe the prevalence and pattern of dental caries in 7-and 12-year-old school children. deft and defs indices were calculated for the primary dentition of 729 7-year-old children, and the four zones defined by Schwarz and Hansen (1979) were used to assess severity. The caries score was 11.4 defs and the distribution of children according to the severity zones showed that 14% had no caries in their primary dentition (zone 1), 11% had caries experience in pits/fissures in molars (zone 2), 14% had proximal caries in canines and/or molars (zone 3), and 61% had incisor and/or smooth surface caries (zone 4). Since, according to this hierarchical severity system, children in zone 4 belong to lower zones (3 & 2) as well, 61% of 7-year-olds had a very severe pattern of caries in their primary dentition (i.e., caries in pits/fissures, proximal surfaces, smooth surfaces and incisors). In the light of this, and the distribution of caries patterns in the permanent dentition of 12-year-olds, the authors indicated that the implementation of oral health promotion and prevention at community level was urgently needed (Petersen et al., 1994).

This severity zone system was further used to assess caries in a group of 119 grade 1 children (6-year-olds) and 113 grade 6 children (12-year-olds) in Wuhan City, China (Petersen and Guang, 1994). It is worthwhile comparing the results of this study with that performed in Romania (Petersen et al., 1994). The difference between the populations is more evident in zones 2 and 3. Less Chinese children had fissure caries in their primary dentition than Romanian children (3.4% vs.11%) but more Chinese children had proximal caries in canines and/or molars than did the Romanians (22.7% vs. 14%). Accordingly, different preventive approaches may be needed for each population.

2.4.5. Aetiology-Based System

2.4.5.1. Caries Patterns

The aetiology-oriented approach to caries classification differs from hierarchical approaches in that the former assumes the caries process to be divergent rather than strictly cumulative. In the hierarchical severity zone system, individuals are placed in a
single category by severity but not by possible aetiology. Further, unlike the hierarchical approach, which presupposes that a child with caries of a certain severity has lesions of all lower degrees, the aetiology-oriented approach suggests some independence between severity and outcome or pattern.

An aetiology-based index for the primary dentition seems to be more appropriate since major caries-site groupings may be associated with different aetiologies. Further, defining children with specific aetiologies may help in assessing their needs and in planning care (Johnsen et al., 1984).

Criteria exist for the tooth-oriented index (dmft, deft); similarly, criteria are necessary for the development of a person-oriented caries index. This would require the definition of categories for caries experience, which would fulfil the following requirements:

1- To be limited to a small number of mutually exclusive categories (Klein et al., 1938).

2- To be applicable to all children in the sample (Gruebbel, 1944).

3- To reflect the caries experience of the individual (Brunelle and Carlos, 1982).

4- To be reproducible, from both intra-and inter-examiner standpoints (Hausen et al., 1982).

5- To be relatively simple to use (National Institute of Dental Research, 1981).

6- To be amenable to statistical analysis (Poulsen and Horowitz, 1974).

7- To allow concise description or report (Katz and Meskin, 1976).

Johnsen, in his first attempt to define patterns in pre-school children, discussed four patterns, two associated with tooth defects (pit and fissure defects and enamel hypoplasia) and two associated with a habit (nursing caries and proximal molar lesions). Nursing caries is claimed to be due to excessive nursing bottle use, especially at night, while proximal molar lesions appear to be part of a total lifestyle (Johnsen, 1984). In a subsequent study (Johnsen et al., 1984) minor modifications in describing caries patterns were made, assigning them by site and severity to three main classes: lesions associated with developmental defects (pit and fissure caries and enamel hypoplasia), smooth
surface lesions (facial-lingual lesions and proximal molar lesions), and rampant caries. Each child was placed in one - and only one - of the six main categories by priority, inversely to the order listed in the classification. They were then subcategorised (except for caries-free) to “minimal” or “extensive” as defined. Categories were not necessarily hierarchical by severity and a given child could have caries lesions at more than one of the sites or site groupings defined. For example, if a child had lesions in pit and fissure defects as well as proximal lesions of molars, the child was classified as having the latter.

The criteria for the classification of caries patterns (plus caries-free) are provided in Table 4.

Table 4: Criteria for Classification of Caries Patterns (Johnsen et al., 1984)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Lesions associated with developmental defects</td>
<td>One or more lesions at the sites of pit-and-fissure enamel defects in primary molars.</td>
</tr>
<tr>
<td>1. Pit and fissure defects</td>
<td>a) Minimal: one or more lesions detectable by an explorer as softened enamel, but not detectable by radiography.</td>
</tr>
<tr>
<td></td>
<td>b) Extensive: one or more lesions evident on bitewing radiographs or, in those who had not received radiography, one or more lesions with clinically evident cavitation.</td>
</tr>
<tr>
<td>2. Hypoplasia</td>
<td>Altered enamel contours with a detectable rough surface and darkened enamel or dentine. Enamel defects with smooth surfaces or colour consistent with surrounding enamel were not designated as carious in this study.</td>
</tr>
<tr>
<td></td>
<td>a) Minimal: without enamel or dentine removable with a sharp spoon excavator.</td>
</tr>
<tr>
<td></td>
<td>b) Extensive: with enamel or dentine removable with a sharp spoon excavator.</td>
</tr>
<tr>
<td>B- Smooth surface lesions</td>
<td>(Only cavitated lesions were included; “white spot” lesions were not).</td>
</tr>
<tr>
<td>1. Facial-lingual lesions</td>
<td>a) Minimal: one or more lesions on a facial or lingual surface of any tooth, or on the proximal surface of an incisor tooth.</td>
</tr>
<tr>
<td></td>
<td>b) Extensive: at least one lesion extending to include more than one surface of a tooth.</td>
</tr>
<tr>
<td>2. Proximal molar lesions</td>
<td>a) Minimal: one or more lesions on the proximal surfaces of the primary molars or distal surfaces of the primary canines visible radiographically, but not including the marginal ridge of the occlusal surface or incisal edge.</td>
</tr>
<tr>
<td></td>
<td>b) Extensive: one or more such proximal lesions extending to include part of the occlusal surface or incisal edge.</td>
</tr>
<tr>
<td>C- Rampant caries</td>
<td>14 of the 20 primary teeth having carious lesions including at least one mandibular incisor.</td>
</tr>
</tbody>
</table>

Using these criteria, two hundred subjects aged 3 ½ - 5 from two Head Start programmes were examined in two fluoridated cities to determine the prevalence of specific caries patterns (presumably associated with different aetiologies), and to assess the relationship between these patterns and specific lifestyle variables.
Of the 200 subjects examined, 78 (39%) were caries-free. Of the remaining 122 with one or more carious lesions, 64 had only pit and fissure lesions, 13 children had hypoplastic enamel defects, 22 had facial-lingual lesions mostly fitting the picture of "nursing caries", and 23 had proximal lesions of the molars. Not a single child had "rampant" caries.

More children had carious lesions associated with tooth defects than with smooth surface lesions (statistically significant). For three of the four patterns, more children were classified in the "minimal" categories than in the "extensive" categories. For the facial-lingual pattern, the number of children in the "extensive" category was greater than in the "minimal" category. This finding supports the hypothesis that nursing caries, in most instances, is an "all-or-nothing" phenomenon associated with the insult of hours of excessive nursing. The authors suggest that comparisons of the data on lesion extent for children with facial-lingual and proximal lesions of molars be undertaken cautiously since different teeth are involved. Caries limited to the proximal surfaces of primary molars occurs later than facial-lingual (nursing) caries, and children with these lesions may reflect a different demographic background (Johnsen et al., 1980). These two caries patterns should therefore be considered separately (Johnsen et al., 1984).

No statistically significant differences or trends were found for lifestyle variables between caries-free children and children with tooth defect-related lesions. However, several significant differences were found between the lifestyle measures of caries-free children and those with smooth-surface caries. Mothers of caries-free children were more likely to have completed high school than mothers of children with smooth-surface caries. Children with smooth-surface caries were more likely to spend time frequently with grandparents than were caries-free children. Mothers of caries-free children were less likely to permit the child to eat sweets without restriction than were mothers of children with smooth-surface lesions. Mothers of caries-free children were more optimistic about keeping most of their own teeth beyond the age of 40 than mothers of children with smooth-surface caries. Mothers of caries-free children were more likely to believe that "difficulties in brushing" is the main reason for cavities than mothers of children with smooth-surface caries. Statistically significant differences were based on caries patterns, each including a range of caries levels (minimal and extensive). It is
therefore concluded that caries pattern is correlated with lifestyle, and that caries severity may or may not be correlated.

Using the methods of this study, criteria of a person-oriented caries measure were largely fulfilled. The number of categories was relatively small, all children were included (each in only one category), and the results were reproducible and can be reported using a single graph. One major weakness of this index is the listing of categories by priority. For future studies the authors recommended including a diverse set of background data, which might identify new indicators inherent in different lifestyles.

In another study (Johnsen et al., 1986a) minor modifications were made to these caries pattern definitions. The two caries levels (minimal and extensive) were combined, and rampant caries (14 of the 20 primary teeth having carious lesions including at least one mandibular incisor), was replaced by facial-lingual plus molar proximal lesions which represents a severe form of caries attack (see Table 5).

Table 5: Criteria for classification of caries patterns (Johnsen et al., 1986a)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Definition of pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Lesions associated with developmental defects</td>
<td></td>
</tr>
<tr>
<td>1. Pit and fissure defects</td>
<td>One or more lesions at sites of pit and fissure enamel defects in primary molars: occlusal surfaces of any molar as well as lingual surfaces of maxillary second molars, and facial surfaces of mandibular second molars.</td>
</tr>
<tr>
<td>2. Hypoplasia</td>
<td>Altered enamel contours with a detectably rough surface and darkened enamel or dentino, including areas adjacent to areas of hypoplasia as well as caries on the medial aspect of the facial surface of the primary canines.</td>
</tr>
<tr>
<td>2. Smooth Surface Lesions</td>
<td></td>
</tr>
<tr>
<td>1. Facial-lingual lesions</td>
<td>(Only cavitated lesions were included; “white spot” lesions were not). One or more lesions on a facial or lingual surface of any tooth or a proximal surface of an incisor tooth. Facial surfaces included buccal surfaces of molars and labial surfaces of anterior teeth.</td>
</tr>
<tr>
<td>2. Proximal molar lesions</td>
<td>One or more lesions on the proximal surfaces of the primary molars or distal surfaces of the primary canines.</td>
</tr>
<tr>
<td>3. Facial-lingual plus molar proximal</td>
<td>One or more of both types of smooth surface lesions.</td>
</tr>
</tbody>
</table>

The purpose of the study was to determine caries level and prevalence in low-income children in Ohio, USA. 1310 3½ -5-year-olds from four areas (urban fluoridated, urban non-fluoridated, non-urban with optimal fluoride level and non-urban with sub-
optimal fluoride level) were examined. The results supported the benefit of fluoridation in the primary dentition, demonstrating that fluoride status was more important than residential status: differences in caries between urban and rural children were not found. The percentage of caries-free children was higher in the urban and non-urban fluoridated sites (40% and 50% respectively) compared to the urban and non-urban unfluoridated sites (36% and 41% respectively). Scores for defs in urban and non-urban sites were respectively higher in those non-fluoridated (4.7defs) than in those fluoridated (3.3defs).

The benefit of fluoridation was further illustrated on smooth-surface lesions. The percentages of children with this pattern were higher in non-fluoridated sites. In contrast, the percentages of children with defect-associated lesions were similar for all the four study sites. This is not surprising since, in fluoridated areas, the greatest decrease in caries levels in permanent teeth was on smooth surfaces (Koch, 1982)

Taking into consideration the sub-categories of children with smooth-surface lesions, the facial-lingual pattern predominated, meaning that most destruction had begun before the age of two. This was not the case in fluoridated sites. The lower percentage of children in the facial-lingual categories in these sites was unexpected since these were intended to include children with "nursing" caries. The deleterious effect of prolonged carbohydrate exposure would, in fact, be expected to overcome the benefit of fluoridation. The suppressive effect of fluoride on levels of cariogenic microflora was given as an explanation for this unanticipated finding.

With respect to frequency distribution by severity, results differed significantly for groups of children with defect-associated lesions compared to children with smooth surface lesions. Over half of those with defect-associated lesions had one or two carious surfaces. Children with smooth surface lesions had six or more carious surfaces than those with defect-associated lesions. This supports the notion that defect-associated and smooth surface lesions represent different diseases with different aetiology and severity. The former represents a mechanical defect while the latter reflects lifestyle. Combining children with only defect-associated lesions and those having smooth surface lesions into a single category may place limitations on the measurement of effectiveness of specific intervention (Johnsen et al., 1986a).
A third study by Johnsen et al. (1987) also explored proportional changes in caries patterns between early and late primary dentitions. The same criteria (used in Johnsen et al., 1986a) were employed.

Dental chartings of 438 2-5-year-olds from two sites in fluoridated communities were used. The sample size was relatively small and the study used cross-sectional data, but it showed the possibility of demonstrating proportional changes of caries pattern by age. At both sites the combination of caries-free plus facial-lingual categories comprised over 85% of children younger than 2.5 years. The facial-lingual category was intended to include children who fitted the clinical description of “nursing caries. All children in the facial-lingual category had incisor involvement.

Children younger than 2.5 years of age in the facial-lingual category were more likely to have occlusal lesions of molars than their counterparts without multiple incisor involvement. The facial-lingual category decreased with age while the facial-lingual/molar proximal category increased from 3.5 to 5 years of age.

The findings of this study indicate that children in the facial-lingual category are not only more likely to have occlusal lesions of molars, but to continue developing smooth-surfaces lesions of molars.

The hypoplasia group was small at any age group, with no trend evident. Numbers in the fissure and molar proximal categories increased slightly after first appearing in low proportions. These two groups together did not make up a majority of the children from either site or for any age group.

Caries patterns (Johnsen et al., 1986a) were further used in a study of 347 Inuit (Eskimo) youth aged 5-22 (Zammit et al., 1994). The aim was to record these patterns and to relate them to traditional DMF (dmf) index values, and to examine the cross-sectional data on these patterns for characteristics of caries progression from primary to early adult dentition. Slight additions to the definitions proposed by Johnson et al. (1986a) were used to describe the permanent dentition as well (see Table 6).
### Table 6: Criteria for Classification of Caries Patterns (Zammit et al., 1994)

<table>
<thead>
<tr>
<th>Severity Zones</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caries free (CF)</td>
<td>No detectable carious or treated lesion</td>
</tr>
<tr>
<td>Pit and fissure (PF)</td>
<td>One or more carious lesions in a pit or fissure of an occlusal surface of a molar as well as the lingual groove of a maxillary molar, the buccal groove or pit of a mandibular molar, or the lingual pit of a permanent central or lateral incisor</td>
</tr>
<tr>
<td>Hypoplastic (HTYP)</td>
<td>Evidence of one or more hypoplastic lesions on any surface of any tooth.</td>
</tr>
<tr>
<td>Faciolingual (FL)</td>
<td>One or more carious lesions on the facial or lingual smooth surface of any tooth, or on a proximal surface of an incisor or the mesial surface of a canine. Children with primary dentition aged 5 years and younger are assumed to have baby bottle tooth decay.</td>
</tr>
<tr>
<td>Molar-proximal (MP)</td>
<td>One or more carious lesions on a proximal surface of a molar or the distal surface of a canine.</td>
</tr>
<tr>
<td>Faciolingual with molar-proximal (FL/MP)</td>
<td>One or more carious lesions on both facial and/or lingual surface and a molar-proximal surface.</td>
</tr>
</tbody>
</table>

The caries patterns of the primary and permanent dentitions combined were considered for examining the predominant patterns. Subjects with lesions in more than one category were placed in the more severe category according to the hierarchical progression of disease. About 38 % of subjects had pit and fissure caries, 31 % had molar proximal, 22 % had faciolingual/molar proximal, and only 2 % and 4 % had hypoplastic and faciolingual lesions respectively.

To highlight differences in caries patterns between the primary and permanent dentitions, the data of 15-22-year old subjects (n=65) were compared to those of 5-6-year-olds with complete primary dentition (n=51). The pit and fissure pattern was present in 38 % of the permanent dentition while faciolingual/molar proximal patterns were present in only 26 %. However, with respect to the primary dentition, 68 % of children were affected with this destructive type of decay. In addition to the 17% who belonged to the molar proximal group, 7 % showed the faciolingual pattern. This demonstrates that as many as 92 % of 5-6-year olds experience the three most destructive patterns of tooth decay. The young age group not only experienced the most severe type of decay but also had high dmfs scores.
Using both methods to describe dental caries has both tested the method for recording caries pattern and complemented the traditional method of tooth-oriented measure (Zammit et al., 1994).

2.4.5.2. Caries Analysis System

Douglass et al. (1994) refined the system adopted by Johnsen and co-workers by proposing the ‘caries analysis system’ (a surface-specific aetiology-based system). Caries is categorised into four patterns chosen to represent disease potentially caused by different factors: 'fissure pattern' represents surfaces susceptible to caries due to their anatomy (Parfitt, 1956), 'maxillary anterior pattern' describes the pattern that often develops when an infant sleeps with a feeding bottle (Johnsen, 1984; Ripa, 1988), 'posterior proximal pattern' represents surfaces protected from routine mechanical disturbances (Parfitt, 1956; Rule, 1982), and 'posterior buccal/lingual smooth surface pattern' represents surfaces that generally are affected only in extreme disease (Douglass et al., 1994) (Table 7). Errors in identification of the potential aetiologies of some carious lesions can occur when these are large and involve more than one surface (e.g., fissure pattern versus posterior proximal pattern).

Table 7: Caries Analysis System Criteria (Douglass et al., 1994)

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fissure pattern</td>
<td>Caries present in one or more occlusal fissures of first and/or second molars, buccal pits of maxillary second molars and/or lingual grooves of maxillary second molars</td>
</tr>
<tr>
<td>Maxillary anterior pattern</td>
<td>Caries present on mesial, distal, buccal and/or lingual surfaces of maxillary incisors, including the mesial surface of the canines</td>
</tr>
<tr>
<td>Posterior proximal pattern</td>
<td>Caries present on all contacting posterior smooth surfaces of maxillary and mandibular molars, including the distal surfaces of the canines</td>
</tr>
<tr>
<td>Posterior buccal/lingual smooth pattern</td>
<td>Caries present on all buccal/lingual surfaces of maxillary and/or mandibular molars without pits and fissures</td>
</tr>
</tbody>
</table>

The caries analysis system focuses only on those subjects with caries, and thus emphasises the extent of the disease in those affected. Since children often have more than one caries pattern, they could be classed with multiple patterns.
The system distinguishes between prevalence, severity and distribution. Prevalence is the percentage of the population experiencing a caries pattern, severity is the percentage of available surfaces affected in a specific caries pattern among children positive for that pattern, and distribution is the percentage of the total number of carious surfaces constituting a pattern.

This new caries analysis system (Douglass et al., 1994) was tested on 625 3-4-year-old children from a developed (Connecticut, USA) and a developing (Beijing, China) country. Several surfaces were excluded from the analysis: the buccal surfaces of canines because of the high prevalence of developmental defects. (Silbermann et al., 1991): the lingual surfaces of the maxillary canines, the lingual and mesial surfaces of the mandibular canines, and the mandibular incisors, since they are affected only in rampant caries (Johnsen, 1984). The distal surfaces of the second molars were excluded as these surfaces change character from free smooth surfaces to contacting posterior proximal surfaces (Douglass et al., 1994). In total, 5.7% of the carious surfaces were excluded, of which 25% were buccal surfaces of canines. All carious, restored and missing surfaces were included as they represented both current and past disease.

The results showed differences in caries prevalence between racial/ethnic groups. Prevalence among Hispanic and Black children was similar, but lower in White and higher in Chinese children. Prevalence also increased with age, with the lowest increase in fissure and maxillary anterior caries. This confirms the concept that fissure and maxillary anterior caries are initiated soon after eruption of the teeth, while posterior smooth surface caries take longer to develop (Ripa, 1988; Johnsen et al., 1987). The percentage of children who were caries-positive was approximately equal to the percentage with fissure caries, substantiating the idea that fissure caries is the most common pattern.

Differences were also seen in severity and distribution. Although the Chinese experienced a high prevalence of all caries patterns, they were no more severe than those seen in the Connecticut children. Fissure caries showed similar severity in all groups. The severity of maxillary anterior caries in Hispanics was low (15%), refuting the idea that maxillary anterior caries normally involves the majority of available surfaces. However, the other racial/ethnic groups demonstrated the expected severity of this pattern with 28 - 42 % of available maxillary anterior surfaces being carious in children with this pattern.
Caries distribution is a direct function of prevalence and severity. As these increase in a particular caries pattern, the distribution of that pattern increases. This explains why the distribution of maxillary anterior caries in Chinese and White children is the greatest of the four patterns despite the higher prevalence of fissure caries. Four-year-old Hispanics had a relatively high overall prevalence but a low overall severity. Further, they have low severity in the following three patterns: maxillary anterior, posterior proximal and posterior buccal/lingual smooth surfaces. This demonstrates that the number of individuals affected by a caries pattern - and the degree to which they are affected - can profoundly influence the overall picture of caries within a population group. The authors of the study argue that dmfs values provide only limited information. However, it showed that 3-year-old and 4-year-old Chinese children had more carious surfaces (6.4dmfs and 8.0 dmfs respectively) than the Connecticut children, that the caries experience among 3-year-old Connecticut children was similar (White 1.9dmfs, Black 2.6dmfs and Hispanics 2.2dmfs), and that 4-year-old Hispanics had the fewest carious surfaces (1.9dmfs). It is worth noting that the large standard deviation indicates an unexplainably large variation. The caries analysis system, which includes the dmfs index, provides a more complete and detailed profile of caries experience and patterns.

The authors suggest that knowledge obtained via the caries analysis system can be used to plan prevention and treatment programmes designed to address specific problems unique to each group, for example, fissure sealants for Hispanic children since they primarily experience fissure caries (Weintraub, 1989), and early dietary education for parents (Bruer et al., 1989) and fissure sealants for the Chinese and Whites since they experience a large proportion of maxillary anterior caries and a high prevalence of fissure caries.

The caries analysis system was also employed (Douglass et al., 1995) in a study of 3-6-year-old Chinese children with high levels of caries to further understand prevalence, patterns and progression in developing countries. The percentage of caries-positive children ranged from 67 % in 3-year-olds to 84 % in 6-year-olds. The prevalence, severity and distribution of caries patterns varied greatly among the four age groups studied. The most prevalent caries patterns in the 3-year-olds were the fissure (62%) and maxillary anterior (42%) patterns. The prevalence of the maxillary anterior pattern showed no significant change with age, but that of the fissure pattern increased in
successive age groups reaching a maximum of 82% in 6-year-olds. The posterior proximal pattern changed most between successive age with an increase from 14% in 3-year-olds to 68% in 6-year-olds.

Maxillary anterior caries was the most severe form of disease with up to 49% of available surfaces being carious in 5-year-olds with that pattern. The severity of fissure caries was greater in successive age groups, reaching a maximum of 40% of available surfaces in 5-year-olds. However, only the posterior proximal pattern demonstrated a statistically significant difference in severity with age (12.5% in 3-year-olds compared to 22.5% in 6-year-olds).

A marked difference in distribution of posterior proximal caries due to age was observed (increasing from 6% at 3-year-olds to 29% in 6-year-olds). The distribution of maxillary anterior caries was 55% in 3-year-olds and 22% in 6-year-olds. There was a smaller difference between age groups for the distribution of fissure and posterior buccal/lingual caries.

The authors claim that the high prevalence of the posterior proximal and fissure patterns in this Chinese population may be associated with the high prevalence of the maxillary anterior pattern; it has been shown that the presence of this pattern increases the risk of future development of all forms of posterior caries (Johnsen et al., 1987; O'Sullivan and Tinanoff, 1993a). The high prevalence of the maxillary anterior pattern may be attributed to high levels of enamel hypoplasia (Infante and Gillespie, 1977) or prolonged ad-libitum breast-feeding (Matee et al., 1992b).

The smaller change in prevalence, severity and distribution of fissure caries, and the obvious increase in the posterior proximal pattern with age, together indicate that the development of proximal caries is later than fissure caries since contacts must be closed for caries development (Parfitt, 1956).

The decrease in prevalence and distribution of maxillary anterior caries with age may be explained by the fact that the nursing habit is normally discontinued by three years of age, leading to decreased activity of carious lesions in the maxillary anterior teeth (Douglass et al., 1995).
The findings of this study demonstrated that patterns differ with age: maxillary anterior caries was the most important disease pattern in 3-year-olds while posterior proximal and fissure caries were the most prominent in older age groups.

The caries analysis system was also used to assess dental caries experience and level of mutans streptococci in Apache pre-school children in 1993, and to compare caries levels and patterns in this population with similar information from data collected at the same location 15 years earlier (Douglass et al., 1996). There was no significant difference in either the total dmft (9.2 for the 1978-79 cohort and 8.3 for the 1993 cohort) or the dmfs (19.8 and 19.2, for the two cohorts respectively). Furthermore, no significant differences between cohorts in either the number of caries-positive children or in the prevalence of any caries pattern were found. In both cohorts, 95% of the children were caries-positive; of these, virtually all had fissure caries. The maxillary anterior pattern was the second most prevalent caries pattern, affecting 79% and 73% of children in 1978-79 and 1993 respectively. More than 65% of children in both cohorts were affected by the posterior proximal pattern. There were no significant differences in the overall severity of each pattern between 1978-79 and 1993.

The prevalence of nursing caries (two or more carious teeth in the maxillary anterior pattern) was 74% and 64% in 1978-79 and 1993 respectively. In the 1993 study, the prevalence of the posterior proximal and buccal/lingual patterns was nearly 50% and 100% greater respectively in children with nursing caries than in those who were caries-positive but who had no nursing caries. Since virtually all caries-positive 4-year-old children in this study had fissure caries, it is not surprising that no difference was found in the prevalence of fissure caries in children with and without nursing caries.

The severity of the posterior proximal and buccal/lingual patterns showed no significant differences between children with or without nursing caries, but the severity of the fissure pattern was nearly 50% greater in children with nursing caries.

It is worth noting that the children classified in the high mutans streptococci category (>50CFU) not only had greater mean dmft and dmfs scores but also showed greater prevalence of nursing caries and greater severity of fissure caries than did those in the moderate category (1-50 CFU). The greater severity of fissure caries might be the result of the earlier initiation of the fissure pattern, high level of mutans streptococci and/or the exposure to high levels of fermentable carbohydrate in the bottle (e.g., juice or
sweetened milk). Although children with nursing caries showed a greater prevalence of the posterior proximal pattern than those without, no difference was seen in severity. These children may be too young for differences to be detected between those with and without nursing caries since this pattern develops later than the fissure pattern (Tinanoff, 1988).

Although the caries analysis system was originally designed to differentiate between caries patterns which may have distinct aetiology, in this study it was argued that the risk factors that contributed to nursing caries development, such as high levels of mutans streptococci infection, may be shared by the posterior teeth since prevalence and severity of posterior caries patterns are adversely affected in children with nursing caries (Douglass et al., 1996).

The impact of nursing caries (maxillary anterior caries) was further investigated in a one-year study of 217 3-5-year-old children enrolled in two different Head Start programmes in Connecticut (O’Sullivan and Tinanoff, 1993a). Using the caries analysis system, the association between the maxillary anterior and posterior caries patterns (pit/fissure, posterior proximal, posterior buccal/lingual) was studied. About 60% of the children were caries positive (i.e., with a dmfs of at least one). Among the entire sample, the prevalence of maxillary anterior caries (with or without posterior caries) was 17.5 %. Among caries-positive children its prevalence was 29.2 % (3.1% of children with anterior caries alone and 26.1 % with both anterior and posterior disease), the percentage of children who had posterior caries alone was 70.8 %.

The lower prevalence of the anterior pattern on its own indicates that once the factors necessary for the initiation of the caries process are established, they are difficult to reverse. The greater posterior caries prevalence in children with maxillary anterior caries suggests that the maxillary anterior pattern is a strong predictor of future caries on other tooth surfaces as they become available. Among the children with anterior and posterior patterns, the average total dmfs and the average posterior dmfs were 5.1 and 2.5 times greater respectively than the mean dmfs of children with posterior caries only.

The prevalence of pit/fissure, posterior proximal and buccal/lingual patterns were compared between children who initially presented with the maxillary anterior pattern and those who did not. A significantly larger percentage of children with maxillary anterior caries at the first examination were affected by posterior proximal and
buccal/lingual caries at the time of second examination than were caries-positive children who did not have the maxillary anterior pattern.

The high positive predictive value (86.8%) of the maxillary anterior pattern for pit/fissure caries suggests that the maxillary anterior pattern may be a good predictor of the former. Although the prevalence of posterior proximal and buccal/lingual caries was approximately three times greater in children with maxillary anterior caries, yet there were a lower positive and a higher negative predictive values (>91%) for children who did not develop the posterior proximal or buccal/lingual patterns. This may be due to the young age of the children and the later development of the posterior proximal and buccal/lingual surfaces. In fact, these surfaces are among the last to erupt, reducing the time over which they are susceptible to caries.

The caries analysis system was used again (O'Sullivan et al., 1994) to assess the dental health of Navajo pre-school (<2-5 years) children, not only by measuring the dmfs and tooth index but also by analysing specific patterns of dental caries experience. Caries was categorised into three of the four disease patterns proposed by Douglass et al. (1994): maxillary anterior (all maxillary incisors and mesial surfaces of the maxillary canines), fissure pattern (including all occlusal fissures, buccal pits and lingual grooves of the molars), and posterior proximal (all contacting posterior smooth surfaces). The system was slightly modified by including extracted and restored surfaces to allow for the assessment of dental need as well as treatment.

The results showed that caries experience increased with age: the dmft and dmfs in children < 2 year-old were 0.2 and 0.5 respectively; at 2 year they increased to 1.7 and 3.9, and between 3 and 5 years they increased from 4.5 and 10.7 to 6.6 and 18.9. Not only a higher level of caries was seen, it was also evenly distributed. This greater uniformity suggests all Navajo children may be considered at risk.

The maxillary anterior pattern was the only one seen in children younger than two years of age, with 11% affected. It was also the most prevalent in 3-year-olds, of whom 68% were affected. The high prevalence of maxillary anterior caries may be attributable to linear enamel hypoplasia.

Unlike the other caries patterns investigated, the prevalence of maxillary anterior caries was not successively greater in 3, 4 and 5-year-olds. It is likely that most of these
older children had either discontinued bottle usage or are not predisposed to this disease pattern. Although the prevalence of maxillary anterior caries was high the severity was low. This finding is in contrast to the traditional belief that the greater the prevalence in general, the greater the severity (Grainger, 1967). Fissure caries and posterior proximal caries were first evident in 2-year-olds and increased with age. The prevalence of fissure caries was consistently greater than that of posterior proximal caries, reaching a maximum of 87% in 5-year-olds.

It is interesting to note that 10% of the 2-year-olds had posterior proximal caries. This represents the earliest manifestation of this pattern since these surfaces are among the latest to develop and close contact. It was also found that 70 - 75% of those with the posterior proximal pattern in each age group had the maxillary anterior pattern. This partly agrees with an earlier study (O’Sullivan and Tinanoff, 1993a), which indicated that children with the maxillary anterior pattern were at markedly greater risk of developing the fissure and posterior proximal patterns.

The prevalence of untreated lesions in the maxillary anterior pattern in children younger than two was identical to the total prevalence of the pattern, i.e., none of these children had received treatment. The prevalence of untreated maxillary anterior caries was less in successive age groups. The priority for treatment of this pattern may be low because of the frequently unrestorable nature of these teeth and the reduced importance of maxillary anterior teeth in dental arch development compared to posterior teeth. The total and untreated prevalence of fissure caries and posterior proximal caries was identical for children who were 2 years old and less. The untreated prevalence of the fissure and posterior proximal patterns was greatest in 3-year-olds (44% and 24% respectively). The finding that the severity of the fissure and posterior proximal patterns was greater in successive age groups while the severity of untreated lesions was less may be attributed to the high level of dental care the Navajo Head Start children receive and the treatment priority these patterns are given. Although the prevalence and severity of all caries patterns studied among Navajo pre-school children are high, children in Head Start programmes have received some of the most extensive dental treatment reported.

O’Sullivan and Tinanoff (1996) used the caries analysis system to report on the association between baseline caries patterns and caries development in pre-school children two years later. The study group comprised 142 3-4-year-old pre-school
children. They were categorised at baseline as caries-free (59%), as having pit and fissure but no maxillary anterior caries (28%), or as having maxillary anterior caries either alone or with posterior caries (10%). The remaining 3% were excluded from the analysis since they had anomalous caries patterns. After two years, children who presented at baseline with maxillary anterior or pit and fissure caries had a mean posterior dmfs over seven and four times respectively that of children who were caries-free at baseline. According to the caries analysis system (Douglass et al., 1994), posterior caries was categorised by specific posterior patterns (i.e., posterior proximal and buccal lingual). After two years, these specific patterns were analysed with respect to baseline caries patterns. The results showed that children who at baseline had the pit/fissure pattern and those who had the maxillary anterior pattern had respectively 1.5 times and 2.4 times the increment of pit/fissure caries compared to the caries-free group. This clearly shows that 3-year-olds with a maxillary or pit/fissure pattern will have significantly higher levels of caries by the age of 5 than those who are caries-free at baseline. Compared to children in the caries-free group, those with the pit/fissure pattern suffered proximal and buccal/lingual caries increments of nearly 4 and 3 fold respectively. Children who were categorised with maxillary anterior caries at baseline had a proximal and buccal/lingual caries increment of nearly eight times those of children in the caries-free group.

Children with the anterior maxillary pattern not only began the study with a greater level of caries than children who were categorised with the pit/fissure pattern without maxillary caries, their two-year incidence of pit/fissure caries also was greater. Together these results suggest that both the pit/fissure and maxillary anterior caries patterns have a hierarchical relationship with continued decay and an increased but varying risk of posterior tooth surface involvement, depending on their early caries pattern.

Thibodeau and O'Sullivan (1996) used the caries analysis system in order to assess the correlation between levels of salivary mutans streptococci and the prevalence, incidence and distribution of caries patterns in the primary dentition. A total of 146 children of low socio-economic status (initial mean age 3.8 years) were examined for dental caries at baseline and then once annually for two years. At baseline, children were categorised by their level of salivary mutans streptococci into low (0 CFU), moderate (1-50 CFU), or high (>50 CFU) groups (Thibodeau et al., 1993).
At baseline, 12.1%, 28.8% and 72.2% of the children in the low, moderate and high salivary mutans streptococci (SMS) ranges respectively had some form of caries. The average dmfs were 0.15, 1.47 and 4.67 for the three ranges. This suggests that children with low baseline SMS levels are more likely to be caries-free.

When baseline SMS ranges were compared for each of the four caries patterns - pit/fissure, maxillary anterior, posterior proximal and buccal/lingual – all except the last were significantly different. More than half the children with high baseline SMS had pit/fissure caries at baseline examination compared to only 12% of those in the low SMS group. After two years, children in the high SMS group had the highest prevalence of each pattern, and children in the low SMS group had the lowest prevalence of pit/fissure, maxillary anterior and posterior proximal patterns. Of the children with the maxillary anterior pattern at the second examination, none had a low baseline SMS level. No children with low baseline SMS developed the maxillary anterior pattern.

The incidence of maxillary anterior, posterior proximal and buccal/lingual patterns (i.e., the increase in the number of children with those patterns) was greater in the high baseline SMS group than in the low SMS group. The incidence of pit/fissure caries was approximately 25% in all the three baseline SMS ranges. The relative risk for developing pit/fissure, maxillary anterior and posterior proximal caries in the high SMS group was significantly greater than for children in the low group. None in the low SMS range had all four patterns after 2 years, while 3% and 11% of the children in the moderate and high SMS groups, respectively, had all patterns.

With respect to severity of pit/fissure caries, children with high baseline SMS levels had more carious surfaces showing this pattern at baseline and after two years than did children in the low and moderate groups.

This study was the first to establish a relationship between SMS levels and caries patterns in pre-school children with respect to the number of patterns and their prevalence. The results showed baseline SMS levels were associated with both cross-sectional and longitudinal caries experience, number of caries patterns and the severity of those patterns.

A study by Dini et al. (1998) on 3-6-year-old children in Brazil considered the differing caries patterns in primary teeth in areas with contrasting fluoridation history.
Two methods of defining pattern were used: the caries analysis system and tooth type system, grouped into anterior, posterior and both. When tooth types were grouped together, the prevalence of caries affecting both anterior and posterior teeth differed between the two types of area. There was little difference in the proportion of children with caries confined to molars or to incisors (and/or canines). In 5-6-year-olds in the area with only two years of fluoridation, the prevalence of caries affecting both anterior and posterior teeth was approximately equal to that for caries confined to molars (44% vs. 40% respectively). In contrast this more extensive form of caries was less prevalent than molar caries alone (17% vs. 36% respectively) in the areas where fluoridation had been undertaken for over 10 years.

In terms of caries analysis system patterns, the differences between the two areas were greatest with respect to the posterior proximal patterns of caries.

The findings of the two methods indicate that fluoridation can prevent the most extensive patterns of caries in primary teeth.

It is interesting to note that the simple classification based on whether anterior or posterior teeth or both were affected by caries appeared to reflect differences between the two areas at least as well as the caries analysis system.

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All the patterns discussed in this review have added to our knowledge of dental caries and its distribution in primary teeth. They have all opened new avenues for further research, but each has its own limitations. The severity zone system is rather complicated and assumes that children in each zone will also be included in zones of lesser severity, an assumption that is not always correct. The caries analysis system uses a system of groupings that are not mutually exclusive. Thus a high proportion of children with caries affecting posterior proximal surfaces may also have caries in the fissures. This negates the aetiology-based concept, which claims that differences in pattern reflect differences in aetiology, and consequently the need for different preventive measures (Johnsen et al., 1984).

Dini et al. (1998) argue that the system of reporting the prevalence of disease affecting the posterior and/or anterior teeth (tooth type system) is often more simple than the severity zone system. Further, the tooth type system may also have a methodological
advantage over the caries analysis system in that it employs mutually exclusive groups. The simple method of grouping appears to reflect differences between the two areas at least as well as the caries analysis system and it may also show differences related to aetiological factors. These authors recommend that the association between the three caries patterns and the underlying aetiological factors have to be further studied before the hypothesis that these patterns are aetiologically related can be substantiated.
2.5. ORAL CLEANLINESS

2.5.1. Definitions

Oral cleanliness is the state in which all surfaces of all teeth are plaque free (Löe, 2000).

Dental plaque is a soft, non-calcified bacterial deposit which accumulates on the surfaces of teeth and other firm objects in the mouth. It can be removed by mechanical cleaning, e.g., by tooth brushing (Manson, 1986).

2.5.2. Plaque formation

The deposition of plaque at the gingival margin occurs on all surfaces of all teeth and is clinically recognisable with or without disclosing solution in less than 24 hours after the last brushing (Löe et al., 1965). After initial establishment, plaque rapidly accumulates in a coronal direction until, after approximately one week (if not actively removed) its thickness and extension reaches its maximum. Whereas there are no major differences in the thickness of plaque, its occlusal and incisal extension may vary in different groups of teeth, as well as on various tooth surfaces. This probably reflects the masticatory pattern of the individual and the movement of the tongue and cheeks. Friction through mastication may limit its occlusal and incisal extension (Löe et al., 1972) - but not on the cervical margin, even with excessive chewing of course foodstuffs (Lindhe and Wicen, 1969). Crowding or other irregularities in the positioning of teeth, and inflammatory or other changes in the marginal gingivae, may modify the rate of plaque growth (Saxton, 1973). Plaque formation is also influenced to some extent by the amount, physical characteristics and chemical composition of saliva. Hyposalivation and xerostomia generally seem to increase plaque formation (Löe, 2000). Although self-cleaning may have been a valid principle in the past, in the light of the above this is no longer so: plaque must be removed actively (Löe, 1970). Clinical studies show that in the absence of plaque, even with frequent additions of sucrose to the daily diet, caries fail to develop (Löe et al., 1972).
2.5.3. Plaque Control

The methods of plaque control are chemical and mechanical, the latter being the most widely employed.

2.5.3.1. Mechanical tooth cleaning

2.5.3.1.1. Tooth brushing and inter-dental cleaning

Tooth brushing and other mechanical cleaning procedures are now considered the most reliable means of controlling plaque, provided cleaning is sufficiently thorough and performed at regular intervals (e.g., tooth brushing is considered effective when plaque accumulations are found on 10% or less of available tooth surfaces [O'Leary et al., 1972]). Nowadays, most people exercise some measure of oral hygiene, with tooth brushing the method of choice. However, wide variations exist between and within countries not only in the proportion of children who brush but also in the frequency of brushing.

Under the best of circumstances, tooth brushing alone is able to clean only the buccal, lingual and occlusal tooth surfaces (excluding pits and fissures); proximal and interdental areas are essentially left untouched (Kinane, 1998). This is most unfortunate since these are the areas in which caries most often develops, and where gingival and periodontal lesions are most frequently found (Löe, 2000).

2.5.3.1.2. Tooth brushing ability

Tooth brushing ability is defined as achieving a level of manual dexterity sufficient to manipulate a toothbrush, to employ a tooth brushing technique, and to brush a buccal or lingual surfaces in its entirety (Unkel et al., 1995).

The removal of plaque by tooth brushing is dependent on coordinated muscular movements, innate skills, and the ability to understand instructions (Simmons et al., 1983). The latter authors note that children younger than four do not comprehend the language necessary to achieve effective tooth brushing.
Ogasawara et al. (1992) investigated the readiness for tooth brushing of young children, and defined four developmental levels:

1- Under 18 months:

The infant cannot put the tip of the brush on the surface of a tooth even when told to do so. This is the “cannot brush level”.

2- Over 18 - 42 months:

The infant can brush at least the mandibular occlusal surfaces and the labial surfaces of the anterior teeth. It is thought that guidance in brushing begins to take effect from this stage.

3- Over 42 - 54 months:

The child can brush almost anywhere from the occlusal and buccal surfaces to the lingual surfaces of the anterior teeth.

4- Over 54 – under 60 months:

Some can brush part of the molar lingual surfaces but even these children cannot brush all regions.

5- 60 months and older:

The child can brush all regions.

The authors point out that a child cannot be expected to brush his teeth independently before 18 months of age. After 5 years of age, children have the ability to brush all regions. Consequently, there is a need for guardians to give a finishing touch to their children’s tooth brushing at least up to the age of 5 years or until they enter primary school.

Tooth brushing ability improves with increasing age and by 10 years it approaches that of adults. Approximately 4% of tooth surfaces remain unbrushed in 10-year-olds and adults. The ability of males and females is similar (Unkel et al., 1995).
2.5.3.1.3. **Tooth brushing habits**

Little is known about the way tooth brushing habits relate to people’s day to day activities and lifestyles, but tooth brushing frequency appears to be influenced by a number of factors, including smoking, drinking, eating, bedtime and watching television (Schou et al., 1990). Tooth brushing is closely associated with personal cleanliness and increases in line with the frequency of other oral hygiene practices, bathing and hair washing (Macgregor and Balding, 1987). The behaviour of young children is subject to the influence of his/her mother’s dental health knowledge, attitudes, beliefs and practices (Grytten et al., 1988; Crawford and Lennon, 1992).

Tooth brushing practices vary from one country to another (Honkala et al., 1990) and with a number of demographic and behavioural factors such as gender and social class (Schou et al., 1990). A study of 5-year-olds in Athens and South London (Zoitopoulos et al., 1997) showed that 82.7% of the former brushed their teeth compared to 98.4% of the latter. This is much higher than that reported in a Romanian study on the oral health behaviour of grade 1 (7-year-old) school children (Petersen et al., 1994). Only 37% brushed their teeth at least twice a day; 26% had their teeth cleaned by their mothers every day. The poorer the country, the poorer the oral hygiene of its children. In Cambodia, oral hygiene was rated as poor in 80% of children. Only 10% reported using a toothbrush (Todd et al., 1994).

As might be expected, those from higher social classes who have a higher level of education are believed to be more knowledgeable about dentally-related behaviours. A study in the early 70s (Beal and Dickson, 1974) showed that the percentages of 5-year-olds who brushed their teeth at least once a day were 92%, 74% and 64% for social classes I and II, III and IV and V respectively: children from higher social classes were more likely to brush their teeth regularly.

The findings of *The National Diet and Nutrition Survey* suggest that children from non-manual backgrounds are more likely to have started having their teeth brushed - or to have begun brushing themselves - before the age of one than are children from the manual social class group (55% compared to 44%) (Hinds and Gregory, 1995).
The effect of ethnicity on oral health has been investigated. A study on caries experience and oral cleanliness of Asian and White Caucasian children aged 5 and 6 years attending multi-racial schools in Trafford and Glasgow (Bedi and Elton, 1991) showed no significant difference in oral cleanliness among the three Asian ‘at risk’ groups (Asian Muslim children with non-English speaking mothers, Asian non-Muslim children with non-English speaking mothers, and Asian Muslim children with English speaking mothers) in either city with respect to oral cleanliness. The groups were then combined into one ‘high risk’ group for further analysis and significant differences to the White population were seen in both cities. Some 53% of Asian children had poor oral cleanliness compared to 38% of White children in Trafford, while in Glasgow 50% of Asians had poor oral cleanliness compared to 28% of White children. On the other hand, no statistically significant difference was detected between the percentage of White and non-Muslim children with English speaking mothers with respect to poor oral cleanliness (38% for both groups).

In Amsterdam (Verrips et al., 1992), the oral health of 674 5-year-olds (Turkish, Moroccan, Surinamese, Dutch and others) was investigated. Plaque accumulation was measured according to the method described by Green and Vermilion (1964). All children, except one Surinamese child, had plaque. The proportion of children with small amounts of plaque was about 50% in the Dutch and Surinamese but only 28% in the Turkish and 22% in the Moroccans.

2.5.3.1.4. Time trend in the improvement of oral health

Two studies (Silver, 1992; Whittle and Whittle, 1995) have investigated the change in dental health related behaviour with time. Silver (1992) examined three samples of 3-year-olds over two 8-year periods. The results indicated that tooth-brushing habits have continued to improve both in frequency and with respect to the age at which brushing has started. Some 80% of people claimed that their children brushed daily in 1973, 88% claimed this in 1981, and 90% in 1989. There was also an increase in the proportion of children who claimed to have started brushing when younger than one year old (28%, 38% and 68% respectively). Although no significant differences in brushing behaviour were found between the social classes in the first two surveys, there was a marked tendency in 1989 for children of non-manual class families to start brushing earlier and to
brush more frequently. Evidence linking reported brushing behaviour and caries experience remains equivocal; the strong relationship between the proportion of caries-free children and the frequency of brushing found in 1981 and the lower mean dmft of children who started brushing earlier in 1973, was not seen in the other year groups (Silver, 1992).

In the second study (Whittle and Whittle, 1995), data from two BASCD surveys (1989-90 and 1993-94) were compared. Clear improvements were identified in both Salford and Trafford regarding the proportion of children who had their teeth brushed with toothpaste by their first birthday (46% and 47% respectively in the first survey compared to 60% and 62% in the second).

2.5.4. Toothpaste

Toothpaste plays a key role in removing plaque. Its removal can be increased substantially if toothpaste is employed during brushing (Lobene et al., 1983). This is mainly due to the presence of the detergent and abrasive material in the toothpaste (Forward, 1991).

The benefits to oral health of tooth brushing with a fluoride-containing dentifrice are beyond doubt (Holt and Murray, 1997). It is a popular and convenient way of preventing caries and many believe it to have been the most significant factor in the decline in caries experience in many developed countries since the 1970s (Glass, 1982).

When fluoride products - including dentifrices - are used, they cause an initial high concentration of fluoride in the saliva, which falls with time as it is cleared from the mouth (Brunn et al., 1984: Zero et al., 1992). Very importantly, fluoride can be retained at concentrations in the saliva between 0.03 ppm and 0.1 ppm for 2-6 hours depending on the product and the individual (Zero et al., 1992). As far as its caries preventive effect is concerned, frequency of brushing is crucial since fluoride toothpaste is effective even when an unsatisfactory brushing technique is employed (Kuusela et al., 1996). The toothbrush acts as a vehicle to carry fluoride to the teeth. It is now recognised that not only the frequency of brushing but also the method used to rinse the mouth after brushing are important influences on decay experience (Chesters et al., 1992). In an in vitro study on seven adults wearing complete dentures, it was shown that the degree of demineralisation of enamel and dentine at proximal sites is related to water rinsing after
brushing with sodium fluoride-containing toothpaste (Sjögren et al., 1995). When a small amount of water together with the dentifrice foam was swirled around the dentition as a slurry for 1 minute, the demineralisation rate was reduced. On the other hand, when more water was used for rinsing, an increase in the demineralisation rate occurred. This was further emphasised in a later study where tooth brushing frequency and rinsing method (using/not using a beaker) after brushing were strongly correlated with caries experience and caries increments (Chestnut et al., 1998).

The carious process is a delicate balance between demineralisation and remineralisation and in the mouth there is a see-sawing between these two phenomena depending on the cariogenic challenge present (O’Mullan, 1994). The presence of fluoride has been shown to promote the process of remineralisation (Koulourides et al., 1980). There is also evidence to show that low levels of fluoride in plaque affect plaque metabolism (including glycolysis) in such a way that acid production is reduced (Hamilton, 1977).

It is now believed that fluoride’s effect is largely therapeutic and its action mainly topical, although some pre-eruptive effect, especially in pits and fissures, has also been demonstrated (Groeneveld et al., 1990).

There has been a debate as to the quantity of paste that should be used for children. Instructions have varied. The British Society of Paediatric Dentistry (BSPD, 1996) recommends that children under the age of six should use an amount of toothpaste no greater than a small pea. This advice has become widespread and is now printed on many toothpaste tubes. Nonetheless parents are not generally aware of this advice. In a report, 59.9% of parents who claimed they usually used fluoride toothpaste for their toddlers indicated that they covered one third or less of an infant or child-size toothbrush head with toothpaste, while 10.8% indicated that they covered more than two thirds of the brush head (including one parent whose toddler used an adult-size brush) (Jones et al., 1996).

2.5.5. Oral cleanliness and caries

A drawback in studies on the relationship of oral cleanliness and caries experience is that the indices used are different in nature. Caries experience is usually measured by quantitative indices (dmft/s or DMFT/S) while plaque is usually described by a
qualitative index. The combined use of these indices in a single investigation may be inappropriate because of the transient nature of plaque deposits. Plaque indices refer strictly to the standard of oral cleanliness at the moment of the examination while caries indices give the total caries experience accumulated from the time of tooth eruption (Sutcliffe, 1989).

Although the role of dental plaque in the aetiology of dental diseases has been well reviewed (Bowden and Edwardsson, 1994), the role of oral hygiene in the prevention and control of these diseases is less clear-cut (Løe, 2000). Addy et al. (1990) argue that the frequency with which the teeth are brushed does not necessarily imply effective plaque removal.

The confounding issues of plaque removal and the profound effect of fluoride toothpaste have complicated our understanding for the role of dental hygiene in dental caries. It is well to remember that, during the last decade, in most industrialised countries there has been no such thing as tooth brushing without fluoride. The likelihood that the caries-reducing effect of tooth brushing per se will be further clarified, is doubtful (Løe, 2000)

Sutcliffe (1989) concluded that there was no unequivocal evidence that good oral cleanliness reduces caries experience, nor was there sufficient evidence to condemn the value of good oral cleanliness as a caries-preventing measure.

2.5.5.1. Studies on pre-school children

Studies on pre-school children have been few, and those on the correlation between caries prevalence and oral hygiene have given contradictory results. A strong correlation between caries and oral hygiene has been reported in 3-year-olds (Schröder and Granath, 1983) and 5-year-olds (Kleemola-Kujala and Rasanen, 1982), but other studies indicate no correlation in children of 18 and 36 months (Grytten et al., 1988; Johnsen et al., 1980 respectively).

Wendt et al. (1994) carried out a prospective study of oral health in 671 pre-school children living in Sweden who were followed from the age of 1 to 3 years. Children who were free of caries at 3 years had their teeth brushed more frequently at 1 and 2 years of age and had a lower prevalence of visible plaque at these ages than did children with
caries. These children also used fluoride toothpaste more often at 2 years of age. This finding agrees with that indicated by Kalsbeek et al. (1992) and Verrips et al. (1992).

Other studies reported on the relationship between caries and age of commencement of brushing, frequency of brushing, brushing with the help of an adult (mainly the parents), frequency of brushing with a toothpaste and fluoride concentration in toothpastes.

**Age of commencement of tooth brushing**

The age at which oral hygiene measures are commenced is important in establishing and maintaining the oral health of children. *The National Diet and Nutrition Survey* demonstrated that under half (49%) of the children surveyed started tooth brushing (by themselves or with help) before the age of one year. For another 40%, tooth brushing started the following year. Hence, tooth cleaning had started by 2 years of age for 89% of these pre-school children (Hinds and Gregory, 1995). In another British study on 5-year-olds and under, 83% of children started to brush before 2 years of age (Hunter et al., 1997).

An Australian study reported that 41.3% of children commenced tooth brushing at or before the age of 12 months (Wyne et al., 1997).

The younger the children are when they start tooth brushing the lower the proportion that have tooth decay. Hinds and Gregory (1995) reported that 12% of children who started tooth brushing before the age of one year had some experience of decay, compared to 19% of those who started between the ages of one and two, and 34% of those who did not start tooth brushing until after two.

In another study (Williams and Hargreaves, 1990), age at which tooth brushing started was not significantly associated with caries prevalence in Asian children resident in a fluoridated city in Canada. Similar findings were recorded in a non-fluoridated city in Canada (Derkson and Ponti, 1982).

**Frequency of tooth brushing**

Early reports on the relationship between frequency of tooth brushing and the state of oral hygiene were conflicting (Dale, 1969). Precision studies on the association
between frequency of brushing and the incidence of caries and periodontal disease are still scarce (Löe, 2000).

Frequency of brushing was investigated in Great Britain and found to be associated with dental decay experience in each age cohort studied. For example, among the group aged 3½ - 4½ years, 24% of children whose teeth were brushed more than once a day had experience of dental decay compared to 38% of those whose teeth were brushed once a day, and compared to almost half (48%) of those whose teeth were brushed less often (Hinds and Gregory, 1995).

Bjarnason et al. (1995) assessed the dental health of 631 Latvian 3-4-year-old nursery school children. Generally the children brushed their own teeth without adult assistance. Daily tooth brushing was reported for 60% of the children. Of those, 38% used fluoride-containing toothpaste. Some 40% did not brush their teeth regularly. No significant associations were found between caries experience and tooth brushing frequency. The limited use of fluoride can account for the absence of a relationship between tooth brushing habit and caries experience. Also the lack of parental assistance (making the standard of tooth brushing questionable) may obscure the impact of this oral hygiene practice.

The interaction of snacks, frequency of tooth brushing and dfs has also been investigated (Stecksen-Blicks and Holm, 1995). Irregular tooth brushing was shown to potentiate the impact of frequent snacking. Children who had high snack intakes and brushed irregularly had significantly higher caries experience (5.7dfs) than those with low snack intake and who brushed regularly (1.4dfs).

**Brushing alone or with help**

Ogasawara et al. (1992) showed that children do not have the ability to brush all regions before 5 years of age – therefore, they really need the help of an adult. The British Society of Paediatric Dentistry (BSPD) (1996) recommends that an adult supervise the amount of toothpaste and the tooth brushing technique used up to at least 7 or 8 years of age.

The frequency of brushing with and without help and its relationship with dental caries has been investigated in a number of studies.
A British study on children aged 5 years and under indicated that 87% of mothers said their child’s teeth were cleaned on a regular basis; the remaining 13% admitted that they were not. Some 43% of children brushed their teeth unaided and just over one third had the help of a parent or parents. In 22% of the sample, a parent took the full responsibility of cleaning the child’s teeth (Hunter et al., 1997).

In another British study on a younger age group, it was found that children who brushed their own teeth had higher prevalence of dental decay than those who were helped. This was most noticeable in the youngest age cohort (1 ½ - 2 ½ years) in which 7% of children who always brushed their own teeth had experience of decay compared to only 1% of those whose tooth brushing was shared between the child and an adult, and 4% in children whose teeth were brushed by an adult only (Hinds and Gregory, 1995). The differences, however, were not statistically significant (p>0.05).

In 4-year-old Swedish children (Stecksen-Blicks and Holm, 1995), the differences in mean dfs between groups who brushed once or twice daily with help from parents (1.6dfs and 1.3dfs respectively) and a group who brushed irregularly (3.7dfs) were statistically significant. It is worth noting that fluoride toothpaste was used by almost all (92%) of these children.

An Australian study reported that independent brushing was undertaken by 8.2% of children aged one year and under, 8.9% of children between one and two years, and 22.5% between two and three years. Parents of 77 infants aged 12-36 months completed questionnaires on behavioural risk factors, and the caries experience of the infant was then assessed. Comparisons were then made between the children with caries and those without. Some 33% of caregivers in the caries group reported that they cleaned their child’s teeth every day while over 70% of caregivers in the non-caries group did so (Wyne et al., 1997).

The age of the child when parents start to brush his/her teeth appears to be the most important potential risk factor. The later they start the greater dmfs their children suffer. Verrips et al. (1992) found that when parents started when their child was 2 years old their child’s mean dmfs was 5.7 compared to 10 if they started at 4 years and older. This has been supported by a more recent study (Creedon and O’Mullan, 2001). The age of commencement of tooth brushing (along with a number of other variables such as water fluoridation status, whether or not the child took a feeding bottle to bed, and the
number of sweet snacks and drinks taken in a day) is a significant factor in the multivariate logistic regression model: the later the onset of tooth brushing the higher the risk of caries. These findings concur with those of other studies (Tee, 1987; Wendt et al., 1994; Hinds and Gregory, 1995)

**Frequency of brushing with toothpaste**

The use of toothpaste was investigated in samples of 60 and 68 children (mean age 18 months) in a low and a high caries area. Some 60% of children in the low caries area used toothpaste on two or more occasions compared to 37% of those children in the high caries area (Jones et al., 1996)

**Fluoride concentration in children’s toothpaste**

Children’s teeth may be brushed with toothpaste from a very early age (Blinkhorn, 1978). However, some reports suggest that children who begin to use fluoride toothpaste regularly from an early age (between 1 and 3 years) have an increased prevalence of diffuse enamel opacities or very mild fluorosis (Osuji et al., 1988; Milsom and Mitropoulos, 1990). These reports have encouraged manufacturers in some countries to develop special toothpastes for children with low concentrations of fluoride in an attempt to reduce enamel opacities in permanent dentition (Horowitz 1992; Beltran and Szpunar, 1988). However, it is important to note that the effectiveness of these toothpastes, for example those below 600 ppm, has not been established (O’Mullan, 1994). Winter et al. (1989) carried out a clinical trial with a large sample of Norfolk preschool children and found that there were fewer caries-free children amongst those who used a specially formulated toothpaste with a fluoride concentration of 550 ppm compared to those who used a control paste containing 1050 ppm. Combined clinical and radiographic data of 477 children in the test group and 428 in the control group were compared. Of the children in the test group, 52% were free of caries, compared to 58% of the control group. Values for decayed surfaces, when only dentine caries was considered, were 1.86 and 1.53 per child for the test and control groups respectively.
2.5.6. Gingivitis

Gingivitis is an inflammatory lesion, mediated by host/parasite interactions, which remains limited to the gingival tissue and does not involve the underlying periodontal ligament, cementum and alveolar bone. The apical extent of the junctional epithelium and the coronal attachment remain at the cemento-enamel junction (Chapple, 1996).

The problem is broadly classified to acute and chronic. This review is limited to plaque-induced chronic gingivitis.

2.5.6.1. Periodontium in health and disease

The periodontium of the primary dentition differs from that of the adult. The gingiva are more red, flabbier, and lack the stippling of adult gingivae. The tissue is less fibrous and more vascular (Casamassimo, 1988).

The periodontium of the pre-schooler has traditionally been characterised as generally healthy, with disease confined mainly to the marginal gingivae.

Gingivitis appears first as an inflammation of the papillary gingiva, spreading to the marginal gingiva and occasionally progressing to involve the attached gingivae. Gingivitis in pre-schoolers leads to no appreciable or irreversible tissue damage. In many cases, the inflammation will be confined to the papillae and the gingival margin despite large accumulations of plaque. The gingival tissue becomes reddened and swollen and will bleed upon probing or brushing as the condition worsens. However, the individual response to plaque as an aetiological agent is variable; some children have large amounts of plaque and yet have healthy gingivae and vice versa (Casamassimo, 1988).

Gingivitis is also associated with gross caries and poor quality restorations.

2.5.6.2. Oral cleanliness and gingivitis

The onset of gingivitis is more related to the maturation and the age of the plaque (that is its bacterial composition) than to its amount (Löe et al., 1965; Theilade et al., 1966). Subclinical tissue changes appear 2 days after plaque development (Loe et al., 1967). A pilot study suggested that the gingivae could remain in clinical health with
complete removal of plaque once a day or once every second day (Löe, 1970). This was confirmed in more definitive studies showing that longer intervals between cleaning were insufficient for maintaining gingival health (Lang et al., 1973). However, most people are unable to perform cleaning sufficiently well every 48 hours to maintain gingival health.

It was found that during the initial three days of a ‘no oral hygiene period’, children with deciduous dentition formed less plaque than older subjects (Matsson, 1978; Ramberg et al., 1994). Children with deciduous dentition seem to respond to plaque formation with less gingivitis than adults with permanent dentition (Ramberg et al., 1994). Gingivitis, therefore, is more prevalent in adults than in children. Hugoson et al. (1981) examined five hundred children and young adults for gingivitis and observed that while the majority of 3-year-olds had healthy gingivae, 97% of the 20-year-olds showed signs of gingivitis. This is in agreement with the findings of other studies (Matsson, 1978; Ramberg et al., 1994). Matsson (1978) showed that, under comparable plaque conditions, adults have a higher tendency to develop gingival inflammation than preschool children. This author concludes that there is a real difference in the tendency to develop gingivitis between pre-school children and adults. Despite plaque accumulation, the gingival ability to remain healthy in young children has been confirmed in a study (Wendt et al., 1994) where, although plaque was present in children at the age of 1 and 2 years, few developed gingivitis at 3 years of age.

2.5.6.3. Prevalence of gingivitis

Studies on gingivitis in children have been scarce. Further, it is very difficult to compare results from studies that have used different criteria to define gingivitis, such as bleeding/no bleeding on probing (Arnlaugsson and Magnusson, 1996; Seow et al., 1996), omitting the first grade (slight change in colour) from the index of Löe and Silness (1963) (Masiga and Holt, 1993), or combining grades 2 and 3 of the same index (Roeters et al., 1995).

Arnlaugsson and Magnusson (1996) studied the prevalence of gingivitis in 230 6-year-olds in Reykjavik, Iceland, and found 26% to have healthy gingivae.

A longitudinal study in the Netherlands (Roeters et al., 1995) on a sample of 252 2-5-year-olds found that until the age of 3.5 years plaque and gingivitis scores increased. However, statistically significant differences were found only between the youngest (1.9-
2.5) and the other age groups. Explanations given by the authors were the lesser control by the parents over the oral hygiene of their children, or changes in the number of teeth. The posterior location of the second primary molars (after their eruption) may hamper the effectiveness of tooth brushing.

In an inner city area of London, 36% of 3-year-olds and 41% of 4-year-olds were found to have gingivitis (Cushing and Gelbier, 1988). Another study in Nairobi on 446 3-5-year-old children showed that 37%, 33%, and 40% of 3, 4 and 5-year-olds respectively had gingivitis (Masiga and Holt (1993). In these two studies, gingival inflammation did not increase with age.

It is worth noticing that research on the prevalence of gingivitis in 5-7-year-olds has yielded very different results, with figures varying from 9% to 85% (Stamm, 1986). The question therefore arises as to whether there is a real difference between the study groups or whether the differences are the result of the different methods used to test for gingivitis.
2.6. **AIMS AND OBJECTIVES OF THE STUDY**

2.6.1. **Overall aims**

To determine the relationship between oral health and socio-demographic factors in children attending a kindergarten in Amman.

2.6.2. **The objectives**

a) To select a group of children attending kindergartens in Amman

b) To collect baseline information of the condition of pre-school children’s oral health, in terms of caries, plaque and gingivitis.

c) To describe caries status in terms of dental caries prevalence as well as through dmft and tooth-type patterns.

d) To collect socio-demographic status, oral hygiene practices, feeding habits during infancy and eating habits information via a self administered questionnaire.

e) To test the association between oral health (dental caries, plaque and gingivitis levels) and socio-demographic status, oral hygiene practices, feeding habits during infancy and eating habits information.

f) To describe the association between the prevalence and severity of dental caries for the study population and their socio-demographic status.

g) To describe the association between oral cleanliness and gingivitis and socio-demographic factors.
3. MATERIALS AND METHODS

The study subjects were 4- and 5-year-olds drawn from the population of children attending kindergartens in Amman, the capital of Jordan.

The study group (n=1140) comprised 569 4-year-olds and 571 5-year-olds. The distribution of the sample according to gender was 582 boys and 558 girls.

The study was based on an oral examination (caries, plaque and gingivitis) and a questionnaire. Radiographs were not taken.

3.1. Pilot Study

A pilot study was essential for this investigation. Two kindergartens were visited where 48 children were selected for dental examination. A preliminary questionnaire was sent to the parents along with a covering letter explaining the purpose of the study. This letter also requested their co-operation and consent for their children to participate. The school headteacher emphasised the importance of the study and encouraged the co-operation of the parents. Since the questionnaire was devised using information published in previous studies (Holt, 1991; Holt et al., 1996) and from the National Diet and Nutrition Survey (Hinds and Gregory, 1995), parents were asked to comment on its clarity and validity. All questions were translated into Arabic.

The questionnaire inquired about their children’s life style, asking for information on oral hygiene practices, diet during infancy and current dietary habits. Family socio-economic status was also requested through two variables: the educational level and occupation of the parents.

Two days later, the oral examinations were performed and data collected on the following: caries experience (dmfs), plaque accumulation and gingivitis, trauma to the anterior teeth and erosion, plus weight and height of the child.

These preliminary dental examinations and feedback from the questionnaire proved to be of value in modifying both. The clinical examination was too long. Consequently, many procedures were omitted from the main study and others were modified. The dmfs index was replaced by the dmft index. With respect to plaque, the percentage of plaque-covered surfaces (revealed by a food colour dye) was replaced by the criteria of the
simple prevalence index (visible/not visible) advocated by WHO in 1977. Scoring for
gingivitis was based on the Gingival Index of Löe and Silness (1963). For both
conditions (plaque and gingivitis), slight modifications were needed for the primary
dentition of the studied population.

The questionnaire was revised in light of the feedback from parents and lengthy
discussions with the head and class teachers. Some questions were omitted while others
were modified.

3.2. Training and calibration

Two kindergartens catering to clienteles of two different socio-economic levels
were selected for the training and calibration of the examiner (A.S) before proceeding to
the main study. This was undertaken with the help of an experienced epidemiologist (R.
D. Holt).

Fifteen children were examined in the first school by both the epidemiologist and
the examiner (who used the same criteria). Kappa statistics for the presence or absence
of caries were used to determine inter-examiner reliability with respect to the diagnosis
of dmft values. Reasonable agreement was observed (kappa = 0.78). To ensure a higher
Kappa score, examination criteria were further discussed before visiting the second
school. Thirty-four children were examined and this time much higher agreement was
reached (Kappa = 0.91).

The Kappa statistics for the two schools combined indicated good agreement
(Kappa = 0.86).

During the main study, duplicate examinations were carried out for 10% of the
sample, and a Kappa statistics of 0.98 obtained for intra-examiner reliability.

3.3. The Main Study

3.3.1. Population and sample

At the time of the study, kindergartens in Amman were independent and not state
funded. Therefore, the participation of each kindergarten selected in the study was
sought separately. A list of kindergartens in Amman, plus the number of children
attending them, was obtained from the Department of Education. A total of 22,569
children were enlisted in 275 kindergartens. These institutions were then stratified by monthly tuition fees into seven categories: $\leq 10$JDs (category 1), 11-20JDs (category 2), 21-30JDs (category 3), 31-40JDs (category 4), 41-50JDs (category 5), 51-60JDs (category 6) and $\geq 60$JDs (category 7). The number of kindergartens (K) and the number of children attending them (N) in each category were: category 1 (K=16; N=1129), category 2 (K=105; N=8806), category 3 (K=49, N=4516), category 4 (K=49; N=2935), category 5 (K=16; N=1806), category 6 (K=16; N=1110) and category 7 (K=24; N=2267). For the purpose of analysis, the seven categories were aggregated into three larger categories: $> 40$JDs per month, 21-40JDs per month, and $\leq 20$JDs per month.

A two-stage sampling procedure was used to select kindergartens from each stratum. In the first stage, a proportional, simple, random sampling procedure was used to select 34 kindergartens. The number of kindergartens (K) and the number of children attending the selected kindergartens (N) by category were: category 1 (K=2; N=137), category 2 (N=13; N=1069), category 3 (K=6; N=534), category 4 (K=6; N=377), category 5 (K=2; N=214), category 6 (K=2; N=138) and category 7 (K=3; N=279).

The head teachers were asked to consent to their kindergartens being part of the survey. On refusal, another kindergarten from the same stratum was randomly selected.

In the second stage of sampling, and using class lists of children classified by age and gender from the sampled kindergartens, children were selected using systematic random sampling. Schools were asked to circulate to the parents of the selected children a letter explaining the nature and purpose of the study, seeking consent for their child to take part, and to collect the returns. Of the 1200 children selected, questionnaires were returned for a total of 1140 (95%). Of the 60 who did not return their forms, 43 (72%) were those of children in the highest tuition fee stratum schools.

3.3.2. The Questionnaire

Questionnaires with their envelopes were left with the classroom teacher to be given in person to the parent(s) of each selected child when they came to collect him/her. Questionnaires for children who returned home on school buses were given to the
teacher on bus route duty, in order that they be handed to each child upon reaching home.

The covering letter accompanying the questionnaire included the full name, address and telephone number of the investigator, and parents were invited to call if they had any queries. In return, they were asked to provide a telephone/fax number or contact address in case any answer required clarification or information was missing.

To ensure confidentiality, parents were asked to seal the envelope properly before returning it to the schoolteachers.

Parents who did not respond were reminded by head teachers. Those who lost the questionnaire were given another copy.

Background data (collected by the questionnaire) included several demographic variables such as name, birth date, sex, sibling number and the child’s birth order.

Socio-economic indicators included the educational level of the parents as well as their occupations.

The level of educational attainment of the child’s parents was recorded using seven categories (which for the purpose of analysis were aggregated into three: intermediate college or university, vocational or secondary, and primary or preparatory plus unspecified or none stated).

The occupation of the father recorded in the questionnaire was subsequently coded using the Registrar General’s Classification of Occupation (Office of Populations, Censuses and Surveys, 1980). Results were then grouped into three categories of occupational status: I-III Non-manual, III-Manual-V, and ‘not classified in this way’.

The information requested on oral hygiene practices included tooth brushing frequency, the use of toothpaste, and the age at which the child started to brush with/without help.

With respect to milk-feeding, several practices were investigated such as: the method of feeding (breast and/or bottle), breast-feeding frequency, the age of weaning, and whether the child slept with the mother and for how long, the commencement of bottle feeding, its frequency and age of termination, whether bottle-feeding was practiced at naptime/night time, and if sugar/honey was added to milk in the feeding bottle.
Information was also sought about the use of comforters during early childhood (given at bed time or night-time), the consumption of confectionery at bedtime or naptime, and whether the child had been given sweetened drinks in a feeding bottle (the type of liquid was recorded and whether it was given at naptime, night time or while the child was awake, and the point at which this practice terminated).

The questionnaire also recorded information on the types of snack foods and drinks most frequently consumed, and the most usual foods eaten at breakfast and dinner. The questions offered checklists of suitable items as well as open-ended sections for other types of food and drinks. For snack foods, the list included biscuits/cakes, confectionery (including candies, chocolates, lollipops, toffee), desserts (including ice-cream, fruit in syrup and jam sandwiches), savory foods (cheese sandwiches, potato chips), chewing gum and fresh fruits. For drinks, the list included fresh fruit juices, canned fruit juices, squashes, carbonated drinks, teas with sugar (standard tea with sugar or herbal infusions with sugar). For breakfast, the list included milk with sugar, tea with sugar, savory items (thyme [ground finely and mixed with olive oil], olives, chickpeas/beans, eggs, sourcream and cheese) and marmalade/jam/honey/halawi. For dinner, the list included cooked vegetables with or without meat, milk with sugar, tea with sugar, savory items (thyme, olives, sourcream, cheese, eggs, chickpeas/beans) and marmalade/jam/honey/halawi.

3.3.3. Clinical examination

Clinical examinations were conducted to diagnose caries and the presence/absence of plaque and gingivitis.

At the time of the examination, the investigator was unaware of the parents’ response to the questionnaire.

The children were examined at the school premises by one investigator (A.S) who was trained and calibrated as mentioned above. Another dentist, trained as a recorder in the pilot study as well as in the two kindergartens selected for training and examiner calibration, acted as a recorder.

Children were examined under natural light but not in direct sunlight. A well-lit classroom, a patio or a teacher’s office was used for this purpose. The child sat in an
ordinary chair facing a window. A plane mirror and a periodontal probe were used for examinations.

3.3.3.1. Caries

Diagnosis of caries rested on visible evidence of a lesion extending into dentine. The periodontal probe was only used to remove plaque and not to confirm or refute doubtful diagnoses.

Caries was recorded using the dmft index. A tooth was considered decayed (d) if there was visible evidence of a cavity that involved the dentine. Filled teeth with recurrent caries were included as decayed. The missing component (m) included teeth lost through caries. For children under the age of five, any missing tooth was considered extracted due to caries. For 5-year-olds, a missing incisor tooth was considered exfoliated and not recorded in the (m) component unless caries was definitely present in the adjacent anterior teeth. That specific tooth was then regarded as lost due to caries. Any missing molar for 5-year-old was regarded as extracted due to caries (Palmer et al., 1984)

The traditional tooth-oriented index scores of decayed, missing and filled teeth were calculated from the dental charts by summing the dmft components.

3.3.3.2. Plaque and gingivitis

Scoring for plaque was based on the criteria of the simple prevalence index advocated by WHO in 1977: grade 1 = soft deposits clearly visible to the naked eye; grade 0 = not visible. Six surfaces were examined and scored: the labial/buccal surface of teeth 55, 51, 65, 71 and the lingual surfaces of teeth 85 and 75 (Masiga and Holt, 1993). Each of the six surfaces was scored on this 0-1 grade.

The same six surfaces were also examined and probed with a periodontal probe to record gingivitis. Scoring for this disorder was based on the gingival index of Löe and Silness (1963): 0 = no evidence of gingivitis, 1 = redness or a slight change in colour with no bleeding on gentle probing, 2 = bleeding on gentle probing, 3 = spontaneous bleeding.

Plaque was expressed as the number of sites with plaque (0-3 and 4 or more) and the extent of gingivitis as the number of sites affected by gingivitis (0 or 1 or more).
3.3.4. Data analysis

Data were processed and analysed at the Computer Centre, University of Jordan, using SAS software, and at the Eastman Dental Institute using SPSS software.

Prevalence rates, mean dmft and the prevalence of different caries patterns were calculated. Non-parametric tests (Mann-Whitney U-test and Kruskal-Wallis) were used to compare dmft ranks among groups.

The Chi-squared test was used to examine the association between grouped dmft (dmft=0, dmft=1-4 and dmft>4) and each of the socio-demographic variables, and to analyse the relationships between prevalence of caries and caries patterns with socio-demographic factors, oral hygiene and feeding habits. The same test was further used to examine the association of oral cleanliness and gingivitis with socio-demographic variables, oral health behaviours (tooth-brushing frequency, use of toothpaste, and age at which the child started to use toothpaste), and also with caries prevalence and severity. Different types of food/drinks consumption and their association with caries prevalence were also examined by Chi-squared analysis.

When moving from univariate associative analysis towards multivariate logistic analysis, variables that had shown statistically significant (pair-wise) associations with prevalence and severity of caries, and with gingivitis, were simultaneously incorporated into logistic regression modelling.

Forward stepwise multiple logistic regression was first employed to determine which of the explanatory variables had significant effects on the above three dichotomised response variables when the effects of the other variables were taken into account. This stepwise screening identifies significant variables in decreasing order of importance at the 5% level.

The significant explanatory factors for a particular response, identified by the above stepwise screening process, were then incorporated into a logistic regression model to identify and quantify the strength of association of each with the response in question. This strength of association was measured and characterised by both regression coefficients and the odds ratio.
4. RESULTS

4.1. Prevalence and severity of dental caries

There were 582 boys and 558 girls in the sample. Of the 1140 children included, 569 were aged 4 years and 571 were 5 years old at the time of examination.

Of the children, 765 (67%) had some caries experience. On average children had a dmft of 3.6 per child. Three hundred and seventy five children (33%) were clinically caries free, 391 (34%) had a dmft between 1 and 4 and 374 (33%) had more than 4 decayed missing or filled teeth.

Caries prevalence, mean dmft and distributions in terms of dmft values in relation to age and gender are shown in Table 1.

Older children had a significantly higher mean dmft and fewer were caries free. Differences in caries distribution and mean dmft between genders were not statistically significant.

Table 1: Number and percentage of children with caries experience, caries distribution and mean dmft (sd) according to age and gender.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>With caries</th>
<th>Caries distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n(%)</td>
</tr>
<tr>
<td>4</td>
<td>569</td>
<td>351(61.7)</td>
</tr>
<tr>
<td>5</td>
<td>571</td>
<td>414(72.5)</td>
</tr>
<tr>
<td>All</td>
<td>1140</td>
<td>765(67.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>With caries</th>
<th>Caries distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n(%)</td>
</tr>
<tr>
<td>Boys</td>
<td>582</td>
<td>409(70.3)</td>
</tr>
<tr>
<td>Girls</td>
<td>558</td>
<td>356(63.8)</td>
</tr>
</tbody>
</table>

\(^1\) \(p < 0.0001\) (Mann-Whitney U-test)
\(^2\) \(p < 0.0001\) (Chi-square test)
\(^3\) \(p = 0.062\) (Mann-Whitney U-test)
\(^4\) \(p = 0.06\) (Chi-square test)

Values for dmft and its components in relation to age are shown in Table 2 and graphically in Figure 1.
Table 2: dmft and its components in relation to age.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>decayed mean(sd) (%)</th>
<th>missing mean (sd) (%)</th>
<th>filled mean(sd) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>569</td>
<td>2.8(3.7) (90.3)</td>
<td>0.1(0.3) (0.0)</td>
<td>0.3(1.0) (9.7)</td>
</tr>
<tr>
<td>5</td>
<td>571</td>
<td>3.6(3.7) (87.8)</td>
<td>0.1(0.4) (2.4)</td>
<td>0.4(1.1) (9.8)</td>
</tr>
<tr>
<td>All</td>
<td>1140</td>
<td>3.2(3.7) (88.9)</td>
<td>0.1(0.3) (2.8)</td>
<td>0.3(1.1) (8.3)</td>
</tr>
</tbody>
</table>

For the group as whole, the mean dmft value of 3.6 was made up of 3.2 decayed teeth (89% of the total), 0.1 missing (2.8%) and 0.3 filled teeth (8.3%). Decayed teeth made up 90% of the mean dmft in 4 year olds and 88% of that in 5 year olds.

Figure 1: Values for dmft and its components in relation to age

Percentage of dmft components according to age.
Of the children, 835 (73%) had fathers whose occupation fell into the non-manual categories (I-III Non-manual), 212 (19%) in the manual categories (III Manual – V) and the occupation of fathers of the remaining 93 (8%) could not be classified in this way.

Of the mothers of children in the sample, 631 (55%) had received an education that included time spent at an intermediate college or university. For a further 376 (33%), their education had been limited to secondary school and/or vocational education. Mothers of the remaining 133 children (12%), had received no schooling or had only primary school education or had not specified what their level of education had been.

Two hundred and thirty five of the children (21%) attended kindergartens with the highest tuition fees. A further 384 (34%) attended those with the middle range and 521 (46%) attended kindergartens with the lowest monthly fees.

It can be seen from Table 3 that there were consistent differences in caries prevalence and dmft across the three proxy measures of social class. Thus, prevalence was higher in children whose father’s occupation was in the manual or could not be classified, in those whose mothers had received the least education and in those who attended schools with the lowest fees. Mean dmft values were also higher in these groups and there were more children with dmft values greater than 4. Differences showed consistent trends across the three social class groupings based on fathers occupation (p<0.0001) and across the three groups in relation to monthly fees for the kindergartens attended (p<0.0001). Differences across the three groups in relation to mother’s education also showed significant differences (p<0.003) but there appeared to be little difference in outcome measures for caries between those whose mothers had education which included intermediate college and/or university education and those whose mothers had education limited to vocational and/or secondary school level.
Table 3: Number and percentage of children with caries experience and caries distribution according to father’s occupation, mother’s education and kindergarten fees.

<table>
<thead>
<tr>
<th></th>
<th>With caries</th>
<th>Caries distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n (%)</td>
</tr>
<tr>
<td><strong>Father’s occupation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-III Non-manual</td>
<td>835</td>
<td>530(63.5)</td>
</tr>
<tr>
<td>III Manual - V</td>
<td>212</td>
<td>161(75.9)</td>
</tr>
<tr>
<td>Not classified</td>
<td>93</td>
<td>74(79.6)</td>
</tr>
<tr>
<td><strong>Mother’s education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate college/University</td>
<td>631</td>
<td>410(65.0)</td>
</tr>
<tr>
<td>Secondary school/Vocational education</td>
<td>376</td>
<td>249(66.2)</td>
</tr>
<tr>
<td>No schooling/Primary school/Not specified</td>
<td>133</td>
<td>106(79.7)</td>
</tr>
<tr>
<td><strong>Kindergarten fees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 40 JD’s</td>
<td>235</td>
<td>124(53.0)</td>
</tr>
<tr>
<td>21 – 40 JD’s</td>
<td>384</td>
<td>261(68.0)</td>
</tr>
<tr>
<td>≤ 10 – 20 JD’s</td>
<td>521</td>
<td>380(72.9)</td>
</tr>
</tbody>
</table>

$^1$ p < 0.0001 (Kruskal-Wallis)
$^2$ p < 0.0001 (Chi-square test)
$^3$ p < 0.002 (Kruskal-Wallis)
$^4$ p < 0.003 (Chi-square test)

The results of multi-variate analysis using a stepwise multiple regression procedure are summarised in Table 4.

It can be seen that age of the child, gender, social class based on the father’s occupation (between those in social classes I-III Non-manual and those in other groups), and fee scale of the kindergarten attended, all had a statistically significant independent effect on caries prevalence when other variables were taken into account. Older children had 1.6 times the likelihood of having caries, those who were from families in social classes III Manual-V or who could not be classified had 1.5 times the risk and those attending kindergartens with the lowest fee scales had 1.4 times the risk. In the case of caries involving 4 or more teeth, age, mother’s education and kindergarten fees had a
significant independent effect with older children having 1.8 times the risk of having a dmft of 4 or more.

Table 4: Logistic regression: p values, odds ratios and 95% confidence intervals for the association between caries prevalence and severity with all variables in study.

<table>
<thead>
<tr>
<th></th>
<th>Caries prevalence (dmft≥ 1/dmft=0)</th>
<th>Caries severity (dmft&gt;4/dmft≤4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p</td>
<td>OR</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 yrs/4 yrs</td>
<td>0.0001</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys/girls</td>
<td>0.02</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Father’s occupation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not classified, III - V/ I - IIIIM</td>
<td>0.01</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Mother’s education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No school, primary, not specified/ Intermediate, university, secondary, vocational education</td>
<td>0.09</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Kindergarten fees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤10 – 20 JD's/ &gt;21 JD's</td>
<td>0.02</td>
<td>1.4</td>
</tr>
</tbody>
</table>

4.2. Patterns of dental caries

Table 5 shows the distribution of caries according to tooth type and age of the children. Primary molars were the most commonly affected teeth. At the age of 4 years, 42% of the children had experience of caries in the first primary molars and 43% in second primary molars. The percentage of children with experience of caries in first molars increased to 59% and in the second molar to 57% at the age of 5 years. In both ages caries in primary incisors was seen in 35% of the children and 10% had caries in primary canines.
Table 5: Number and percentage of children (n=1,140) with caries, mean dmft by tooth type and age.

<table>
<thead>
<tr>
<th></th>
<th>4-year-old (n=569)</th>
<th>5-year-old (n=571)</th>
<th>All (n=1140)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All teeth</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number (%) with caries</td>
<td>351(61.7)</td>
<td>414(72.5)</td>
<td>765(67.1)</td>
</tr>
<tr>
<td>Mean dmft (sd)</td>
<td>3.1(3.9)</td>
<td>4.1(4.0)*</td>
<td>3.6(4.0)</td>
</tr>
<tr>
<td><strong>Primary incisors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number (%) with caries</td>
<td>185(32.5)</td>
<td>215(37.7)</td>
<td>400(35.1)</td>
</tr>
<tr>
<td>Mean dmft (sd)</td>
<td>0.9(1.6)</td>
<td>1.0(1.5)**</td>
<td>1.0(1.6)</td>
</tr>
<tr>
<td><strong>Primary canines</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number (%) with caries</td>
<td>51(9.0%)</td>
<td>65(11.4)</td>
<td>116(10.2)</td>
</tr>
<tr>
<td>Mean dmft (sd)</td>
<td>0.2(0.6)</td>
<td>0.2(0.6)**</td>
<td>0.2(0.6)</td>
</tr>
<tr>
<td><strong>First primary molars</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number (%) with caries</td>
<td>240(42.2)</td>
<td>337(59.0)</td>
<td>577(50.6)</td>
</tr>
<tr>
<td>Mean dmft (sd)</td>
<td>1.0(1.4)</td>
<td>1.5(1.5)*</td>
<td>1.3(1.5)</td>
</tr>
<tr>
<td><strong>Second primary molars</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number (%) with caries</td>
<td>242(42.5)</td>
<td>323(56.6)</td>
<td>565(49.6)</td>
</tr>
<tr>
<td>Mean dmft (sd)</td>
<td>1.0(1.4)</td>
<td>1.4(1.5)*</td>
<td>1.2(1.5)</td>
</tr>
</tbody>
</table>

Mann-Whitney U test:
* p<0.0001
** p=0.05 (not significant)
*** p=0.17 (not significant)

Table 6 shows prevalence of caries and prevalence according to tooth type patterns in relation to socio-demographic factors, oral hygiene habits and feeding method.

Differences between the two ages were seen in the prevalence of caries, in the prevalence of caries in molars, incisors and/or canines, with older children having a higher prevalence in each case (Table 6). Prevalence of caries and of caries in molars alone was higher in children whose social class was in the manual group or could not be classified.

Frequency of brushing, age at which tooth-brushing began and age at which use of toothpaste was started, showed association with the prevalence of caries and with the more extensive form of the disease (i.e. caries in molars, incisors and/or canines) (p<0.05). Those who started brushing their teeth or started using toothpaste before or at the age of 24 months had less caries than did those who started brushing their teeth or using toothpaste later than this.
Table 6: Number and percentage of children (n=1,140) with caries, caries patterns and socio-demographic factors, oral hygiene habits and feeding method.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>With caries</th>
<th>With caries just in incisors</th>
<th>With caries in incisors and/or canines</th>
<th>With caries in molars</th>
<th>With caries in molars, incisors and/or canines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>All</td>
<td>1140</td>
<td>765 (67.1)</td>
<td>74 (6.5)</td>
<td>80 (7.0)</td>
<td>337 (29.6)</td>
<td>348 (30.5)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>569</td>
<td>351 (61.7)</td>
<td>44 (7.7)</td>
<td>46 (8.1)</td>
<td>157 (27.6)</td>
<td>148 (26.0)</td>
</tr>
<tr>
<td>5</td>
<td>571</td>
<td>414 (72.5)*</td>
<td>30 (5.3)</td>
<td>34 (6.0)</td>
<td>180 (31.5)</td>
<td>200 (35.0)*</td>
</tr>
<tr>
<td>Social class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-III Non-manual</td>
<td>835</td>
<td>530 (63.5)</td>
<td>56 (6.7)</td>
<td>61 (7.3)</td>
<td>228 (27.3)</td>
<td>241 (28.9)</td>
</tr>
<tr>
<td>III Manual – V and not classified</td>
<td>305</td>
<td>235 (77.0)*</td>
<td>18 (5.9)</td>
<td>19 (6.2)</td>
<td>109 (35.7)†</td>
<td>107 (35.1)†</td>
</tr>
<tr>
<td>Frequency of brushing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>never/occasionally</td>
<td>673</td>
<td>468 (69.5)</td>
<td>45 (6.7)</td>
<td>47 (7.0)</td>
<td>197 (29.3)</td>
<td>224 (33.3)</td>
</tr>
<tr>
<td>Daily</td>
<td>467</td>
<td>297 (63.6)†</td>
<td>29 (6.2)</td>
<td>33 (7.1)</td>
<td>140 (30.0)</td>
<td>124 (26.6)†</td>
</tr>
<tr>
<td>Tooth-brushing started</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never/ &gt; 24 months</td>
<td>803</td>
<td>561 (69.9)</td>
<td>50 (6.2)</td>
<td>54 (6.7)</td>
<td>247 (30.8)</td>
<td>260 (32.4)</td>
</tr>
<tr>
<td>≤ 24 months</td>
<td>337</td>
<td>204 (60.5)†</td>
<td>24 (7.1)</td>
<td>26 (7.7)</td>
<td>90 (26.7)</td>
<td>88 (26.1)†</td>
</tr>
<tr>
<td>Toothpaste use started</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>never/ &gt;24 months</td>
<td>848</td>
<td>592 (69.8)</td>
<td>53 (6.3)</td>
<td>57 (6.7)</td>
<td>258 (30.4)</td>
<td>277 (32.7)</td>
</tr>
<tr>
<td>≤ 24 months</td>
<td>292</td>
<td>173 (59.2)†</td>
<td>21 (7.2)</td>
<td>23 (7.9)</td>
<td>79 (27.1)</td>
<td>71 (24.3)†</td>
</tr>
<tr>
<td>Feeding method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast-feeding</td>
<td>297</td>
<td>208 (70.0)</td>
<td>14 (4.7)</td>
<td>15 (5.1)</td>
<td>98 (33.0)</td>
<td>95 (32.0)</td>
</tr>
<tr>
<td>Bottle-feeding</td>
<td>71</td>
<td>39 (54.9)</td>
<td>4 (5.6)</td>
<td>5 (7.0)</td>
<td>16 (22.5)</td>
<td>18 (25.4)</td>
</tr>
<tr>
<td>Both</td>
<td>772</td>
<td>518 (67.1)</td>
<td>56 (7.3)</td>
<td>60 (7.8)</td>
<td>223 (28.9)</td>
<td>235 (30.4)</td>
</tr>
</tbody>
</table>

Chi-square test
* p < 0.0001
† p < 0.05

Two hundred and ninety seven children had been wholly breast fed and 71 wholly bottle fed. The remaining 772 had been both breast and bottle fed. Information relating to ever breast-fed and ever bottle-fed children is shown separately in Tables 7 and 8.

For the 1,069 children who had been wholly or partly breast fed, breast-feeding duration, breast-feeding frequency and the habit of sleeping with the mother showed statistically
significant association with the prevalence of caries and with the more extensive form of the disease. Seventy nine per cent of those children who were breast-fed beyond the age of 18 months had experience of caries compared with 66 % of those who were breast-fed for period equal to or less than 18 months. These children also had a higher prevalence of the more extensive form of the disease. In addition, those who were breast-fed on demand had more caries and more extensive form of the disease than did those not breast-fed on demand. The same was true for children who had the habit of sleeping with the mother. These children also had more experience of caries and a higher prevalence of the more extensive pattern of the disease than did those who did not have this habit (Table 7).

Table 7: Number and percentage of children (n=1,069) wholly or partly breast-fed and caries patterns according to breast-feeding habits.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>With caries</th>
<th>With caries just in incisors</th>
<th>With caries in incisors and/or canines</th>
<th>With caries in molars</th>
<th>With caries in molars, incisors and/or canines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td><strong>Breast-feeding duration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 6 – 18 months</td>
<td>904</td>
<td>596(65.9)</td>
<td>58(6.4)</td>
<td>61(6.7)</td>
<td>279(30.9)</td>
<td>256(28.3)</td>
</tr>
<tr>
<td>&gt; 18 months</td>
<td>165</td>
<td>130(78.8)†</td>
<td>12(7.3)</td>
<td>14(8.5)</td>
<td>42(25.5)</td>
<td>74(44.8)*</td>
</tr>
<tr>
<td><strong>Breast-feeding frequency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>not on demand</td>
<td>305</td>
<td>184(60.3)</td>
<td>26(8.5)</td>
<td>27(8.9)</td>
<td>94(30.8)</td>
<td>63(20.7)</td>
</tr>
<tr>
<td>On demand</td>
<td>764</td>
<td>542(70.9)†</td>
<td>44(5.8)</td>
<td>48(6.3)</td>
<td>227(29.7)</td>
<td>267(34.9)*</td>
</tr>
<tr>
<td><strong>Sleeping with mother</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>402</td>
<td>247(61.4)</td>
<td>29(7.2)</td>
<td>30(7.5)</td>
<td>115(28.6)</td>
<td>102(25.4)</td>
</tr>
<tr>
<td>Yes</td>
<td>667</td>
<td>479(71.8)†</td>
<td>41(6.1)</td>
<td>45(6.7)</td>
<td>206(30.9)</td>
<td>228(34.2)†</td>
</tr>
</tbody>
</table>

Chi-square test
* p < 0.0001
† p < 0.05

Further analysis of the data showed that frequency of brushing, age at which toothbrush started and age at which toothpaste started, showed statistically significant association with breast-feeding duration. Those who were wholly or partly breast fed beyond the age of 18 months were less likely to start brushing their teeth before the age of 24 months
and or to have started using toothpaste before the same age (p<0.01) (tables not presented).

Amongst the 843 who had been wholly or partly bottle-fed, bottle-feeding frequency and the addition of sugar/honey to milk in the bottle similarly showed a positive association with the prevalence of caries (Table 8). As in the case of children who were breast-fed on demand, children who were bottle-fed on demand showed a higher prevalence of caries and of the more extensive form of the disease than did those who were fed according to a schedule (p<0.05)(Table 8). Children who had sugar or honey added to milk in a bottle had more caries and a higher prevalence of the more extensive pattern of the disease. Children who were bottle-fed at nap, bed or night time were less likely than those fed at other times to develop the pattern of caries where molars alone were affected but had higher experience of caries as a whole, of caries in incisors and/or canines and of the more extensive pattern of disease (Table 8).

Table 8: Number and percentage of children (n=843) wholly or partly bottle-fed and caries patterns according to bottle-feeding habits.

<table>
<thead>
<tr>
<th>Bottle-feeding Duration</th>
<th>n</th>
<th>With caries n (%)</th>
<th>With caries just incisors n (%)</th>
<th>With caries in incisors and/or canines n (%)</th>
<th>With caries in molars n (%)</th>
<th>With caries in molars, incisors and/or canines n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6 - 18 months</td>
<td>111</td>
<td>69(62.2)</td>
<td>9(8.1)</td>
<td>9(8.1)</td>
<td>31(27.9)</td>
<td>29(26.1)</td>
</tr>
<tr>
<td>&gt; 18 months</td>
<td>732</td>
<td>488(66.7)</td>
<td>51(7.0)</td>
<td>56(7.7)</td>
<td>208(28.4)</td>
<td>224(30.6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bottle-feeding Frequency</th>
<th>n</th>
<th>With caries n (%)</th>
<th>With caries just incisors n (%)</th>
<th>With caries in incisors and/or canines n (%)</th>
<th>With caries in molars n (%)</th>
<th>With caries in molars, incisors and/or canines n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>not on demand</td>
<td>341</td>
<td>203(59.5)</td>
<td>25(7.3)</td>
<td>26(7.6)</td>
<td>98(28.7)</td>
<td>79(23.2)</td>
</tr>
<tr>
<td>on demand</td>
<td>502</td>
<td>354(70.5)†</td>
<td>35(7.0)</td>
<td>39(7.8)</td>
<td>141(28.1)</td>
<td>174(34.7)†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Addition of sugar/honey</th>
<th>n</th>
<th>With caries n (%)</th>
<th>With caries just incisors n (%)</th>
<th>With caries in incisors and/or canines n (%)</th>
<th>With caries in molars n (%)</th>
<th>With caries in molars, incisors and/or canines n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk without sugar</td>
<td>334</td>
<td>194(58.1)</td>
<td>25(7.5)</td>
<td>28(8.4)</td>
<td>88(26.3)</td>
<td>78(23.4)</td>
</tr>
<tr>
<td>Milk with sugar</td>
<td>509</td>
<td>363(71.3)*</td>
<td>35(6.9)</td>
<td>37(7.3)</td>
<td>151(29.7)</td>
<td>175(34.4)†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bottle-feeding time</th>
<th>n</th>
<th>With caries n (%)</th>
<th>With caries just incisors n (%)</th>
<th>With caries in incisors and/or canines n (%)</th>
<th>With caries in molars n (%)</th>
<th>With caries in molars, incisors and/or canines n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>During day when awake</td>
<td>199</td>
<td>108(54.3)</td>
<td>8(4.0)</td>
<td>9(4.5)</td>
<td>71(35.7)</td>
<td>28(14.1)</td>
</tr>
<tr>
<td>At nap, bed time or night</td>
<td>644</td>
<td>449(69.7)*</td>
<td>52(8.1)</td>
<td>56(8.7)†</td>
<td>168(26.1)†</td>
<td>225(34.9)*†</td>
</tr>
</tbody>
</table>

Chi-square test
* p < 0.0001
† p < 0.05

Information sought about all children regarding sugar intake during early life included questions about use of comforters (given at bed time or nap time), consumption of
confectionery at bed time or nap time and whether the child had been given sweetened drinks in a feeding bottle. This information is summarised in Table 9.

Table 9: Number and percentage of children, caries patterns and use of comforters, confectionery and sweetened drinks.

<table>
<thead>
<tr>
<th>Use of comforter</th>
<th>n</th>
<th>With caries</th>
<th>With caries just in incisors</th>
<th>With caries in incisors and/or canines</th>
<th>With caries in molars, incisors and/or canines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Never used</td>
<td>991</td>
<td>637(64.3)</td>
<td>54(5.4)</td>
<td>60(6.1)</td>
<td>304(30.7)</td>
</tr>
<tr>
<td>Used/using</td>
<td>149</td>
<td>128(85.9)*</td>
<td>20(13.4)*</td>
<td>20(13.4)†</td>
<td>33(22.1)†</td>
</tr>
<tr>
<td>Confectionery at bed or night time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>1083</td>
<td>714(65.9)</td>
<td>70(6.5)</td>
<td>75(6.9)</td>
<td>319(29.5)</td>
</tr>
<tr>
<td>Yes</td>
<td>57</td>
<td>51(89.5)*</td>
<td>4(7.0)</td>
<td>5(8.8)</td>
<td>18(31.6)</td>
</tr>
<tr>
<td>Sweetened drinks feeding time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>545</td>
<td>350(64.2)</td>
<td>30(5.5)</td>
<td>32(5.9)</td>
<td>164(30.1)</td>
</tr>
<tr>
<td>During the day when awake</td>
<td>431</td>
<td>304(70.5)</td>
<td>34(7.9)</td>
<td>38(8.8)</td>
<td>130(30.2)</td>
</tr>
<tr>
<td>at nap, bed time or night time</td>
<td>164</td>
<td>111(67.7)</td>
<td>10(6.1)</td>
<td>10(6.1)</td>
<td>43(26.2)</td>
</tr>
<tr>
<td>Sweetened drinks terminated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>545</td>
<td>350(64.2)</td>
<td>30(5.5)</td>
<td>32(5.9)</td>
<td>164(30.1)</td>
</tr>
<tr>
<td>≤ 12 months</td>
<td>139</td>
<td>97(69.8)</td>
<td>14(10.1)</td>
<td>15(10.8)</td>
<td>46(33.1)</td>
</tr>
<tr>
<td>&gt; 12 months</td>
<td>456</td>
<td>318(69.7)</td>
<td>30(6.6)</td>
<td>33(7.2)</td>
<td>127(27.9)</td>
</tr>
</tbody>
</table>

Chi-square test
* p < 0.0001
† p < 0.05

Use of comforters was associated with a higher experience of caries, with those children who used (or were using) comforters having more experience of caries, more caries in incisors, in incisors and/or canines and more often experiencing the more extensive pattern of disease than did those who never used comforters. However those children who used or had used comforters were significantly less likely to develop caries confined to molar teeth. Confectionery eaten by infants at bed or night-time was associated with the prevalence of caries and with the more extensive pattern of the disease. In relation to sweetened drinks, children who had been given sweetened drinks in a feeding bottle
beyond the age of 12 months had a higher prevalence of caries involving molars, incisors and/or canines (p<0.05).

Multiple logistic regression analysis were carried out for the outcomes of caries prevalence, caries in incisors, caries in incisors and/or canines, caries in molars and caries in molars and incisors and/or canines. It has to be taken into account that the groups of children involved in the analysis for the different outcomes are not mutually exclusive. When all variables were entered into the logistic regression analysis, age, social class, sleeping with the mother, use of comforter and having confectionery at bed or night time were demonstrated to be significant independent risk factors for caries experience. Bottle-feeding time and use of comforters had a significant independent effect on caries in incisors alone and on caries in incisors and/or canines (Table 10).

Children who had been bottle-fed at nap, bed or night-time had a greater risk of experiencing caries in incisors and in incisors and/or canines than did those who had been bottle-fed during the day when awake. In contrast, children who had never been breast-fed or who had been breast-fed for more than 18 months and those who were bottle-fed at nap, bed or night time were at significantly lower risk of showing the pattern of caries confined to molars although they had an increased risk of showing the more extensive pattern of disease.
Table 10: Logistic regression: Odds ratios and 95% confidence intervals for the association between caries experience and patterns of disease with variables that were significant in the univariate analysis*.

<table>
<thead>
<tr>
<th></th>
<th>Caries OR (95%CI)</th>
<th>Caries in incisors OR (95%CI)</th>
<th>Caries in incisors and/or canines OR (95%CI)</th>
<th>Caries in molars OR (95%CI)</th>
<th>Caries in molars and incisors and/or canines OR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 yrs/4 yrs</td>
<td>1.7 (1.3-2.2)</td>
<td>1.6 (1.2-2.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Social class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not classified, III-M-V/ I – III/M</td>
<td>1.6 (1.2-2.2)</td>
<td>1.5 (1.2-2.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breast-feeding duration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never or &gt;18/≤ 6-18 months</td>
<td>0.7 (0.5-0.9)</td>
<td>1.5 (1.1-2.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breast-feeding frequency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never or on demand / not on</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>demand</td>
<td>1.8 (1.3-2.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sleep with the mother</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes/no</td>
<td>1.7 (1.3-2.2)</td>
<td>1.6 (1.2-2.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bottle-feeding time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At nap, bed or night time/</td>
<td>1.7 (1.1-2.9)</td>
<td>1.7 (1.1-2.8)</td>
<td>0.7 (0.5-0.9)</td>
<td>1.8 (1.3-2.3)</td>
<td></td>
</tr>
<tr>
<td>during the day when awake</td>
<td></td>
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<tr>
<td><strong>Use of comforter</strong></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Used or using/never used</td>
<td>2.7 (1.6-4.4)</td>
<td>2.5 (1.4-4.3)</td>
<td>2.2 (1.3-3.8)</td>
<td>2.5 (1.7-3.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Confectionery at bed or night</strong></td>
<td>2.3 (1.1-6.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(results are presented only for variables that showed statistically significant association with one or more outcomes in the final multivariate model).

4.3. Food and drink consumption and dental caries

Table 11 shows the number and proportions of children in relation to types of snack foods consumed and to socio-demographic factors. It also shows the prevalence of caries and the severity of caries in relation to snack foods consumption. In this sample of children, savory snack foods and fresh fruit were reported to be the most popular snacks and chewing gum and dessert the least. Confectionery was said to be eaten regularly by 76% of the 4-5-year old children and biscuits/cakes by 71%. It can be seen that more younger children (4-year-olds) and boys tended to consume confectionery and more girls had chewing gum.

In relation to the three socio-economic measures, there was a trend for more children from lower classes to have confectionery, dessert foods and savory foods and fewer to
have fresh fruit. Only in the case of dessert foods were social class differences statistically significant.

In relation to prevalence of caries, significantly more children with caries had confectionery and had dessert foods (p <0.05). When severity of caries was considered significantly more children with dmft greater than 4 had dessert foods (p <0.05).

Drinks consumed between mealtimes are shown in Table 12. Fewer children were reported as having drinks than snack food. Carbonated drinks were the most popular and fruit squashes the least. Fewer older children had canned fruit juices (p<0.05). There was also some trend for more boys to have carbonated drinks and fruit squashes although differences were not statistically significant.

There were consistent differences in more children from lower social classes drinking teas with sugar and fruit squashes and fewer drinking fresh fruit juices (p<0.05). More children from lower classes drank carbonated drinks but the difference was not (statistically) significant for all three social class measures. More children who had caries and more children who had dmft greater than 4 drank fruit squashes and teas with sugar (p<0.05).
Table 11: Number and percentage of children according to type of snack foods consumption, socio-demographic factors and prevalence and severity of caries.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>569 409(71.9)</td>
<td>450(79.1)</td>
<td>322(56.6)</td>
<td>465(81.7)</td>
<td>336(59.1)</td>
<td>443(77.9)</td>
</tr>
<tr>
<td>5</td>
<td>571 406(71.1)</td>
<td>414(72.5)*</td>
<td>342(59.9)</td>
<td>466(81.6)</td>
<td>311(54.5)</td>
<td>466(81.6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>582 422(72.5)</td>
<td>458(78.7)</td>
<td>345(59.3)</td>
<td>483(83.0)</td>
<td>313(53.8)</td>
<td>451(77.5)</td>
</tr>
<tr>
<td>girls</td>
<td>558 393(70.4)</td>
<td>406(72.8)*</td>
<td>319(57.2)</td>
<td>448(80.3)</td>
<td>334(59.9)*</td>
<td>458(82.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kindergarten fees</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 40 JDs</td>
<td>235 162(68.9)</td>
<td>170(72.3)</td>
<td>114(48.5)</td>
<td>178(75.7)</td>
<td>134(57.0)</td>
<td>193(82.1)</td>
</tr>
<tr>
<td>21–40 JDs</td>
<td>384 276(71.9)</td>
<td>304(79.2)</td>
<td>215(56.0)</td>
<td>311(81.0)</td>
<td>232(60.4)</td>
<td>314(81.8)</td>
</tr>
<tr>
<td>≤ 10–20 JDs</td>
<td>521 377(72.4)</td>
<td>390(74.9)</td>
<td>335(64.3)*</td>
<td>442(84.8)*</td>
<td>281(53.9)</td>
<td>402(77.2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social class</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I–III Non manual</td>
<td>835 601(72.0)</td>
<td>632(75.7)</td>
<td>466(55.8)</td>
<td>675(80.8)</td>
<td>477(57.1)</td>
<td>673(80.6)</td>
</tr>
<tr>
<td>III Manual – V/</td>
<td>305 214(70.2)</td>
<td>232(76.1)</td>
<td>198(64.9)*</td>
<td>256(83.9)</td>
<td>170(55.7)</td>
<td>236(77.4)</td>
</tr>
<tr>
<td>not classified</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mother’s education</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intern. college/</td>
<td>631 453(71.8)</td>
<td>467(74.0)</td>
<td>352(55.8)</td>
<td>508(80.5)</td>
<td>347(55.0)</td>
<td>518(82.1)</td>
</tr>
<tr>
<td>University</td>
<td>376 262(69.7)</td>
<td>293(77.9)</td>
<td>225(59.8)</td>
<td>311(82.7)</td>
<td>226(60.1)</td>
<td>293(77.9)</td>
</tr>
<tr>
<td>Secondary school/</td>
<td>133 100(75.2)</td>
<td>104(78.2)</td>
<td>87(65.4)*</td>
<td>112(84.2)</td>
<td>74(55.6)</td>
<td>98(73.7)</td>
</tr>
<tr>
<td>vocational training</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No schooling/</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Caries prevalence</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caries free</td>
<td>375 261(69.6)</td>
<td>261(69.6)</td>
<td>197(52.5)</td>
<td>311(82.9)</td>
<td>200(53.3)</td>
<td>305(81.3)</td>
</tr>
<tr>
<td>With caries</td>
<td>765 554(72.4)</td>
<td>603(78.8)*</td>
<td>467(61.0)*</td>
<td>620(81.0)</td>
<td>447(58.4)</td>
<td>604(79.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Caries severity</th>
<th>Biscuits/cakes n (%)</th>
<th>Confectionery n (%)</th>
<th>Dessert n (%)</th>
<th>Savory n (%)</th>
<th>Chewing-gum n (%)</th>
<th>Fresh fruit n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dmft ≤ 4</td>
<td>766 543(70.9)</td>
<td>568(74.2)</td>
<td>422(55.1)</td>
<td>630(82.2)</td>
<td>427(55.7)</td>
<td>603(78.7)</td>
</tr>
<tr>
<td>dmft &gt; 4</td>
<td>374 272(72.7)</td>
<td>296(79.1)</td>
<td>242(64.7)*</td>
<td>301(80.5)</td>
<td>221(58.8)</td>
<td>306(81.8)</td>
</tr>
</tbody>
</table>

JDs – Jordanian dinars (1.00 British pounds sterling is equivalent to 1.014 Jordanian dinars)

* p< 0.05
Table 12: Number and percentage of children according to types of drink, socio-demographic factors and prevalence and severity of caries.

<table>
<thead>
<tr>
<th>Drinks</th>
<th>n</th>
<th>Fresh fruit juices n (%)</th>
<th>Carried fruit juices n (%)</th>
<th>Squashes n (%)</th>
<th>Carbonated drinks n (%)</th>
<th>Teas with sugar n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>569</td>
<td>280(49.2)</td>
<td>326(57.3)</td>
<td>141(24.8)</td>
<td>325(57.1)</td>
<td>239(42.0)</td>
</tr>
<tr>
<td>5</td>
<td>571</td>
<td>290(50.8)</td>
<td>290(50.8)*</td>
<td>160(28.0)</td>
<td>334(58.5)</td>
<td>240(42.0)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>582</td>
<td>287(49.3)</td>
<td>306(52.6)</td>
<td>164(28.2)</td>
<td>353(60.7)</td>
<td>248(42.6)</td>
</tr>
<tr>
<td>Girls</td>
<td>558</td>
<td>283(50.7)</td>
<td>310(55.6)</td>
<td>137(24.6)</td>
<td>306(54.8)</td>
<td>231(41.4)</td>
</tr>
<tr>
<td><strong>Kindergarten fees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 40 JDs</td>
<td>235</td>
<td>133(56.6)</td>
<td>115(48.9)</td>
<td>49(20.9)</td>
<td>113(48.1)</td>
<td>45(19.1)</td>
</tr>
<tr>
<td>21–40 JDs</td>
<td>384</td>
<td>203(53.4)</td>
<td>226(58.9)</td>
<td>92(24.0)</td>
<td>233(60.7)</td>
<td>143(37.2)</td>
</tr>
<tr>
<td>≤ 10–20 JDs</td>
<td>521</td>
<td>232(44.5)*</td>
<td>275(52.8)*</td>
<td>160(30.7)*</td>
<td>313(60.1)</td>
<td>291(55.9)*</td>
</tr>
<tr>
<td><strong>Social class</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I-III Non manual</td>
<td>835</td>
<td>436(52.2)</td>
<td>474(56.8)</td>
<td>203(24.3)</td>
<td>479(57.4)</td>
<td>305(36.5)</td>
</tr>
<tr>
<td>III Manual-V/</td>
<td>305</td>
<td>134(43.9)*</td>
<td>142(46.6)*</td>
<td>98(32.1)*</td>
<td>180(59.0)</td>
<td>174(57.0)*</td>
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</tr>
<tr>
<td><strong>Mother’s education</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Interm. college/</td>
<td>631</td>
<td>340(53.9)</td>
<td>350(55.5)</td>
<td>142(22.5)</td>
<td>341(54.0)</td>
<td>219(34.7)</td>
</tr>
<tr>
<td>University</td>
<td>376</td>
<td>174(46.3)</td>
<td>213(56.6)</td>
<td>111(29.5)</td>
<td>231(61.4)</td>
<td>171(45.5)</td>
</tr>
<tr>
<td>Secondary school/</td>
<td>133</td>
<td>56(42.1)*</td>
<td>53(39.8)*</td>
<td>48(36.1)*</td>
<td>87(65.4)*</td>
<td>89(66.9)*</td>
</tr>
<tr>
<td>vocational training</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No schooling/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not specified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Caries prevalence**

| Caries free | 375 | 203(54.1) | 189(50.4) | 78(20.8) | 202(53.9) | 130(34.7) |
| With caries  | 765 | 367(48.0) | 427(55.8) | 222(29.2)* | 457(59.7) | 349(45.6)* |

**Caries severity**

| dmft ≤ 4 | 766 | 391(51.0) | 402(52.5) | 181(23.6) | 435(56.8) | 291(38.0) |
| dmft > 4  | 374 | 179(47.9) | 214(57.2) | 120(32.1)* | 224(59.9) | 188(50.3)* |

JDs - Jordanian dinars

* p< 0.05

Major types of foods consumed at breakfast are shown in Table 13. Both savory items and milk/tea with sugar were reported for more than 85% of the children with approximately one third having the food items that were high in NME sugars (marmalade/jam/honey/halawi). There was little difference in foods and drinks at
breakfast with age or gender and no consistent difference with all three social class measures. More of the children with caries had been reported as having sweet food items at breakfast.

The findings in relation to foods and drinks eaten at dinner (Table 14) were in some respect similar to those seen at breakfast. The great majority of children had savory foods at dinner time and about 40% had cooked vegetables with or without meat. Of the children, 50-60% drank milk or tea with sugar at dinner time and just less than one third had items considered very high in NME sugars. There were no obvious differences with age but fewer girls had milk/tea with sugar and fewer had marmalade/jam/honey/halawi at dinner time.

Consistently more children from lower social classes had cooked vegetables at dinner time (p<0.05). There were also trends for fewer children in lower classes to have milk/tea with sugar or to have savory items but these were not consistently significant.

Although no social class differences were obvious in relation to children having items such as marmalade/jam/honey/halawi at dinner time, significantly more children with caries did so (30%) compared with those who were caries free (23%).
Table 13: Number and percentage of children according to types of food and drink most often consumed at breakfast, socio-demographic factors and prevalence and severity of caries.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Food and drinks at breakfast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td>4</td>
<td>569</td>
</tr>
<tr>
<td>5</td>
<td>571</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>582</td>
</tr>
<tr>
<td>Girls</td>
<td>558</td>
</tr>
<tr>
<td>Kindergarten fees</td>
<td></td>
</tr>
<tr>
<td>&gt; 40 JDs</td>
<td>235</td>
</tr>
<tr>
<td>21–40 JDs</td>
<td>384</td>
</tr>
<tr>
<td>≤ 10–20 JDs</td>
<td>521</td>
</tr>
<tr>
<td>Social class</td>
<td></td>
</tr>
<tr>
<td>I–III Non manual</td>
<td>835</td>
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<tr>
<td>III Manual-V</td>
<td>305</td>
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<tr>
<td>not classified</td>
<td></td>
</tr>
<tr>
<td>Mother’s education</td>
<td></td>
</tr>
<tr>
<td>Interm. college/University</td>
<td>631</td>
</tr>
<tr>
<td>Secondary school/vocational training</td>
<td>376</td>
</tr>
<tr>
<td>No schooling/Primary school/not specified</td>
<td>133</td>
</tr>
<tr>
<td>Caries prevalence</td>
<td></td>
</tr>
<tr>
<td>Caries free</td>
<td>375</td>
</tr>
<tr>
<td>With caries</td>
<td>765</td>
</tr>
<tr>
<td>Caries severity</td>
<td></td>
</tr>
<tr>
<td>dmft ≤ 4</td>
<td>766</td>
</tr>
<tr>
<td>dmft &gt; 4</td>
<td>374</td>
</tr>
</tbody>
</table>

JDs – Jordanian dinars

* p < 0.05
Table 14: Number and percentage of children according to types of food and drinks most often consumed at dinner, socio-demographic factors and prevalence and severity of caries.

<table>
<thead>
<tr>
<th>Food and drinks at dinner</th>
<th>( n )</th>
<th>( n(%) )</th>
<th>( n(%) )</th>
<th>( n(%) )</th>
<th>( n(%) )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>569</td>
<td>237(41.7)</td>
<td>328(57.6)</td>
<td>509(89.5)</td>
<td>155(27.2)</td>
</tr>
<tr>
<td>5</td>
<td>571</td>
<td>233(40.8)</td>
<td>330(57.8)</td>
<td>509(89.1)</td>
<td>163(28.5)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>582</td>
<td>229(39.3)</td>
<td>357(61.3)</td>
<td>526(90.4)</td>
<td>183(31.4)</td>
</tr>
<tr>
<td>Girls</td>
<td>558</td>
<td>241(43.2)</td>
<td>301(53.9)*</td>
<td>492(88.2)</td>
<td>135(24.2)*</td>
</tr>
<tr>
<td><strong>Kindergarten fees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 40 JDs</td>
<td>235</td>
<td>73(31.1)</td>
<td>172(73.2)</td>
<td>218(92.8)</td>
<td>49(20.9)</td>
</tr>
<tr>
<td>21–40 JDs</td>
<td>384</td>
<td>131(34.1)</td>
<td>213(55.5)</td>
<td>338(88.0)</td>
<td>113(29.4)</td>
</tr>
<tr>
<td>≤ 10–20 JDs</td>
<td>521</td>
<td>266(51.1)*</td>
<td>273(52.4)*</td>
<td>462(88.7)</td>
<td>156(29.9)*</td>
</tr>
<tr>
<td><strong>Social class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-II Non manual</td>
<td>835</td>
<td>308(36.9)</td>
<td>500(59.9)</td>
<td>756(90.5)</td>
<td>236(28.3)</td>
</tr>
<tr>
<td>III Manual-V/</td>
<td>305</td>
<td>162(53.1)*</td>
<td>158(51.8)*</td>
<td>262(85.9)*</td>
<td>82(26.9)</td>
</tr>
<tr>
<td>not classified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mother’s education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intern. college/University</td>
<td>631</td>
<td>241(38.2)</td>
<td>367(58.2)</td>
<td>561(88.9)</td>
<td>176(27.9)</td>
</tr>
<tr>
<td>Secondary school/vocational training</td>
<td>376</td>
<td>144(38.3)</td>
<td>216(57.4)</td>
<td>345(91.8)</td>
<td>105(27.9)</td>
</tr>
<tr>
<td>No schooling/Primary school/not specified</td>
<td>133</td>
<td>85(63.9)*</td>
<td>75(56.4)</td>
<td>112(84.2)</td>
<td>37(27.8)</td>
</tr>
<tr>
<td><strong>Caries prevalence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caries free</td>
<td>375</td>
<td>140(37.3)</td>
<td>204(54.4)</td>
<td>335(89.3)</td>
<td>88(23.5)</td>
</tr>
<tr>
<td>With caries</td>
<td>765</td>
<td>330(43.1)</td>
<td>454(59.3)</td>
<td>683(89.3)</td>
<td>230(30.1)*</td>
</tr>
<tr>
<td><strong>Caries severity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dmft ≤ 4</td>
<td>766</td>
<td>307(40.1)</td>
<td>429(56.0)</td>
<td>693(90.5)</td>
<td>208(27.2)</td>
</tr>
<tr>
<td>dmft &gt; 4</td>
<td>374</td>
<td>163(43.6)</td>
<td>229(61.2)</td>
<td>325(86.9)</td>
<td>110(29.4)</td>
</tr>
</tbody>
</table>

JDs - Jordanian diners

* p< 0.05
When dietary and socio-demographic variables were combined in stepwise multiple logistic regression (Table 15), six emerged as having a significant independent effect. Two dietary factors having independent effect on caries prevalence were confectionery consumption between meals and the child having marmalade/jam/honey/halawi at breakfast. In each case, the odds ratio suggested that children for whom these were reported had approximately 1.5 times the risk of having caries. Only one dietary factor, consumption of teas with sugar, had an independent effect on the severity of caries. Age and kindergarten tuition fees showed significance with both, caries prevalence and severity.

Table 15: Logistic regression: Odds ratios and 95% confidence intervals (95% CI) for the outcomes of caries prevalence (dmft≥1/dmft=0), caries severity (dmft>4/dmft≤4) and socio-demographic and dietary habits.

<table>
<thead>
<tr>
<th></th>
<th>Caries prevalence (dmft≥1/dmft=0)</th>
<th>95% CI</th>
<th>Caries severity (dmft&gt;4/dmft≤4)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 years/4 years</td>
<td>1.6</td>
<td>1.3 - 2.1</td>
<td>1.8</td>
<td>1.4 - 2.3</td>
</tr>
<tr>
<td><strong>Kindergarten fees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 10–20 JDs/ &gt;21 JDs</td>
<td>1.4</td>
<td>1.1 - 1.8</td>
<td>1.3</td>
<td>1.1 - 1.7</td>
</tr>
<tr>
<td><strong>Social class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not classified, III M-V / I - III NM</td>
<td>1.7</td>
<td>1.2 - 2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Confectionery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes/no</td>
<td>1.6</td>
<td>1.2 - 2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teas with sugar</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes/no</td>
<td>1.4</td>
<td>1.1 - 1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Marmalade/jam/honey/halawi at breakfast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes/no</td>
<td>1.5</td>
<td>1.1 - 2.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

JDs – Jordanian dinars
4.4. Oral cleanliness and gingivitis

The sample of 1,140 children included in this study was made up of 582 boys and 558 girls. Of these children, 65 (29 boys and 36 girls) were excluded from the analysis because not all sites could be scored for plaque and gingivitis. Thus the results presented here refer to 1,075 children, 553 boys and 522 girls. Of these children, 556 were 4 and 519 were 5-years-old.

Table 16 shows the oral cleanliness (sites with plaque) and the absence or presence of gingivitis in relation to sociodemographic and oral health behaviours. In the sample the majority of children (83%) had 4 or more sites with dental plaque and two thirds of them had one or more sites affected by gingivitis. No differences in either oral cleanliness or in the absence/presence of gingivitis could be seen between the two age groups or between boys and girls. Differences in oral cleanliness of the children were seen across one of the three proxy measures of social class (Table 16) and consistent differences in percentages of children with sites affected by gingivitis were also seen across all three measures of social class. More children whose father’s occupation was in the manual social classes or who could not be classified and more children who attended kindergartens with lowest tuition fees had 4 or more sites with dental plaque or had one or more sites affected by gingivitis. In addition more children whose mothers had received the least education had one or more sites affected by gingivitis. Differences in oral cleanliness and in the absence/presence of gingivitis were seen in relation to oral health behaviours. Children who were reported to brush their teeth daily, to always use toothpaste or who started using toothpaste before the age of 24 months had less sites with dental plaque and had less sites affected by gingivitis than did the others.
Table 16: Oral cleanliness, absence or presence of gingivitis in relation to sociodemographic factors and oral health behaviours.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Oral cleanliness (sites with plaque)</th>
<th>Gingivitis extent (number of sites affected)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-3</td>
<td>4 or more</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>556</td>
<td>93(16.7)</td>
<td>463(83.3)</td>
</tr>
<tr>
<td>5</td>
<td>519</td>
<td>85(16.4)</td>
<td>434(83.6)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>522</td>
<td>89(17.0)</td>
<td>433(83.0)</td>
</tr>
<tr>
<td>Boys</td>
<td>553</td>
<td>89(16.1)</td>
<td>464(83.9)</td>
</tr>
<tr>
<td><strong>Kindergarten fees</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 40 JD’s</td>
<td>213</td>
<td>62(29.1)</td>
<td>151(70.9)</td>
</tr>
<tr>
<td>21–40 JD’s</td>
<td>367</td>
<td>64(17.4)</td>
<td>303(82.6)</td>
</tr>
<tr>
<td>≤ 10–20 JD’s</td>
<td>495</td>
<td>52(10.5)</td>
<td>443(89.5)*</td>
</tr>
<tr>
<td><strong>Social class</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-IIl Non manual</td>
<td>789</td>
<td>135(17.1)</td>
<td>654(82.9)</td>
</tr>
<tr>
<td>III Manual-V/not classified</td>
<td>286</td>
<td>43(15.0)</td>
<td>243(85.0)</td>
</tr>
<tr>
<td><strong>Mother's education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intern. college/University</td>
<td>589</td>
<td>107(18.2)</td>
<td>482(81.8)</td>
</tr>
<tr>
<td>Secondary school/vocational</td>
<td>357</td>
<td>51(14.3)</td>
<td>306(85.7)</td>
</tr>
<tr>
<td>No schooling/Primary school/</td>
<td>129</td>
<td>20(15.5)</td>
<td>109(84.5)</td>
</tr>
<tr>
<td>not specified</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frequency of brushing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>daily</td>
<td>439</td>
<td>91(20.7)</td>
<td>348(79.3)</td>
</tr>
<tr>
<td>never/occasionally</td>
<td>636</td>
<td>87(13.7)</td>
<td>549(86.3)†</td>
</tr>
<tr>
<td><strong>Use of toothpaste</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>always</td>
<td>1037</td>
<td>172(16.6)</td>
<td>865(83.4)</td>
</tr>
<tr>
<td>never/occasionally</td>
<td>38</td>
<td>6(15.8)</td>
<td>32(84.2)</td>
</tr>
<tr>
<td><strong>Toothpaste use started</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 24 months</td>
<td>277</td>
<td>57(20.6)</td>
<td>220(79.4)</td>
</tr>
<tr>
<td>never/ &gt; 24 months</td>
<td>798</td>
<td>121(15.2)</td>
<td>677(84.8)†</td>
</tr>
</tbody>
</table>

* p < 0.0001
† p < 0.05

Caries prevalence and severity according to oral cleanliness and absence/presence of gingivitis are shown in Table 17 and in Figures 2 and 3. A positive association between the number of sites with plaque and absence/presence of gingivitis and severity of caries can be seen in the 4-5-year-olds. Of those children who were caries-free, 73% had 4 or
more sites with dental plaque and 93% of those who had a dmft of 4 or more, had 4 or more sites with plaque. Presence of gingivitis was seen in one half of the caries-free children but was seen in 81% of those who had a dmft of 4 or more (Table 17, Figure 3).

Table 17: Caries prevalence and severity according to oral cleanliness and absence or presence of gingivitis.

<table>
<thead>
<tr>
<th>Caries prevalence</th>
<th>Oral cleanliness (sites with plaque)</th>
<th>Gingivitis extent (sites affected)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>0-3 sites</td>
</tr>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>caries free</td>
<td>358</td>
<td>97(27.1)</td>
</tr>
<tr>
<td>with caries</td>
<td>717</td>
<td>81(11.3)</td>
</tr>
<tr>
<td>Caries severity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dmft &lt; 4</td>
<td>661</td>
<td>150(22.7)</td>
</tr>
<tr>
<td>dmft ≥ 4</td>
<td>414</td>
<td>28(6.8)</td>
</tr>
</tbody>
</table>

*p< 0.0001

Figure 2: Percentage of children and oral cleanliness (sites with plaque) according to caries prevalence and severity.

- 4-+ sites
- 1-3 sites

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Results of the multi-variate analysis are summarised in Table 18. When socio-demographic, oral health behaviours and caries prevalence and severity were combined in the stepwise logistic regression, kindergarten fees, caries prevalence and severity were the only significant predictors for oral cleanliness and absence/presence of gingivitis. Children who had experience of caries had almost twice (1.7 times) the likelihood of having 4 or more sites with dental plaque or of having one or more sites affected by gingivitis. Children who had a dmft of 4 or more had almost three times the chances of having 4 or more sites with dental plaque.
Table 18: Logistic regression: *p* values, odds ratios and 95% confidence intervals for the outcomes of oral cleanliness and absence or presence of gingivitis*.

<table>
<thead>
<tr>
<th></th>
<th>Oral cleanliness (sites with plaque)</th>
<th>Gingivitis extent (sites affected)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(95% CI)</td>
</tr>
<tr>
<td><strong>p</strong></td>
<td><strong>OR</strong></td>
<td><strong>p</strong></td>
</tr>
<tr>
<td>Kindergarten fees</td>
<td>0.0001</td>
<td>2.5</td>
</tr>
<tr>
<td>&lt; 21 JD's/21 JD's</td>
<td>0.0004</td>
<td>1.7</td>
</tr>
<tr>
<td>Caries prevalence</td>
<td>0.0001</td>
<td>2.9</td>
</tr>
<tr>
<td>Caries severity</td>
<td>0.0001</td>
<td>2.9</td>
</tr>
</tbody>
</table>

*results are presented for variables that showed statistically significant association with the outcomes in the

4.5. Caries and gingivitis: Risk factors and indicators

The previous sections of this study looked upon caries prevalence and severity from different perspectives using different sets of variables (socio-demographic; oral hygiene behaviour and feeding during infancy; dietary practices). Each part has identified some significant factors. On the other hand this last part looked globally at the three dichotomised variables: presence of caries, of severe caries, and of gingivitis in terms of a wider class of explanatory variables.

Explanatory variables that have potential for statistical associations with these three dichotomous outcomes were entered into a stepwise logistic regression analysis. Only variables demonstrating statistically significant associations at the 5% level were kept in the final models.

Results of this more comprehensive analysis are summarised in Table 19. Six factors emerged as having a significant effect on the presence of caries. Children who had used comforters and those who had 4 or more sites with dental plaque had almost 3 times the likelihood of having caries. Five-year-olds, children who had the habit of sleeping beside their mother, who regularly had confectionery as a snack or who had
marmalade/jam/honey/halawi at breakfast or dinner had almost twice the chance of having caries than those not having these habits. Prolonged breast feeding exerted an independent effect on both caries severity and gingivitis. Children who were breast-fed for more than 18 months had 2.3 times the likelihood of having severe caries and 3 times the chance of having gingivitis compared to those who were never breast-fed. Bottle-fed children who were not fed on demand appeared significantly less likely to have severe caries than those who were wholly breast fed. The strongest association with gingivitis was plaque. Those who had 4 or more sites with dental plaque had 8.6 times the chance of having gingivitis.

Table 19: Logistic regression: Odds ratios and 95% confidence intervals for caries prevalence, caries severity and gingivitis with variables that were statistically significant in the bivariate analysis*.

<table>
<thead>
<tr>
<th>Caries prevalence (dmft =0/ dmft ≥1)</th>
<th>Caries severity (dmft ≤4/ dmft &gt;4)</th>
<th>Gingivitis (no/yes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.7</td>
<td>1.3-2.2</td>
</tr>
<tr>
<td>4years/5 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kindergarten fees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;21 JDS/ ≤ 10–20 JDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dental plaque</td>
<td>2.5</td>
<td>1.8-3.6</td>
</tr>
<tr>
<td>&lt;4 sites/ ≥4 sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast feeding duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>never (base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;6 – 18 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 18 months</td>
<td>2.3</td>
<td>1.1-4.8</td>
</tr>
<tr>
<td>Bottle feeding frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>never (base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>not on demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>on demand</td>
<td>0.6</td>
<td>0.4-0.8</td>
</tr>
<tr>
<td>Sleeping beside the mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no/yes</td>
<td>1.5</td>
<td>1.2-2.0</td>
</tr>
<tr>
<td>Use of comforters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no/yes</td>
<td>2.9</td>
<td>1.8-4.7</td>
</tr>
<tr>
<td>Confectionery (as snack food)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no/yes</td>
<td>1.6</td>
<td>1.2-2.2</td>
</tr>
<tr>
<td>Marmalade/jam/honey/halawi at breakfast or dinner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no/yes</td>
<td>1.5</td>
<td>1.1-2.0</td>
</tr>
</tbody>
</table>

*results are presented for variables that showed statistically significant association with one or more outcomes in the final multivariate model.
5. DISCUSSION

The majority of studies on caries and gingivitis in young children in the Middle East have considered only one or a relatively small number of factors. The present study investigates the relationship between oral health (in terms of dental caries, plaque and gingivitis) and a wide range of factors such as social class, oral hygiene behaviours, infant feeding and eating habits.

The study is composed of five main parts
1- Prevalence and severity of dental caries in relation to socio-demographic factors.
2- Prevalence and pattern of dental caries in relation to oral hygiene practices and dietary habits during infancy.
3- Food and drink consumption, socio-demographic factors and dental caries.
4- Oral cleanliness, gingivitis, dental caries and oral health behaviour.
5- Risk indicators and factors in relation to caries, severe caries and gingivitis.

5.1. Study sample and parameters studied

This relatively large study sample is composed of 1140 pre-school children (569 aged 4 years and 571 aged 5 years). Of these, 582 were boys and 558 were girls.

This study is the first to employ three proxy measures of social class, including the fee of the kindergartens attended by the children, maternal education level and paternal occupation.

Oral hygiene practices were questioned in relation to the frequency of brushing and the age at which tooth brushing and the use of toothpaste started. The study of feeding during infancy included recording the method of feeding (breast, bottle or both), whether feeding was on demand, the age of weaning from the breast or bottle, whether bottle milk was given naptime, bed time or during the night, and if sugar was added to bottle milk. The use of comforters and of sweetened drinks in feeding bottles was also investigated. The investigation of eating habits during early childhood included recording the taking of snacks and food choices at breakfast and dinner.
5.2. Prevalence of dental caries in relation to socio-demographic factors

The first part of the present study considers the prevalence and severity of dental caries and studies the relationship between caries experience and socio-demographic factors.

Sixty seven per cent of the 1140 children had some caries experience. The mean dmft score per child was 3.6. These data compare poorly with those of children in developed countries such as the United Kingdom. In one recent UK survey, 36% of a nationally based sample of 4-6-year-olds had some caries; mean dmft was 1.0 per child (Walker et al., 2000). However, in comparison with the results of studies from countries neighbouring Jordan (reported over the last 5 years) the caries levels seen in the present work may be slightly lower. In Saudi Arabia for example, a prevalence of 73% and a mean dmft of 4.8 were recently reported for a large sample of pre-school children in Jeddah (Al-Malik et al 2001, 2002), and in Kuwait, 81% of a sample of 4-year-olds had caries and a mean dmft of 4.6 (Vigild et al., 1996). The values reported here are a little lower than the 75% reported by Janson and Fakhouri in 1993 for 3-6-year-olds in one of the suburbs of Amman. Prevalence appears to be similar to the 63% in the sample studied by Hamdan and Rock (1993). Severity, on the other hand, may be higher, with a mean value of 2.15 dmft reported by these authors compared to the present value of 3.6 - more than one tooth per child more.

Prevalence increased significantly with age, suggesting that caries activity was continuing in the present 4-5-year-olds.

There was also some suggestion in the multivariate analysis that caries was more common in boys than in girls. Although this finding may be true, and concurs with results reported by others (Al-Shammery, et al., 1990; Al-Khateeb et al., 1990; Hamdan and Rock 1993; Janson and Fakhouri 1993), the difference was small in absolute terms and was not seen in univariate analysis.

Of the 1140 children studied, 73% had fathers whose occupation fell into the non-manual categories (I-III Non-manual) and 19% had fathers whose occupation fell into the manual categories (III Manual-V). The occupation of the fathers of the remaining 8% could not be classified in this way. Basing class on the occupation of the head of household using a classification originally designed for use in another country - and with a different culture - might be thought inappropriate. However, in this study, the
Registrar General’s classification—which was designed for use in the UK—appears to have been a reasonably satisfactory indicator, perhaps indicating the Westernised culture of the city.

Some 631 (55%) of the children’s mothers had received education up to the intermediate college or university level. Education had been limited to secondary school and/or vocational education for 376 mothers (33%). The mothers of the remaining 133 children (12%) received no schooling, had received only primary school education, or did not specify their level of education.

Two hundred and thirty five of the children (21%) attended kindergartens with the highest tuition fees. A further 384 (34%) attended those in the middle range, and 521 (46%) attended kindergartens with the lowest monthly fees.

In common with many investigations, the present study showed a clear relationship between caries prevalence and social class. Children from social class III Manual-V, or who had non-classified backgrounds, who attended kindergartens with the lowest monthly fees, or whose mothers had received less education, had higher levels of disease. This finding is in line with that reported in numerous other investigations in industrialised countries and confirms the relationship reported by Hamdan and Rock (1993) for the same city. In Saudi Arabia too, the same relationship between social class and caries has now been well demonstrated (Al Mohammadi et al., 1997; Al-Malik et al., 2001). It has also been demonstrated in Abu Dhabi (Al-Mughery et al., 1991) and Kuwait (Al Dashti et al., 1995). However, this finding is in contrast with results reported by Janson and Fakhouri who failed to find a relationship in their smaller and more carefully selected sample.

Although differences showed consistent trends across the three social class groupings, one third of the children in the non-manual group were free of caries compared to one fourth and one fifth in the manual and non-classified groups respectively. This may indicate that a difference in caries experience (in a significant proportion of children) cannot be solely explained by differences in social class.

School types (indicated by fees) have proved to be a valuable indicator of oral health in Jordan and Saudi Arabia (Al-Khateeb et al., 1990; Hamdan and Rock 1993; Al Malik 2001), and were also of value in this study. In multivariate analysis, fees showed a consistent independent effect with both caries prevalence and with more extensive
caries - children at low fee kindergartens fairing worst. In univariate analysis, fees also proved to be consistently related to caries and dmft values.

Maternal education level proved to be a significant factor in univariate analysis with respect to both prevalence and severity. The high prevalence of caries seen among children of mothers with the lowest educational level is consistent with the findings of other studies (Al-Dashti et al., 1995; Al-Hosani and Rugg-Gunn, 1998; Holan et al., 1991; Thomas and Startup, 1992; Verrips et al., 1992), but the difference seen here was not consistent when investigated by multivariate analysis, suggesting that maternal education might have only a very limited independent effect on top of the other two alternative measures of social class, and may have caused some element of confounding. The findings also suggest that maternal education was a less good proxy measure of oral health for this sample of children. Relatively few mothers had education confined to primary school or less, and the lack of discrimination may reflect the higher levels of educational achievement now enjoyed by the majority of Jordanian women, or at least by those whose children attended kindergarten schools in Amman.

It should be remembered that the caries prevalence and severity reported here are likely to be underestimates of disease among young children in Amman city. It is the children of the poorest families who have least access to kindergartens, and the present results suggest that these children are likely to have high levels of disease.

5.3. **Prevalence and pattern of dental caries in relation to oral hygiene practices and dietary habits during infancy**

The study considered five different outcomes of prevalence and patterns of caries and their association with oral hygiene and infant feeding habits.

With respect to oral hygiene, 673 of the 1140 children (59%) had never or had only occasionally brushed their teeth while 467 children (41%) brushed their teeth daily. Eight hundred and three (70%) children had never brushed their teeth or started to brush after 24 months of age, while 337 (30%) started brushing their teeth before or at 24 months. Eight hundred and forty eight children (74%) had never used toothpaste or started to use it after 24 months of age, and 292 children (26%) started to use toothpaste before or at the age of 24 months.
Frequency of brushing, age at which tooth brushing began, and age at which use of toothpaste was started, showed associations with caries prevalence. Those who started brushing their teeth or started using toothpaste at or before 24 months of age had less caries experience than those who started brushing their teeth or those who used toothpaste later. This significant association of frequency of brushing and caries has been reported in other studies (Stecksen-Blicks and Holm, 1995). On the other hand, the present findings contrast with those reported by Dini et al., (2000), who stated that neither frequency of brushing nor age at which tooth brushing started was significant.

Two hundred and ninety seven children (26%) had been wholly breast-fed and 71 (6%) had been wholly bottle-fed. The remaining 772 (68%) had been both breast and bottle-fed.

In Kuwait, more children (79%) were wholly breast-fed, but a similar percentage of children (7%) were solely bottle-fed. A further 13% of mothers supplemented breast-feeding with the bottle (Al Dashti et al., 1995), compared to 68% in the present sample. This difference may be attributed to the fact that most young mothers in Jordan work. In contrast to Jordan and Kuwait, a much higher percentage of both White (38%) and Pakistani children (24%) in the UK are reported to be bottle-fed (Watt, 2000).

In Jordan as a whole, professionals in maternity centres and family health clinics give advice to mothers on breast-feeding. It is recommended that weaning take place between 6 months and one year. Mothers who are in paid employment are advised to introduce a feeding bottle by the end of their maternity leave (currently 3 months but under review by the government for reduction to 2 months) in order to wean their children completely by the end of six months. Mothers without work commitments, who are more often from lower social classes, are encouraged to wean their children at between nine and twelve months of age. This difference in weaning pattern was reflected in the results of the study. Mothers of children attending kindergartens with lower tuition fees were more likely to breast-feed their children for more than 18 months.

For the 1069 children who had been wholly or partly breast-fed, 904 (85%) were weaned at or before 18 months, 764 children (71.5%) were breast-fed on demand and a relatively high number, 667 (62%), slept beside their mother. Furthermore, 165 (15%) were weaned at later than 18 months.
Eight hundred and forty three children were wholly or partly bottle-fed. Of these, 111 children (13%) were weaned at or before 18 months, while 732 (87%) were weaned later than 18 months. Five hundred and two (60%) children were bottle-fed on demand. Only 334 (40%) drank their milk without sugar; 509 (60%) had milk to which sugar was added. Six hundred and forty four children (76%) were bottle-fed at naptime, bedtime or during the night.

The information sought for all children regarding their sugar intake during early life included questions about the use of comforters (given at bedtime or naptime), consumption of confectionery at bed, and whether children had been given sweetened drinks in a feeding bottle. The use of comforters was not prevalent in the sample: only 149 (13%) of children used them. Fifty-seven of children (5%) were given confectionery at bedtime.

With respect to sweetened drinks, 545 children (48%) had never been given sweetened drinks in a feeding bottle, 431 (38%) were given such a drink during the day (while awake), and just 164 (14%) received such at nap, bedtime or during the night. Some 139 (12%) children stopped having a sweetened drink in a bottle at or before 12 months; 456 (40%) stopped this later.

With regard to feeding during infancy, children who were breast-fed after 18 months of age, who were breast-fed on demand, or who slept beside their mother, had high caries prevalence. Similar findings have been reported by other authors (Matee et al., 1992b; Tsubouchi et al., 1994; Al Dashti et al., 1995; Wendt, 1995). As in the case of children who were breast-fed on demand, children who were bottle-fed on demand also showed a higher prevalence of caries. Children who had sugar or honey added to their bottle of milk had more caries. This is in line with the findings of earlier studies (Winter and colleagues, 1966; Williams and Hargreaves, 1990). Bottle-feeding at naptime, bedtime, or during the night has been shown to be associated with caries (Ollila et al., 1998; Dini et al., 2000; Creedon and O'Mullane, 2001). The results of the present study confirm that these habits are associated with caries prevalence.

Children who used comforters or had confectionery at night had more caries experience. This finding agrees with that reported in other studies (Winter et al, 1971a; Holt et al, 1988; Holt et al., 1996; Ollila et al., 1998)
With respect to tooth types, primary molars were the most commonly affected. At the age of four, 42% of the children had experience of caries in these teeth, rising to 58% at the age of five years.

In both the 4- and 5-year-old age groups, caries in the primary incisors was seen in 35% of the children; 10% had caries in the canines.

Prevalence of caries in incisors is very much higher than that seen in children of equivalent age in the UK and Australia (O'Brian, 1994; Seow et al., 1996) but nearly equal to that seen in at least one recent study from the Middle East (Al-Malik et al., 2002) where 34% of a sample of 2-5-year-olds in Jeddah, Saudi Arabia, had caries affecting their incisors and/or canines. This may indicate common determinants of disease in countries with similarities in culture.

When tooth type patterns (incisors and/or canines; molars; both) were investigated, 44% of children with caries had caries confined to molars. In 11% it was limited to incisors and or canines, and in 45% caries affected both the posterior and anterior teeth. This distribution pattern is broadly similar to that seen in 5-6-year-olds in a recentlyfluoridated area of Araraquara, Brazil, where 45% of children with caries had only molars affected and 49% had caries in both molars and anterior teeth. However, fewer Brazilian children (6%) had incisors (and/or canines) affected alone (Dini et al., 1998).

Prevalence of caries in molars alone and prevalence of the more extensive pattern (incisors and/or canines and molars) increased with age, the difference in the latter pattern being highly significant.

Caries in molars alone was more common in children who belonged to the manual or non-classified social classes.

Children who never brushed their teeth or started to brush their teeth and use toothpaste after 24 months of age, had a higher prevalence of the more extensive form of the disease (i.e., caries in molars, and incisors and/or canines).

Patterns of disease were considered separately for children who had been wholly or partly breast-fed and those who had been wholly or partly bottle-fed. The extensive pattern of caries was seen more often in children who had been fed on demand (either breast or bottle) and in those children who had been breast-fed for more than 18 months. Also in children who were bottle-fed at nap-time, bedtime or during the night. The
association between the lengths of time a mother breast-fed her child, and the extensive caries pattern has also been reported by Dini et al. (2000).

On the other hand, caries in the anterior teeth, was associated with the use of comforters. This finding is in line with that reported in other studies (Holt et al., 1996; Ollila et al., 1998).

Caries confined to molars was negatively associated with two factors that might be regarded as more likely to produce high levels of disease, namely bottle feeding at nap, bed or during the night (rather than while awake), and either never having been breast-fed or having been breast-fed for longer than 18 months. This finding may reflect differences in the age at which caries develops. For children with caries confined to molars, initiation and progression begin later than in other patterns. By this time, children may be less likely to have been breast-fed or bottle-fed at naptime or during the night; the relationship may simply be to age at which disease begins.

The present findings also suggest apparently varying degrees of susceptibility. Thus, children with low susceptibility may remain at some risk of caries confined to molars. The results would, however, seem to confirm a different aetiology for this pattern. Risk factors may act only after the eruption of molars and may not be related to infant feeding. Douglass et al. (2001) also suggest a different aetiology for disease occurring later in childhood.

In many of the children in this sample, caries affected not only the molars but also the incisors and/or canines. In these cases, the influence of other aetiological agents may be masked by the overwhelming effect of comforters.

5.4. Food and drink consumption, socio-demographic factors and dental caries

Snack foods were consumed by a high percentage of children. Savory foods were reported to be eaten by 82%, and fresh fruits by 80%, reflecting the high accessibility of these foods.

A review of the literature on the consumption of sugar in developing countries has emphasized that sugar (sucrose) use is increasing, particularly in the Middle East where consumption seems to be higher than in other developing countries (Ismail et al., 1997). Studies of food habits (Musaiger, 1996) or types of food consumption and dental caries prevalence (Wyne and Khan, 1995; Al-Shammery, 1999) have been carried out in Arab
countries, but there is no previous information about the most popular choice of items for snacks or drinks between meals in Jordanian pre-school children. In this study, among the most popular high non-milk sugar snacks, confectionery and biscuits were reported to be consumed by 76% and 71% of children respectively.

One study performed on 4-6-year-olds in Saudi Arabia reported a high percentage (88.2%) of children to regularly consume sweet snacks (Wyne and Khan, 1995). Amongst 4-year-olds in Norwich, England, biscuits/cakes were also popular food items but were eaten by only 40% of children (as mid-morning or at school break time snacks). Confectionery was eaten by only 4% (Holt, 1991). The lower percentage of English children who consume NME sugars may reflect their better access to dental health education.

It may be concluded that savory snacks are a very popular food choice amongst both Jordanian and English children. In the most recent National Diet and Nutrition Survey of Young People in England (Gregory and Lowe, 2000) 92% of 4-6-year-old boys and 91% of girls of the same age were reported to consume savory snacks - a little higher than the observed proportions of boys and girls in Jordan.

More than 50% of children in the current study were reported to regularly consume canned fruit juices and carbonated drinks. Squashes were consumed regularly as snack drinks by 26% and teas with sugar by 42%. A higher percentage of English children in Norwich (47%) were reported to consume fruit squash at mid-afternoon or at school (Holt, 1991). A higher percentage of children of similar age (75%) were reported to have canned soft drinks and packed fruit juices in the capital of Saudi Arabia (Wyne and Khan, 1995), while 67% were reported to have carbonated drinks in England (Gregory and Lowe, 2000), reflecting the increasing popularity of this type of drink.

The food choices made by Jordanian children at breakfast and dinner had not been studied before. The findings of this study with respect to foods and drinks eaten at dinner were in some respect similar to those seen at breakfast. The great majority (90%) of children had savory foods at dinner and 40% had cooked vegetables with or without meat. Some 50-60% drank milk or tea with sugar at dinner and just less than one third had items considered very high in NME sugars. There were no obvious differences with respect to age, but fewer girls had milk/tea with sugar and fewer had marmalade/jam/halawi at dinner.
More children with caries reported consuming marmalade, jam, honey or halawi. When all these variables were considered in multivariate analysis, consumption of confectionery and having marmalade/jam/honey/halawi at breakfast were independently associated with the prevalence of caries.

The present results consistently show more children from lower social classes had cooked vegetables at dinnertime. On the other hand, there was no consistent difference between items eaten at breakfast or dinnertime in relation to any of the three social class measures.

More than 40% of the present sample of 4-5-year-olds drank tea with sugar. The cariogenicity of this drink may counterbalance the protective effect of fluoride in the tea. There is another general health issue raised by this relatively high consumption of tea; the tannin in tea is inhibitory to the absorption of iron and other minerals from other sources in the diet. Therefore, tea is not recommended for pre-school children (Department of Health, 1994) who are known to be a high-risk group for anaemia (Watt et al., 2000)

This study consistently shows that children who attend kindergartens with the lowest monthly fees, who are from families in social classes III Manual-V (or who could not be classified), and whose mothers have less education, are those who consume more dessert and confectionery, more squashes, more carbonated drinks, more tea with sugar and less fresh fruit juices. The study in Norwich provided little evidence of the influence of social class on the consumption of snacks or drinks as a whole, or on the consumption of sweet items amongst English children of the same age. However in a larger British study, and similar to the Jordanian children, 4-6-year-olds from less advantaged households in England were less likely to drink fruit juice or eat fruit (Gregory and Lowe, 2000).

5.5. Oral cleanliness and gingivitis, dental caries and oral health behaviour

Oral cleanliness was investigated in terms of the number of sites with dental plaque and the presence/absence of gingivitis. The association of these two outcomes with age, social class, oral health behaviours and also with caries prevalence and severity was considered.
The presence of gingivitis and of four or more sites with dental plaque was seen in a high proportion of children. The majority of children (83%) had 4 or more sites with dental plaque and two thirds of them had one or more sites affected by gingivitis. Lower percentages of 5-year-olds (37%) and 6-8-year-olds (71%) were reported to have gingivitis in Kenya (Masiga and Holt, 1993; Ng’ang’a and Valderhaug, 1991). Lower percentages of 5-year-old Scottish children from deprived (30%) and non-deprived (32%) areas were also reported to have gingivitis in the beginning of a dental health campaign on oral hygiene and gingival health (Schou and Wight, 1994).

No difference in oral cleanliness or gingivitis, were seen amongst different ages or between genders. These findings corroborate those of other studies of children of broadly similar age (Ng’ang’a and Valderhaug, 1991; Koroluk et al., 1994). Koroluk et al. (1994) suggest that this result might be expected since the level of manual dexterity does not vary significantly between different age groups and genders in early childhood.

Differences in oral cleanliness of the children were seen across one (kindergarten fees) of the three proxy measures of social class, while the three social class measures proved to be an important risk indicator for the presence/absence of gingivitis, a finding in contrast with the results of other studies of children in Kenya, Sierra Leon and Scotland (Masiga and Holt, 1993; Normak, 1993; Schou and Wight, 1994).

Oral hygiene behaviours were important risk indicators for the differences seen in oral cleanliness and the presence/absence of gingivitis amongst children in the present study. Frequency of brushing has been shown to be associated with the level of oral cleanliness and with the presence/absence of gingivitis in adolescence and adult life (Lang et al., 1973; Lang et al., 1995; Kallio and Murtomaa, 1997; Syrjala et al., 1999), but few studies have attempted to show the relationship between brushing frequency, oral cleanliness and gingivitis in pre-school children.

The association between caries and oral hygiene has not always been clear-cut (Löe, 2000) but in this study there was a positive association between the number of sites with plaque and caries prevalence and severity. A higher percentage of children (93.2%) with 4 dmft or greater, had 4 or more sites with plaque, gingivitis is seen in 81% of those with severe caries. However, although tempting, this finding cannot be taken as implying a direct link between plaque and caries.
Social class is commonly related to caries and the same relationship was demonstrated in this sample. Plaque levels were also related to social class so that the relationship between plaque/gingivitis and caries may reflect a common determinant (or determinants) related to social class. The relationship may, for example, be linked to frequency of brushing with fluoride toothpaste. Children in higher social classes may brush their teeth more frequently and thus have cleaner teeth (and less gingivitis). Because they will also be using fluoride toothpaste more often, their caries levels are also likely to be lower.

It may also be that higher levels of plaque (and gingivitis) are a consequence of higher levels of caries. Not only may the presence of untreated caries itself encourage plaque accumulation, it may also effectively discourage brushing. One of the reasons for this behaviour might be an episode of pain or bleeding from the gingiva caused during the brushing procedure. In this sample, 89% of the dmft values were made up of decayed teeth. Oral pain has been reported to affect high percentages of children, adolescents and adults (Todd et al., 1994; Adulyanon et al., 1996; Vigild et al., 1999; Shepherd et al., 1999). Amongst 8-year-old English schoolchildren, a recent episode of toothache was shown not only to result in a visit to the dentist but also to disrupt normal activity in play, eating, sleeping and going to school (Shepherd et al., 1999). Certainly it seems likely that children would avoid procedures likely to elicit or exacerbate pain. However, it appears that no studies have attempted to measure the effect that pain due to dental caries has on children refraining from brushing their teeth - and as consequence in their having poorer oral cleanliness and more gingivitis.

5.6. Caries and gingivitis: risk factors and indicators.

Many authors have emphasized the complex and multi-factorial nature of caries development, and suggest that many interactive risk factors and indicators are involved. In a country with limited resources like Jordan, identifying risk factors and indicators as well as children at high risk of developing disease would allow preventive efforts to be focused in a cost-effective fashion.

In this last part of the study, the three dichotomous variables: presence of caries, of severe caries, and of gingivitis, were studied in association with age, kindergarten tuition fees, dental plaque, oral hygiene behaviours, infant feeding and dietary practices.
The results show caries to be well established in the majority of children by the
time they attend kindergarten and to continue to increase with age. This statistically
significant increase in caries prevalence and in severity suggests that caries activity is
continuing in these 4-5-year-olds.

On the other hand, no difference in gingivitis was seen between the different age
groups. This result may be expected since, as mentioned above, the level of manual
dexterity does not vary significantly between different age groups in early childhood
(Koroluk et al., 1994). Inability to brush efficiently would result in the accumulation
and maturation of plaque, which is believed to be a direct cause of gingivitis and adult
periodontitis (Löe, 2000).

With respect to the association with kindergarten fees and plaque accumulation,
more children who attended kindergartens with lower tuition fees, and more children
who had 4 or more sites with dental plaque, had caries experience, a dmft greater than 4,
and gingivitis.

Significant differences in caries prevalence, caries severity and gingivitis were
also seen in relation to oral hygiene behaviour. The age of commencement of brushing
with toothpaste appeared to have an effect on caries prevalence (the younger this age the
less the caries experience). This result concurs with those of other studies (Tee, 1987;
Wendt et al., 1994; Hind and Gregory, 1995; Creedon and O’Mullan, 2001). Frequency
of brushing was not significantly related to caries prevalence, but was significantly
associated with caries severity and gingivitis. It is believed that brushing with fluoride
toothpaste causes an initial high concentration of fluoride, which falls with time as
fluoride is cleared from the mouth (Brunn et al., 1984; Zero et al., 1992). Further, Zero
et al. (1992) indicate that fluoride could be retained in saliva at concentrations between
0.03 and 0.1ppm for 2 to 6 hours depending on the product and the individual. Thus, the
greater the frequency of brushing, the longer fluoride is retained in the mouth. The
presence of fluoride, even in this small concentration, may not only inhibit dissolution
of tooth minerals by acids (Featherstone et al., 1990) but also enhance remineralisation
of early enamel lesions (Featherstone, 1999). This may explain how severity may be
reduced with increased frequency of brushing.
With respect to gingivitis, onset seems to be more related to the maturation and age of plaque than to its quantity (Löe et al., 1965). Tooth brushing is considered to be the most reliable means of controlling plaque, provided cleaning is sufficiently thorough and performed at regular intervals (Featherstone, 1999). Frequency of brushing disrupts plaque and prevents its maturation, thus promoting gingival health.

The three dichotomous response variables (presence of caries, severe caries and gingivitis) were studied in relation to feeding practices during infancy. Prevalence of caries was highest amongst children who had been breast-fed for more than 18 months, amongst those who were breast-fed or bottle-fed on demand, amongst those who were in the habit of sleeping beside the mother, and in those who used a comforter. Other studies have reported on the association between caries prevalence and bottle-feeding on demand, sleeping beside the mother and the use of comforters (Holt et al., 1996; Olliila et al., 1998).

Caries severity was associated with prolonged bottle-feeding (more than 18-months). In children with this dietary habit, newly erupted molars may be attacked at a critical time when many of the rod’s crystals are not fully mineralised (Crabb, 1976). A higher dmft score would be the outcome.

In early childhood, it was observed that more children with caries, with severe caries, and with gingivitis took desserts and fruit squashes. Confectionery and tea with sugar increased the prevalence and severity of caries. Children who ate marmalade/jam/honey/halawi for breakfast/dinner had more caries experience.

As well as having direct effects, inappropriate infant feeding habits may be followed by unfavourable dietary habits, which influence oral health later in childhood (Hallonsten et al., 1995). The findings here appear to confirm this association. Children who were never breast-fed, who were breast-fed for more than 18 months, and those who were breast-fed on demand consumed more snack foods and drinks high in NME sugars and more marmalade/jam/honey/halawi at breakfast or dinner.

In the present study, children who were wholly or partly breast-fed beyond the age of 18 months were less likely to start brushing their teeth before the age of 12 months. That this association was absent in the case of bottle-fed children may have been because bottle-feeding beyond 18 months was so common in this sample.
The association seen between caries prevalence and oral hygiene and dietary habits, including consumption of sugar containing items, confirms the relationships reported in previous studies (Stecksen-Blicks and Borssen, 1999; Dini et al., 2000; Mattila et al., 2000; Mora-Leon and Martinez-Olmos, 2000; Tinanoff and Palmer, 2000; Wandera et al., 2000; Creedon and O’Mullane, 2001; Vanobbergen et al., 2001).

Multivariate associations were also sought. All explanatory variables that showed statistically significant associations with the three dichotomous outcomes in the univariate analysis were entered into a stepwise logistic regression analysis. Only variables demonstrating statistically significant associations at the 5% level were kept in the final model.

**Caries prevalence logistic modelling:**

Six variables emerged out of the 15 that were statistically significant in the univariate analysis. These prominent variables, in order of decreasing importance, were: use of comforters, dental plaque, age, sleeping beside the mother, confectionary as snack food), and the consumption of marmalade/jam/honey/halawí at dinner/breakfast. Odds ratio analysis showed that children, who used comforters, and those who had 4 or more sites with dental plaque, had almost 3 times the likelihood of having caries. It also showed that 5-year-olds who had the habit of sleeping beside their mother, who regularly took confectionery as a snack, and who had marmalade/jam/honey/halawí at breakfast/dinner, had almost twice the chance of experiencing caries.

The results of this analysis confirmed that the habit of sleeping beside the mother and the use of comforters were significantly associated with caries prevalence. This finding is in line with that reported in other studies (Holt et al., 1996; Ollila et al.,1998).

**Caries severity logistic modelling:**

Four variables emerged out of the 14 identified by univariate analysis, with plaque being the most significant of all followed, in descending order of importance, by age, use of comforters, and breast-feeding on demand. Odds ratio analysis showed that children with four or more sites with dental plaque had four times the likelihood of having more than 4 dmft. It also showed that 5-year-olds, who were breast-fed on demand, and those who used comforters, had almost twice the likelihood of having more than 4 dmft.
Gingivitis logistic modelling:

Of the 10 variables identified by univariate analysis, only two emerged as significant: dental plaque and kindergarten fees. In this model, plaque appeared to have the strongest significant effect on gingivitis. Odds ratio analysis showed that children who had four or more sites with dental plaque had almost nine times the chance of having gingivitis. Although kindergarten fees failed to show a significant effect on the other two outcomes investigated (caries prevalence and caries severity), it did prove to have an effect on gingivitis. Children from kindergartens with lower fees had a higher chance of having gingivitis.

Multivariate analysis confirmed the multifactorial nature of caries in these young children with both plaque and dietary factors having significant effect on caries prevalence, and on caries severity. In contrast, gingivitis was significantly related to only two variables, social class (measured through the fees of the kindergarten) and dental plaque, perhaps indicating a more straightforward aetiology of the disease. The presence of plaque on four or more of the six sites was a risk factor for all three oral health outcomes, with a particularly strong effect on gingivitis.

Although significant in univariate analysis, the relationship between social class and caries failed to emerge as significant in multivariate analysis. Its effect may, however, have been mediated and compensated through the effect of other variables. On-demand breast-feeding, for example, which was related to caries in univariate analysis and to severe caries in multivariate analysis, was more common in the disadvantaged children. The presence of four or more sites with dental plaque and the habit of not brushing/infrequent brushing were also more common amongst those children attending kindergartens with the lowest tuition fees.
6. CONCLUSION

6.1. The main conclusions of this study

1- Children had on the average a dmft of 3.6 per child, 33% were clinically caries-free, 34% had a dmft between 1 and 4 and the high-risk group (>4dmft) constituted one third of the sample. Treatment need was very high, since decayed teeth made up 89% of the dmft value.

2- There were consistent differences in caries prevalence and dmft across the three proxy measures of social class. Prevalence was higher in children, whose father’s occupation was in the manual class (or could not be classified), in those whose mothers had received the least education, and in those who attended schools with the lowest fees.

3- Caries prevalence was high in children who had one or more of the following:
   - Breast-fed for 18 months or longer.
   - Slept beside the mother.
   - Breast-fed /bottle-fed on demand.
   - Had sugar/honey added to their bottle of milk.
   - Bottle-fed at naptime, bedtime or during the night.
   - Used comforters or confectionery at night.
   - Never/occasionally brushed their teeth.
   - Never/started brushing their teeth or started using a toothpaste after 24 months of age.

4- For tooth type caries patterns:
   - 11% of children with caries had caries in incisors and/or canines only, 44% had caries confined to molars and 45% had the extensive caries pattern (incisors and/or canines and molars).
   - Caries in the incisors and in incisors and/or canines was positively associated with the use of comforters, and with bottle-feeding during nap/bed/night time.
   - Molar pattern was more common in children who belonged to the manual or the non-classified social classes. On the other hand it was negatively associated with bottle-feeding at nap/bed/night time and with breast-feeding for longer than 18 months. It was less often seen in children who were never having been breast-fed.
• Extensive caries pattern was seen in children who had never brushed their teeth or had never used toothpaste. It was also seen in those who started to brush their teeth and to use toothpaste after 24 months of age.

This extensive caries pattern was seen in those who slept beside the mother. It was also seen more often in children who had been fed on demand (either breast or bottle), and seen in those children who were either breast-fed for more than 18 months or never having been breast-fed.

Moreover it was seen in children who were bottle-fed at nap/bed/night time, in those who had sugar/honey added to their bottle of milk, and in children who were given sweetened drinks in their bottle beyond the age of 12 months.

5- Food and drink consumption

• Children who attended kindergartens with the lowest monthly fees, who belonged to social classes III Manual-V (or who could not be classified), and those whose mothers had less education, took more dessert, more squashes, and more teas with sugar. Consumption of these items was associated with caries experience, and with severe caries

6- Oral cleanliness and gingivitis

• The majority of children (83%) had four or more sites with dental plaque and two thirds of the children had one or more sites affected by gingivitis.

• Children who attended kindergartens with the lowest tuition fees had significantly 4 or more sites with dental plaque and had one or more sites affected by gingivitis.

• More children whose father’s occupation was in the manual social class or who could not be classified, and more children whose mothers received the least education had one or more sites affected by gingivitis.

• Children who brushed daily, and who started to use toothpaste before or at 24 months of age had less sites with dental plaque and had less sites affected by gingivitis. These children had less caries experience, and less severe caries.

• 93% of the children, who had a dmft of 4 or more, had at least 4 sites with plaque, and 81% of those who had a dmft of 4 or more had gingivitis.

7- Multivariate analysis has emphasised the role of age, dental plaque, confectionery, consumption of marmalade/jam/honey/halawi at breakfast/dinner, the use of comforters and sleeping beside the mother as being associated significantly with caries
prevalence. For severity, age, use of comforters and breast-feeding duration and plaque accumulation has proved to be the most significant factors. For gingivitis, only three factors has emerged significantly, namely dental plaque, breast-feeding duration and tuition fee.

8- Tuition fees provide readily accessible information, which requires no questions to be put to parents, and they proved to be a good discriminating variable.

6.2. Recommendations

To improve the oral health of 4-5-year-olds in Amman, the design of a health education programme is recommended. This programme should be tailored to the needs of the identified risk groups and should address the risk factors and indicators investigated.

For young children, parents represent the primary source of information about oral health. One way to raise children’s oral health awareness would be to give accurate and scientifically based information to parents.

For parents, paediatricians are the first health workers from whom advice is sought. Accordingly, paediatricians should be encouraged to integrate the oral health message with that of general health. However, kindergartens have great potential for influencing and improving health behaviour. Children can be reached at an age where their habits are being formed. In schools, health education programmes may be conducted by teachers (Honkala, 1993). The advantages of using school personnel include the potential for reaching all children, for continuity in instruction, for the integration of health and oral health with other activities, and the low cost of implementation. A possible disadvantage could be, however, that some teachers have inadequate backgrounds for providing health education (Petersen et al., 1995). For teachers to be able to give proper oral health information they need adequate training and practical support from dentists. Teachers should be provided with educational materials regarding oral hygiene and snacking.

In the light of the above, the following groups should be targeted:

1- Parents, especially expectant mothers and new mothers of infants and toddlers in maternity centres and paediatric clinics.

2- Paediatricians.

3- Head teachers and teachers of kindergartens.
Paediatricians and parents should be able to identify children at high risk of caries in general and of rampant (early childhood) caries in particular. Maxillary incisors should be examined for decalcification or decay. As the child grows older, parents should also be encouraged to examine primary molars. For the purpose of diagnosis, educational materials have to be developed. Lee et al. (1994) have shown that mothers are able to reliably examine their baby’s teeth after watching a 5-minute videotape (“Lift the Lip”).

6.2.1. *How to reduce caries risk for infants and toddlers*

Paediatricians and parents should be encouraged to identify more than one option for reducing caries risk:

1- Infants should not be left to sleep with a bottle containing sugary liquid or milk with added sugar.

2- Prolonged use of feeding bottles should be avoided.

3- Mothers should be encouraged to introduce the cup as early as possible.

4- Prolonged breast-feeding and feeding on demand should be discouraged.

5- Sweetened comforters should be discouraged.

6- Weaning foods should be free of or very low in NME sugars (Department of Health, 1994). This should apply to foods prepared at home for the whole family and those prepared specifically for the child. Items high in sugars should be regarded as “occasional” and be limited to main meals.

6.2.2. *How to reduce caries risk for preschool children*

With respect to diet, parents should:

1- Promote non-cariogenic foods for snacks

2- Limit cariogenic foods to mealtime.

3- Restrict sugar-containing snacks that are slowly eaten such as candies and lollipops.

4- Encourage the consumption of water and milk when the child is thirsty rather than squashes and carbonated drinks.

5- Reduce tea consumption.
With respect to oral hygiene, parents should:

1. Supervise tooth brushing at least up to 7 - 8 years of age (British Society of Paediatric Dentistry, 1996).
2. Parents should be encouraged to start brushing their children’s teeth as soon as they erupt in the oral cavity, even if the baby protests.
3. A small amount (small pea size) of fluoride toothpaste should be used till the age of 6 years (BSPD, 1996).
4. Teeth should be brushed at least twice daily, with stress laid on the importance of brushing last thing at night.

Teachers at kindergartens should be able to:

1. Identify children at high risk of caries.
2. Recognize snacks, which are high in NME sugars.
3. Advise mothers on the substitution of, cariogenic snacks for non-cariogenic ones, especially for children at high risk.
4. Integrate oral hygiene (tooth brushing) into their activities; this could be performed after the mid-morning snack. It is well understood that active participation has a key role in oral health education. Food colours for the disclosure of plaque once a week could be promoted. This proved to be greatly appreciated by pre-school children in the pilot study for the present work.

The Jordanian Dental Association should make use of the residency programme (recently implemented by the Ministry of Health) for new graduates of dental schools. Community visits (mainly to underprivileged kindergartens) should be integrated into this programme.

The Faculty of Dentistry should encourage community visits. These visits should be part of the Preventive Dentistry syllabus. Undergraduates in their final year could lecture on oral health in sessions to which teachers and mothers are invited. In order to provide scientifically based information, appropriate educational materials should be prepared.
REFERENCES

The effect of tooth-brushing frequency, tooth-brushing hand, sex and social class
on the incidence of plaque, gingivitis and pocketing in adolescents: a
longitudinal cohort study.
Community Dental Health 7: 237-247.

Oral impacts affecting daily performance in a low dental disease in Thai
population.
Community Dentistry and Oral Epidemiology 24: 385-389.

Distribution of streptococcus mutans and streptococcus sobrinus at sub-sites in
human approximal dental plaque.
Caries Research 27: 135-139.

ALALUUSUA, S. and RENKONEN, O-V. (1983)
Streptococcus mutans establishment and dental caries experience in children
from 2 to 4 years old.

ALALUUSUA, S., KLEEMOLA-KUJALA, E., NYSTROM, M., EVALAHTI, M. and
GRONROOS, L. (1987)
Caries in the primary teeth and salivary streptococcus mutans and lactobacillus
levels as indicators of caries in permanent dentition.
Pediatric Dentistry 9(2): 126-130.

ALALUUSUA, S., MÄTTÖ, J., GRÖNROOS, L., INNILA, S., TORKKO, H.,
Oral colonization by more than one clonal type of mutans streptococcus in
children with nursing-bottle dental caries.

Caries experience of children aged 6-9 years in Jeddah, Saudi Arabia.

Oral health survey of 5-12-year-old children of National Guard employees in
Riyadh, Saudi Arabia.

Breast-feeding, bottle-feeding and dental caries in Kuwait, a country with low
fluoride levels in the water supply.
Community Dental Health 12: 42-47.
ALDY, D., SIREGAR, H., LIWIJAYA, S.G. and TANYATI, S. (1979)
*Paediatrica Indonesiana* 19: 308-312.

Combination of low parental education attainment and high parental income related to high caries experience in preschool children in Abu Dhabi.
*Community Dentistry and Oral Epidemiology* 26: 31-36.

Prevalence of dental caries in Omani 6-year-old children.
*Community Dental Health* 14: 171-174.

Dental caries in children residing in communities in Saudi Arabia with differing levels of natural fluoride in the drinking water.
*Community Dental Health* 7: 165-171.

The relationship between erosion, caries and rampant caries, and dietary habits in pre-school children in Saudi Arabia.

Erosion, caries and rampant caries in preschool children in Jeddah, Saudi Arabia.
*Community Dentistry and Oral Epidemiology* 30(1): 16-23.

Caries prevalence in boys aged 2, 4 and 6 years according to socio-economic status in Riyadh, Saudi Arabia.
*Community Dentistry and Oral Epidemiology* 25:184-186.

Dental health of 5-year-old children in Abu Dhabi, United Arab Emirates.
*Community Dentistry and Oral Epidemiology* 19: 308-309.

Dental caries prevalence in primary Saudi school children in Riyadh district.

*Community Dentistry and Oral Epidemiology* 18: 320-321.

AL SHAMMER, A.R. (1999)
Caries experience of urban and rural children in Saudi Arabia.
*Journal of Public Health Dentistry* 59(1): 60-64.
AL TITI, M. (1990)


Epidemiological study of oral diseases, oral hygiene and food consumption habits in preschool children in Athens (in Greek). Pedodontia (Greek) 6(3): 103-110. In Lygidakis et al 1996

BAGHURST, K. and BAGHURST, P (1981)
The measurement of usual dietary intakes in individuals and groups. Trans. Menzies Foundation 3: 139-160.

Indicators for oral health and their implications for developing countries. International Dental Journal 33: 60-66.


BARNES L. (1994)


Ethnic indicators of dental health for young Asian schoolchildren resident in areas of multiple deprivation.
British Dental Journal 166: 331-334.

Dental caries experience and oral cleanliness of Asian and white Caucasian children aged 5 and 6 years attending primary schools in Glasgow and Trafford, UK.
Community Dental Health 8: 17-23.


Fluoride in toothpastes for children. Suggestion for change.
Pediatric Dentistry 10(3): 185-188.

Effect of a preventive approach for the treatment of nursing bottle caries.

BIBBY, B.G. (1975)
The cariogenicity of snack foods and confections

BIBBY, B.G. and MUNDORFF, S. A. (1975)
Enamel demineralization by snack foods.
Journal of Dental Research 54: 461-470.

BIRCH, S. (1986)
Measuring dental health: improvements on the DMF index.
Community Dental Health 3(4): 303-311.

Community Dentistry and Oral Epidemiology 17: 41-43.

Caries experience in Latvian nursery school children.
Community Dentistry and Oral Epidemiology 23: 138-141.
BLINKHORN, A. S. (1978)
Influence of social norms on toothbrushing behaviour of preschool children.
*Community Dentistry and Oral Epidemiology* 6: 222 – 226.

The caries experience and dietary habits of Edinburgh nursery school children.

Which bacteria are cariogenic in humans? In: *Risk Markers For Oral Disease*

BOWDEN, G. and EDWARDSSON, S. (1994)

*Journal of Dental Research* 65 (Special Issue): 1528-1529.

Influence of sweetening agents in solution on dental caries in de-salivated rats.
*Archives of Oral Biology* 35:839-844.

BOWEN, W.H., PEARSON, S. K., VAN WUYCKHUYSE, B. C. and TABAK L. A.
(1991)
Influence of milk, lactose reduced milk and lactose on caries in de-salivated rats.
*Caries Research* 25: 283-286.

Effect of milk on cariogenesis.
*Caries Research* 27: 461-466.

BOYER, R.M. and BOWDEN, G.H. (1985)
The microflora associated with the progression of incipient carious lesions of
children living in a water-fluoridated area.
*Caries Research* 19: 298-306.

The global epidemiology of mutan streptococcus. In: *Risk markers for oral

Reasons for the caries decline: what do the experts believe?
Dental Caries: intervened-interrupted-interpreted. Concluding remarks and
cariography. 

BRITISH FLUORIDATION SOCIETY (1995)
The dental health of 5-year-olds. *British Fluoridation Society Briefing. June*

BRITISH SOCIETY OF PAEDIATRIC DENTISTRY (1996)
Fluoride dietary supplements and fluoride tooth pastes for children.

Baby bottle tooth decay in Native American children in Head Start centers.
*Public Health Reports* 104: 50-54.

Preventing baby bottle tooth decay in American Indian and Alaska Native communities; a model for planning.

*Journal of Dental Research* 61: 1346-1351.

Whole saliva fluoride after tooth-brushing with NaF and MFP dentifrices with different F concentrations.

The effects of sugar intake and frequency of ingestion on dental caries increment in a three-year longitudinal study.
*Journal of Dental Research* 67: 1422-1429.

BURT, B. A. (1993)
Relative consumption of sucrose and other sugars: Has it been a factor in reduced caries experience?
*Caries Research* 27 (Supplement 1): 56-63.

BURT, B. A. (1994)
*International Dental Journal* 44: 403-413.

Caldwell, R.C. (1962)  
Adhesion of foods to teeth.  
*Journal of Dental Research* 41: 821-832.

Carlos, J.P. and GitteIssohn, A.M. (1965)  
Longitudinal studies of the natural history of caries II.  
*Archives of Oral Biology* 10: 739-751.

Lactobacilli and streptococci in the mouth of Children.  
*Caries Research* 9: 333-339.

High prevalence of mutans streptococci in a population with extremely low prevalence of dental caries.  
*Oral Microbiology and Immunology* 2: 121-124.

The effect of fluoridation upon the relationship between caries experience and social class in 5-year-old children in Newcastle and Northumberland.  

The relationship between social class and caries experience in five-year-old children in Newcastle and Northumberland after twelve years' fluoridation.  
*Community Dental Health* 1: 47-54.

The relationship between fluoridation, social class and caries experience in 5-year-old children in Newcastle and Northumberland in 1987.  
*British Dental Journal* 167: 57-61.

Casamassimo, P.S. (1988)  

Prevalence and localization of streptococcus mutans in infants and children.  
*Journal of American Dental Association* 91: 606-609.

Periodontal diseases in children and adolescents: Classification, aetiology and management.  
*Dental Update* 23 (5): 210-216.
Effect of oral care habits on caries in adolescents.
Caries Research 26: 299-304.

The influence of tooth-brushing frequency and post-brushing rinsing on caries experience in a caries clinical trial.
Community Dentistry and Oral Epidemiology 26: 406-411.

CHOSACK, A. (1986)
A dental caries severity index for primary teeth.
Community Dentistry and Oral Epidemiology 14: 86-89.

CLEATON-JONES, P., RICHARDSON, B. D., McINNNS, P.M. and FATTI, L. P. (1978a)
Dental caries in South African white children aged 1-5 years.
Community Dentistry and Oral Epidemiology. 6: 78-81.

CLEATON-JONES, P., RICHARDSON, B. D. and RANTSHO, J.M. (1978 b)
Dental caries in rural and urban black preschool children.

CRABB, H.S. (1976)
The porous outer enamel of unerupted human premolars.

CRAWFORD, A. N. and LENNON, M. A. (1992)
Dental attendance patterns among mothers and their children in an area of social deprivation.
Community Dental Health 9: 289-291.

Factors affecting caries levels amongst 5-year-old children in County Kerry, Ireland.
Community Dental Health 18: 72-78.

Oral sugar clearance in children compared with adults.
Caries Research 25: 201-206.

Sugar in baby and infant drinks.
The Lancet 1:539-540.

The dental health of children attending day nurseries in the three inner London boroughs.
*Journal of Paediatric Dentistry* 4: 77-83.

Tooth brushing frequency and its relationship to dental caries and periodontal disease.
*Australian Dental Journal* 14: 120-123.

Early childhood caries—a synopsis.

DEPARTMENT OF EDUCATION AND SCIENCE (1975)


DEPARTMENT OF HEALTH (1994)

DEPARTMENT OF STATISTICS (2000)
*Jordan in Figures*: Issue Number 2. Jordan.

DERKSON, G.D and PONTI, P (1982)
Nursing bottle syndrome, prevalence and etiology in a non-fluoridated city.

Comparison of two indices of caries patterns in 3-6 year old Brazilian children from areas of different fluoridation histories.

Caries and its association with infant feeding and oral health related behaviours in 3-4-year-old Brazilian children.

The University of North Carolina caries risk assessment study. Further developments in caries risk prediction.
*Community Dentistry and Oral Epidemiology* 20: 64-75.
White spots caries in Mexican – American toddlers and parental preference for various strategies.

Dental caries in preschool Beijing and Connecticut children as described by a new caries analysis system.

Caries prevalence and patterns in 3-6-year-old Beijing children.

Temporal changes in dental caries levels and patterns in native American preschool population.
Journal of Public Health Dentistry (56(4): 171-175

Dental caries patterns and oral health behaviours in Arizona infants and toddlers.
Community Dentistry and Oral Epidemiology 29:14-22.

DOWNER, M.C. (1994 a)

DOWNER, M.C. (1994b)
Caries prevalence in the United Kingdom.
International Dental Journal 44: 365-370.

DOWNER, M. C. (1996)
The caries decline. A comment in light of the UK experience.

Effect of cow’s milk on dental caries in the rat.

Caries patterns and their relationship to infant feeding and socio-economic status in 2-4-year-old Chinese children.
International Dental Journal 50: 385-389.

DUGGAL, M. S. and CURZON, M.E.J (1989)
An evaluation of the cariogenic potential of baby and infant fruit drinks.
British Dental Journal 166: 327-330.
The acidogenic potential of herbal baby drinks.
British Dental Journal 180: 98-103.

The effect of citrate in drinks on plaque pH.
British Dental Journal 164: 80-82.

The effect of social class on the prevalence of caries, plaque, gingivitis and
pocketing in 11-12-year-old children.

DUMMER, P.M.H., OLIVER, S.J., HICKS, R., KINGDOM, A. ADDY, M. and
SHAW, W.C. (1990)
Factors influencing the caries experience of a group of children at the ages of
11-12 and 15-16 years: results from an ongoing epidemiological survey.

Early childhood caries: A continuing dilemma.

DURWARD, L. (1991)
Sugar in baby foods.
Dental Update. 18: 162-165.

Publications.

EDGAR, W.M. (1993)
Extrinsic and intrinsic sugars: A review of recent UK recommendations on diet
and caries.

EKMAN, A. (1990)
Dental caries and related factors: A longitudinal study of Finnish immigrant
children in the north of Sweden.

EMILSON, C.G. and THORSELIUS I. (1988)
Prevalence of mutans streptococci and lactobacilli in elderly Swedish
individuals.

EMSLIE, R. D. (1966)
A dental health survey in the Republic of the Sudan.
British Dental Journal 120: 167-178.
Review of oral disease in Africa and the influence of socio-economic factors.

ERONAT, N. and EDEN, E (1992)
A comparative study of some influencing factors of rampant or nursing caries in preschool children.

The effect of fluoridation and social class on caries experience in 5-year-old Newcastle children in 1994 compared with results over the previous 18 years.
*Community Dental Health* **13**: 5-10.

Dependence of *in vitro* demineralisation and remineralisation of dental enamel on fluoride concentration.
*Journal of Dental Research* **69**: 620-625.

FEATHERSTONE, J.D.B. (1999)
Prevention and reversal of dental caries: role of low fluoride.
*Community Dentistry and Oral Epidemiology* **27**: 31-40.

FEJERSKOV, O. and CLARKSON, B.H. (1966)

FEJERSKOV, O., SCHEIE, A. A. A. and MANJI, F. (1992)
The effect of sucrose on plaque pH in the primary and permanent dentition of caries-inactive and active Kenyan children.

FERGUSON, M. (1990)

FINN, S. B. (1973)

Effect of the length and number of intervals between meals on caries in rats
*Caries Research* **18**: 128-133.

FISHER, F.J. (1968)
A field study of dental caries, periodontal disease and enamel defects in Tristan da Cunha.
*British Dental Journal* **125**: 447-453.
FITZGERALD, R.J. and KEYES, P.H. (1960)
Demonstration of the etiologic role of streptococci in experimental caries in the hamster.

Cariogenicity of human plaque lactobacilli in gnotobiotic rats.

Role of toothpastes in the cleaning of teeth.
*International Dental Journal* **41**: 164-170.

Dental caries prevalence in relation to socio-economic status of nursery school children in Goiania-Go, Brazil.
*Community Dentistry and Oral Epidemiology* **24**:357-361.

The relationship between social class and dental health in 5-year-old children in the North and South of England.
*British Dental Journal* **156**: 83-86.

The prevalence of dental caries in preschool children in Baghdad, Iraq.
*Journal of International Association of Dentistry for Children.* **14**: 31-34.

GIBBONS, R. (1986)

Strains of streptococcus mutans and streptococcus sobrinus attach to different pellicle receptors.
*Infection and Immunity* **52**: 555-561.

The first international conference on the declining prevalence of dental caries.

GLASS, R.L. (1983)

Degradation of starch and its hydrolytic products by oral bacteria.
*Journal of Dental Research* **67**: 75-81.
GRAINGER, R.L. (1967)  
International dental epidemiological methods. Manual no.3 Geneva:  
World Health Organization.

GRANATH, L.E., ROOTZEN, H., LILJEGREN, E., HOLST, K. and KÖHLER, L.  
(1978)  
Variation in caries prevalence related to combinations of dietary and oral  
hygiene habits and chewing fluoride tablets in 4-year-old children.  

GREEN, J.C. and VERMILLION, J. R. (1964)  
The simplified oral hygiene index.  

GREGORY, J.R., COLLINS, D.L., DAVIES P.S.W., HUGHES, J.M. and CLARKE,  
*National Diet and Nutrition Survey: children aged 1.5-4.5 years Volume  
1:Report of the diet and nutrition survey. London: Her Majesty’s Stationery  
Office*.

*National Diet and Nutrition Survey: Young People aged 4-18 years. Vol.1:  
Report of the diet and nutrition survey. London: Her Majesty’s Stationary  
Office.*

Laboratory studies of the dental properties of soft drinks.  

Potential dental effects of infant’s fruit drinks studied *in vitro*.  

Prevalence of mutans streptococci in one-year-old children.  

GRINDEFJORD, M., DAHLLÖF, G., EKSTRÖM, G., HÖJER, B. and MODÉER, T.  
(1993)  
Caries prevalence in 2.5-year-old children.  
*Caries Research* 27: 505-510.

Stepwise prediction of dental caries in children up to 3.5 years of age  
*Caries Research* 30: 256-266.

The effect of a high consumption of apples and grapes on dental caries and  
periodontal disease in humans.  
*Clinical Preventive Dentistry* 11: 8-12.
Fluoride in caries prevention: is the effect pre-or post-eruptive.
Journal of Dental Research 69 (Special Number): 751-755.

GRÜBBEL, A. O. (1944)
A measurement of dental caries prevalence and treatment service for deciduous teeth.

Longitudinal study of dental health behaviours and other caries predictors in early childhood.
Community Dentistry and Oral Epidemiology. 16: 356-359.

The cariogenicity of different dietary carbohydrates tested on rats in relative gnotobiosis with a streptococcus producing extra-cellular polysaccharide.

Salivary pellicle modified by milk component mediates caries protection.
Caries Research 28: 182.

Prevalence and severity of periodontal diseases in Saudi Arabian schoolchildren aged 6, 9 and 12 years.
Community Dental Health 7: 429-432.

The Vipeholm dental caries study. The effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for 5 years.

Sugar-eating habits of 405 11-to14-year-old English children

Dental caries and prolonged breast-feeding in 18-month-old Swedish children.

Purification and characterization of cell associated glucosyl transferase synthesizing water-insoluble glucan from serotype c streptococcus mutans.
Journal of General Microbiology 135: 335-344.
Dental caries experience in Jordanian and English school children.
*Community Dental Health* **10**: 151-157.

HAMILTON, I.R. (1977)
Effects of fluoride on enzymatic regulation of bacterial carbohydrate metabolism.

A longitudinal epidemiological study on dental plaque and the development of dental caries-interim results after two years.
*Journal of Dental Research* **56** (Special Issue c): 90-98.

HARRIS, S. (1963)
*Journal of Dental Research* **42**: 1387-1399.

HARRIS, N. O. (1991)

HAUGEJORDEN, O. (1994)
Changing time trend in caries prevalence among Norwegian children and adolescents.
*Community Dentistry and Oral Epidemiology* **22**: 220-251.

Caries in primary dentition and social class in high and low fluoride areas.

HELLER, K.E., SZPUNAR, S.M. and BURT, B.A. (1994)
Changes in children’s oral health status from 1986 to 1993 [abstract].
*Journal of Dental Research* (Special Issue, 1994 Abstracts):103

HELM, S. (1973)
National statistics on caries and oral hygiene derived from the Danish Child Dental Health recording system.
*Community Dentistry and Oral Epidemiology* **1**: 121-126.

Prevalence and distribution of dental caries in preschool children.

Close association between streptococcus sobrinus in the saliva of young children
and smooth-surface caries increment.
*Caries Research* 27: 292-297.

Dental caries experience of 5-year-old children related to their parent's
education levels: a study in an Arab community in Israel.

HOLBROOK, W. P. KRISTINSSON, M.J., GUNNARSDOTTIR, S. and BREIM B.
(1989)
Streptococcus mutans and sugar intake among 4-year-old urban children in
Iceland.
*Community Dentistry and Oral Epidemiology* 17: 292-295.

Dental caries and cariogenic factors in pre-school urban Icelandic children.
*Caries Research* 27: 431-437.

Prediction of dental caries in preschool children.
*Caries Research* 27: 424-430.

Caries in the preschool child: international trends.

Trends in coronal caries prevalence in North-west Europe.

Caries in preschool children: the Camden study.

A third study of caries in preschool aged children in Camden.
*British Dental Journal* 165(6): 87-91.

HOLT, R. D. (1990)
Caries in the preschool child: British trends.

Food and drinks at four daily time intervals in a group of young children.
*British Dental Journal* 171:137-143.
The pattern of caries in a group of 5-year-old children and in the same cohort at 9 years of age.
*Community Dental Health* 12: 93-99.

HOLT, R. D and MOYNIHAN, P.J. (1996)
The weaning diet and dental health.
*British Dental Journal* 181(7): 254-258.

Caries in preschool children in Camden 1993/94.
*British Dental Journal* 181: 405-410.

HOLT, R. D. and MURRAY, J.J. (1997)
Developments in fluoride toothpastes- an overview.
*Community Dental Health* 14: 4-10.

HONKALA, E, KANNAS, L. and RISE, J.(1990)
Oral health habits of school children in 11 European countries

Background factors affecting dental caries in permanent teeth of Finnish and Soviet children.

HONKALA, E. (1993)

HOROWITZ, H.S. (1992)
The need for toothpastes with lower than conventional fluoride concentrations for preschool-aged children.

van HOUTE, J., JORDAN, H.V. and EBERSOLE, J.L. (1985)
Infectivity and natural transmission of the bacterium streptococcus mutans in monkeys (Macacacas-Circularis) at different ages.
*Archives of Oral Biology* 30: 345-351.

van HOUTE, J. (1994)
Role of microorganisms in the caries aetiology.
*Journal of Dental Research* 73: 572-81.

*Swedish Dental Journal* 5: 91-103.
Need for change in standards of caries diagnosis-perspective based on the structure and behaviour of the caries lesion.

HUNTER, P.B. (1988)
Risk factors in dental caries.
International Dental Journal 38: 211-217.

Reported infant feeding, oral hygiene and dental attendance patterns in children aged 5 years and under referred for extraction of teeth under general anaesthesia.

A comparison of the effects of some extrinsic and intrinsic sugars on dental plaque pH.

HUXLEY, H.G. (1977)
The cariogenicity of dietary sucrose at various levels in two strains of rats under unrestricted and controlled frequency feeding conditions.

IBRAHIM, Y.E., GHANDOUR, I. A. and UDANI, T. M. (1986)
The prevalence of dental caries among urban, semi-urban and rural school children in the Sudan.
Odontostomatolog Tropical 9: 157-162.

IBRAHIM, Y.E., BJORVATN, K. and BIRKELAND, J.M. (1997)
Caries and dental fluorosis in a 0.25ppm and a 2.5ppm fluoride area in Sudan.

Suppression of streptococcus sobrinus 6715(g) in plaques by streptococcus mutans 32k (c).

IMFELD, T. (1983)

INFANTE, P.F. and GILLESPIE, G. M. (1977)
Enamel hypoplasia in relation to caries in Guatemalan children.

Dental caries status of young children in a suburban community of Mexico City.
Community Dentistry and Oral Epidemiology 14: 306-309.
Current trends of sugar consumption in developing societies.
*Community Dentistry and Oral Epidemiology* 25: 438-443.

JACOBSEN, N., MELVAER, K.L. and HENSEN-PETTERSEN, A. (1972)
Some properties of salivary amylase.
*Journal of Dental Research.* 51: 381-388.

Taste preference for sweetness in urban and rural populations in Iraq.
*Journal of Dental Research* 75(11): 1879-1884.

JAMES, P.M.C. and PARFITT, G.J. (1957)
The dental condition of London school children over a period of seven years.
*British Dental Journal* 103: 214-216.

Dental health in suburban Jordanian preschool children.
*Swedish Dental Journal* 17: 123-127.

JENKINS, G.N. (1978)

JENKINS, G.N. (1981)
Nutrition and caries.

The acidogenic potential of reference foods and snacks at interproximal sites in the human dentition.
*Journal of Dental Research* 62: 889-892.

JOHNSON, D.C., PAPPAS, L.R., CANNON, D. and GOODMAN, S.J. (1980)
Social factors and diet diaries of caries-free and high caries 2-7-year olds presenting for dental care in West Virginia.

Dental caries patterns in preschool children.

Caries patterns in Head Start children in a fluoridated community.
Caries levels and patterns in Head Start children in fluoridated and non-fluoridated, urban and non-urban sites in Ohio, USA.  

JOHNSON, D.C., GERSTENMAIER, J.H., DISANTIS, T. A. and BERKOWITZ, R.J. (1986b)  
Susceptibility of nursing caries children to future approximal molar decay.  
*Pediatric Dentistry* 8: 168-170.

Proportional changes in caries patterns from early to late primary dentition.  

JOHNSON, N. W. (1991)  

*Community Dental Health* 12(3): 161-166.

Dental health related behaviours in toddlers in low and high caries areas in St Helens, northwest England.  
*British Dental Journal* 181(1): 13-17

JORDAN, H.V., KEYES, P.H. and BELLACK, S. (1972)  

Determinants of self-assessed gingival health among adolescents.  

KALSBEEK, H., VERRIPS, G.H. and BACKER DIRKS, O. (1992)  
Use of fluoride tablets and effect on prevalence of dental caries and dental fluorosis.  
*Community Dentistry and Oral Epidemiology* 20: 241-245.

Consumption of sweet snacks and caries experience of primary school children.  

Changes in caries prevalence in children and young adults of Dutch and Turkish or Moroccan origin in the Netherlands between 1987 and 1993.  
*Caries Research* 30: 334-341.
KAMP, A.A. (1991)

KARMI, G. (1996)
Migration and health.

The assessment of nursing caries and its relationship to high caries in the permanent dentition.

Inappropriate infant bottle feeding. Status of the healthy people 2000 objective.
*Archives of Pediatrics and Adolescent Medicine* **149**: 786-791.


KATZ, R. V. and MESKIN, L.H. (1976)
Testing the internal and external validity of a simplified dental caries index on an adult population.

The prevalence of baby bottle tooth decay among two Native American populations.

Caries experience in the primary dentition of Tanzanian and Finnish 3-7-year-old children.
*Community Dentistry and Oral Epidemiology* **19**: 272-276.

KEYES, P.H. (1962)
Recent advances in dental caries research.

A reappraisal of the value of bitewing radiograph in the diagnosis of posterior proximal caries.
The role of inter-dental cleaning in effective plaque control: Need for inter-
dental cleaning in primary and secondary prevention. In: Proceedings of the
European Workshop on Mechanical Plaque Removal (eds. N P Lang, R.

KLEEMOLA-KUJALA, E. and RASANEN, L. (1979)
Dietary pattern of Finish children with low and high caries experience.
Community Dentistry and Oral Epidemiology 7: 199-205.

Relationship of oral hygiene and sugar consumption to risk of caries in children.
Community Dentistry and Oral Epidemiology 10: 224-233.

KLEIN, H., PALMER, C. E. and KNUTSON, J.W. (1938)
Studies on dental caries: 1. Dental status and dental needs of elementary school
children.
Public Health Reports 53: 751-765.

Evidence of declining caries prevalence in Sweden.

KÖHLER, B. and BRATTHAL, D. (1978)
Intra-familial levels of streptococcus mutans and some aspects of the bacterial

Streptococcus mutans in plaque and saliva and the development of caries.

KÖHLER B. and BJARNASON, S. (1987)
Mutans streptococci, lactobacilli and caries prevalence in 11-and12-year-old
Icelandic children.
Community Dentistry and Oral Epidemiology 15: 332-335.

KÖHLER, B., ANDREEN, I. and JONSSON, B. (1988)
The earlier the colonization by mutans streptococci, the higher the caries
prevalence at 4 years of age.
Oral Microbiology and Immunology 3: 14-17.

KÖNIG, K.G., SCHMID, P. and SCHMID, R. (1968)
An apparatus for frequency-controlled feeding of small rodents and its use in
dental caries experiments.

Nutritional role of sugars in oral health.
Factors related to plaque distribution in a group of Canadian preschool children.

KOSIKOWSKI, F. (1970)

Cariogenicity of nine sugars tested with an intra-oral device in man.
*Caries Research* 10: 427-41.

Enhancement of fluoride effectiveness by experimental cariogenic priming of human enamel.

Biochemical differentiation of certain oral streptococci.
*Journal of Dental Research* 60: 1713-1718.

Tooth-brushing frequency between the ages of 12 and 18 years- longitudinal prospective studies of Finish adolescents.
*Community Dental Health* 13: 34-39.

Tooth-brushing frequency as it relates to plaque development and gingival health.

Preventive behaviours as correlates of periodontal health status.

LAST, J.M. (1983)

Teaching parents at WIC clinics to examine their high caries risk babies.

Is modelling dental caries a ‘normal’ thing to do?
*Community Dental Health* 17: 212-217.
Comparison of tooth surface – specific dental caries attack patterns in US school children from two national surveys.

Colonization by mutans streptococci in the mouths of 3 and 4 year-old Chinese children with and without enamel hypoplasia.

Caries experience in deciduous dentition of rural Chinese children 3-5 years old in relation to the presence or absence of enamel hypoplasia.

LINDHE, J. and WICEN, P.O (1969)
The effects on gingiva of chewing fibrous food.

LINDQUIST B. and EMILSON CG. (1990)
Distribution and prevalence of mutans streptococci in human dentition.
Journal of Dental Research 69: 1160-1166.

Dental location of streptococcus mutans and streptococcus sobrinus in humans harbouring both species.
Caries Research 25: 146-152.

Effects of variously processed starch on pH of human dental plaque.

Comparison of three different methods for measurement of plaque –pH in humans after consumption of soft bread and potato chips.

Intraoral lactic acid production following the ingestion of various starch-containing foods.
Caries Research 27: 214.

Plaque removing effectiveness of brushing with dentifrice or water.
Journal of Dental Research 62(Special Issue): 166.

LÖE, H. and SILNESS, J. (1963)
Gingival Index.
LÖE, H., THEILAND, E. and JENSEN, S. B. (1965)
Experimental gingivitis in man.

LÖE, H., THEILADE, E. and JENSEN, S.B. (1967)
Experimental gingivitis in man III. The influence of antibiotics on gingival
plaque development.
*Journal Periodontal Research* 2: 282-289.

LÖE, H (1970)

Inhibition of experimental caries by plaque prevention.

Oral hygiene in the prevention of caries and periodontal disease.
*International Dental Journal* 50: 129-139.

LOESCHE, W.J. (1986)
Role of streptococcus mutans in human dental decay.


Epidemiological study of oral health and dietary habits in preschool immigrant
children in Athens.

Tooth brushing frequency and personal hygiene in 14-year-old school children.
*British Dental Journal* 162: 141-144.

Distribution of sucrose around the mouth and its clearance after a sucrose mouth
rinse or consumption of three different foods.

Enhancing the virulence of streptococcus sobrinus in rats.
*Journal of Dental Research* 70: 38-43.
MAGBOOL, G. (1992)

MANJI, F. (1986)
Is dental caries on the increase in Kenya?


MANSBRIDGE, J.N. and BROWN, M.D. (1985)
Changes in dental caries prevalence in Edinburgh children over three decades.
Community Dental health 2: 3-13.

MANSBRIDGE, J.N. and BROWN, M.D. (1986)
Changes in dental caries prevalence in Ayr children over 25 years and a comparison with Edinburgh children over the same period.
Community Dental Health 3: 41-52.

MANSON, J. D. (1986)

MARTHALER, T.M (1966)
A standardised system of recording dental Conditions.

MARTHALER, T. M. (1978)

MARTHALER, T. M. (1990)
Changes in the prevalence of dental caries: How much can be attributed to changes in diet?

Caries Research 30: 237-255.

Trends in coronal caries prevalence in South-western Europe.
International Dental Journal 46 (Supplement 1): 193-197.
The prevalence of dental caries and gingivitis and their relationship to social class amongst nursery-school children in Nairobi, Kenya.

Longitudinal survey of the distribution of various serotypes of streptococcus mutans in infants.

Transmission of streptococcus mutans in some selected families.

MATSSON, L. (1978)
Development of gingivitis in preschool children and young adults. A comparative experimental study.
*Journal of Clinical Periodontology* 5: 24-34.

Mutan streptococci and lactobacilli in breast-fed children with rampant caries.
*Caries Research* 26: 183-187.

Rampant caries and linear hypoplasia.
*Caries Research* 26: 205-208.

Caries in five-year-old children and associations with family related factors.
*Journal of Dental Research* 79: 875-881.

*Community Dentistry and Oral Epidemiology* 23: 344-349.

McDOUGALL, W.A. (1977)
Effect of milk on enamel demineralisation and remineralisation in vitro.
*Caries Research* 11: 166-172.

Diet and dental caries in pre-school children.

The study of caries prevalence in children in a developing country.
*ASDC-Journal of Dentistry for Children Mars-April, 56(2): 129-136.*
MELLANBY, M., COUMOULOS, H., and KELLY, M. (1957)
*British Medical Journal* 2: 318-322.

Nutrition, diet and oral health report of an FDI working group.

MILLER, W. D. (1890)

Food and nutrient intakes of British Infants aged 6-12 months. MAFF. London:
Her Majesty’s Stationery Office.

The microflora associated with developing lesions of nursing caries.
*Caries Research* 19: 289-297.

Description and epidemiology of nursing caries.

MILSOM, K. and MITROPOULOS, C.M. (1990)
Enamel defects in 8-year-old children in fluoridated and non-fluoridated parts of
Cheshire

MINISTRY OF HEALTH (1999)
*Annual Statistical Book*, The Hashimate Kingdom of Jordan.

The prevalence of caries and associated factors in children 2-5 years from the
Almanjayar and Cartuja Health Centres of the capital Granada.

Oral starch degradation and its influence on acid production in human dental
plaque.
*Caries Research* 15: 166-175.

The cariogenic potential of several snack foods.
MOSHA, R. J. and ROBISON, V. A. (1989)
Caries experience of the primary dentition among groups of Tanzanian urban preschool children.
*Community Dentistry and Oral Epidemiology* 17: 34-37.

A revised classification of carious lesions by site and size.

Nursing-bottle syndrome: Risk factors.

Cariogenic potential of foods. I. Caries in Rat Model.
*Caries Research* 24: 344-355.

Cariogenic potential of foods. II. Relationship of food composition, plaque microbial counts, and salivary parameters to caries in the rat model.

MURRAY, J.J. and MAJID, Z.A. (1978)
The prevalence and progression of approximal caries in the deciduous dentition in British children.

Caries experience in a selected group of children in Kuwait.

Food habits of mothers and children in two regions of Oman.

Nutritive value of traditional sweets consumed in the Arab Gulf countries.
*International Journal of Food Science and Nutrition* 51: 403-408.

NATIONAL INSTITUTE OF DENTAL HEALTH (1981)

NATIONAL INSTITUTE OF DENTAL RESEARCH (1981)
NATIONAL INSTITUTE OF HEALTH (1989)

Dental health and dietary habits in Greek immigrant children in Southern Sweden compared with Swedish and rural Greek children.

Comparison of dietary habits and dental health of subjects with hereditary fructose intolerance and control subjects.

Sucrose in the dynamics of the caries process.

NEWBRUN, E. (1989)
Frequent sugar intake- then and now: Interpretation of the main results.

NG'ANG'A, P.M. and VALERHAUG, J. (1991)
Oral hygiene practices and periodontal health in primary school children in Nairobi, Kenya.

Carbohydrates in Nutrition; Sweeteners, Diabetes Mellitus; Lactose Intolerance.

NOAH, M. O. (1984)
Caries experience and oral cleanliness in the deciduous dentitions of Ibadan children from different social groups.
Journal of International Association of Dentistry for Children 15: 43-49.

NÖRMAK, S. (1993)
Social indicators of dental caries among Sierra Leonean school children.

O'BRIAN, M. (1994)
Children's dental health in the United Kingdom 1993. London: Her Majesty’s Stationery Office

OFFICE OF POPULATION CENSUSES AND SURVEYS (1980)
Classification of occupations. London: Her Majesty’s Stationery Office.
OFFICE OF POPULATION CENSUSES AND SURVEYS (1994)
Dental Caries Among Children in the United Kingdom in 1993. OPCS Monitor SS94/1. London

Readiness for toothbrushing of young children.

O'LEARY, T. J., DRAKE, R.B. and NAYLOR, J.E. (1972)
The plaque control record.

Prolonged pacifier-sucking and use of a nursing bottle at night: possible risk factors for dental caries in children.

OLOJUGBA, O.O. and LENNON, M. A. (1987)
Community Dental Health 4: 129-135.

Introduction and rationale for the use of fluoride for caries prevention.
International Dental Journal 44(3) (Supplement1): 257-261.

Oral Health in Europe: implications for other oral health issues.
International Dental Journal 46 (Supplement1): 223-229.

Susceptibility of rats, hamsters and mice to carious infection by streptococcus mutans serotype c and d organisms.
Journal of Dental Research 60: 855-859.

Use of the germ-free animal technic in the study of experimental dental caries. I. Basic observations on rats reared free of all microorganisms.

Risk factors for dental fluorosis in a fluoridated community.
Journal of Dental Research 67: 1488-1492.

O'SULLIVAN, D. M. and TINANOFF, N. (1993a)
Maxillary anterior caries associated with increased caries risk in other primary teeth.
Journal of Dental Research 72 (12): 1577 – 1580.
O'SULLIVAN, D. M. and TINANOFF, N. (1993b)
Social and biological factors contributing to caries of the maxillary anterior teeth.
*Pediatric Dentistry* 15(1): 41-44.

Dental caries prevalence and treatment among Navajo preschool children.

The association of early dental caries patterns with caries incidence in preschool children

Cariogenicity depends more on diet than on the prevailing mutans streptococcal species.
*Journal of Dental Research* 75(1): 535-545.

PALMER, J. D., ANDERSON, R. J. and DOWNER, D.C. (1984)
Guideline for prevalence studies of dental caries.
*Community Dental Health* 1(1): 55-66.

PARFIT, G.J. (1955)
The distribution of caries on different sites of the teeth in English children the age of 2-15 years.

PARFIT, G.J. (1956)
Conditions influencing the incidence of occlusal and interstitial caries in children.

Caries experience of 5-year-old children in Alkharj, Saudi Arabia.
*International Journal of Paediatric Dentistry* 7: 43-44.

The Finish family competence study: the relationship between caries, dental health habits and general health in 3-year-old Finish children.
*Caries Research* 27: 154-160.

Caries experience in the deciduous dentition as a predictor for caries in the permanent dentition.

An assessment of dental caries prevalence among Gujurati, Pakistani and White Caucasian five year old children resident in Dewsbury, West Yorkshire.
Community Dental Health 6: 223-232.

Periodontal status in childhood and early adolescence: three-year follow up.

Infant feeding and dental caries, a longitudinal study of Swedish children.
Swedish Dental Journal 9: 201-206.

PETERSEN, P. E. (1983)
Dental health among workers at a Danish chocolate factory.
Community Dentistry and Oral Epidemiology 11: 337-341.

Dental caries among urban school children in Madagascar.
Community Dentistry and Oral Epidemiology 16: 163-166.

Dental knowledge, attitudes and behaviour among Kuwaiti mothers and school teachers.

Community Dentistry and Oral Epidemiology 22: 90-93.

PETERSEN, P. E. and GUANG, L.X. (1994)
Dental caries prevalence in a group of schoolchildren in Wuhan city, PR China, 1993.

Oral health behaviour, knowledge, and attitudes of children, mothers and school teachers in Romania in 1993.
PETERSEN, P. E. (1997)  

Social forces- dentistry and the children of poverty.  

PITTS, N.B., EVANS, D.J. and NUGENT, Z.J. (2001)  
*Community Dental Health* 18: 49-55.

Acidogenic potential and total salivary carbohydrate content of expectorants following the consumption of some cereal-based foods and fruits.  
*Caries Research* 30: 132-137.

An evaluation of a hierarchical method of describing the pattern of caries attack.  
*Community Dentistry and Oral Epidemiology* 2: 7-11.

POULSEN, V.J. (1987)  
Caries risk children in the Danish Child dental Services.  

The relationship between caries, fluoridation and material deprivation in five-year-old children in County Durham.  
*Community Dental Health* 12: 200-203.

POWELL, D. (1976)  
Milk. Is it related to rampant caries of the early primary dentition?  

RAADAL, M., EL HASSAN, F. E. and RASMUSSEN, P (1993)  
The prevalence of caries in groups of children aged 4-5 and 7-8 years in Khartoum, Sudan.  

RADIKE, A.W (1972).  
Plaque and gingivitis in the deciduous and permanent dentition.

RAMOS – GOMEZ, F.J., HUANG, G.F., MASUREDIS, C.M. and BRAHAM, R.L.
(1996)
Prevalence and treatment costs of infant caries in Northern California.

RAMOS-GOMEZ, F.J., TOMAR, S.L., ELLISON, J., ARTIGA, N., SINTES, J. and
VICUNA, G. (1999)
Assessment of early childhood caries and dietary habits in a population of
migrant Hispanic children in Stockton, California.

Social class differences in Britain (2nd edn.) London: Grant McIntyre.

Psychological and behavioural issues in early childhood caries.
Community Dentistry and Oral Epidemiology 26(Supplement 1):32-44.

Effect of adsorbed protein on hydroxyapatite zeta potential and streptococcus
mutans adherence.
Infection and Immunity 39: 1285-1290.

Infant feeding practices and nursing bottle caries.

Nursing caries: a comprehensive review.

ROBERTS, G.J., CLEATON-JONES, P. E., FATTI, L. P., RICHARDSON, B. D.,
Patterns of breast and bottle-feeding and their association with dental caries in 1-
to-4-year-old South African children. 2. A case control study of children with
nursing caries.
Community Dental Health 11: 38-41.

ROBERTS, I.F. and ROBERTS, G.J. (1979)
Relation between medicines sweetened with sucrose and dental disease.
British Medical Journal ii : 14-16.

Dental caries and its determinants in 2- to 5-year-old children.
Adsorption of glucosyltransferase to saliva coated hydroxyapatite: Possible  
mechanisms for sucrose dependent bacterial colonization of teeth.  

ROSEN, S., LENNEY, W.S. and O'MALLEY, J.E. (1968)  
Dental caries in gnotobiotic rats inoculated with lactobacillus casei.  

Pattern of sugar consumption in early childhood.  
*Community Dentistry and Oral Epidemiology* **18**: 12-16.

The effect of eating some British snacks upon the pH of human dental plaque.  
*British Dental Journal* **145**: 95-100.

RUGG-GUNN, A.J., HACKETT, A. F., APPLETON, D. R., JENKINS, G.N. and  
Relationship between dietary habits and caries increment assessed over two  
years in 405 English adolescent schoolchildren.  

RUGG GUNN, A.J. and HACKETT (1989)  

RUGG-GUNN, A.J. (1993)  
Dental caries- milk, cheese, and other protective factors. In: *Nutrition and  

RUGG-GUNN, A.J. (1997)  
Oxford University Press.

Recognition of dental caries.  

44-year dental health survey of Helsinki school children.  

Current concepts in lactose malabsorption and intolerance.  

SAXTON, C.A. (1973)  
Scanning electron microscopic study of the formation of dental plaque.  
*Caries Research* **7**: 102-119.
Microbial composition, pH-depressing capacity and acidogenicity of 3-week
smooth surface plaque developed on sucrose-regulated diets in man.
Caries Research 18: 74-86.

Using a ‘lifestyle’ perspective to understand tooth brushing behaviour in Scottish
schoolchildren.
Community Dentistry and Oral Epidemiology 18: 230-234.

Social and Behavioural Aspects of Caries Prediction. In: Risk Markers for Oral
Disease Vol.1 Dental Caries (ed. N.W. Johnson) Pp.172-197 Cambridge:
Cambridge University Press.

Does dental health education affect inequalities in dental health?
Community Dental Health 11: 97-100.

Social and behavioural indicators of caries experience in 5-year-old children.
Community Dentistry and Oral Epidemiology 23: 276-281.

Dietary habits and oral hygiene as predictors of caries in 3-year-old children.
Community Dentistry and Oral Epidemiology 11: 308-311.

Schwarz, E. and Hansen, E. R. (1979)
Caries experience of Danish children evaluated by the Child Dental Health
recording system.
Community Dentistry and Oral Epidemiology 7: 107-114.

Schwarz, E. (1983)
The Danish oral health care service for children: its achievements.

A child’s sleeping habit as a cause of nursing caries.

Future caries development in children with nursing bottle caries.

Seow, W. K., Amaratunge, A., Bennett, R., Bronsch, D and Lai, P.Y.
(1996)
Dental health of aboriginal pre-school children in Brisbane, Australia.
Community Dentistry and Oral Epidemiology 24: 187-190.
Biological mechanisms of early childhood caries.  
*Community Dentistry and Oral Epidemiology* 26 (Supplement 1): 8-27.

Child-rearing practices and nursing caries.  

Changing caries prevalence in primary and permanent teeth of children in a Jerusalem neighbourhood.  

SHAW, L. and MURRAY, J.J. (1980)  
A family history study of caries-resistance and caries-susceptibility.  

SHEIHAM, A. (1983)  

SHEIHAM, A., MAIZELS, J. and MAIZELS, A . (1987)  
New composite indicators of dental health.  
*Community Dental Health* 4: 407-414.

SHEIKH, C. and ERICKSON, P. R. (1996)  
Evaluation of plaque pH changes following oral rinse with eight infant formulas.  
*Pediatric Dentistry*. 18(3): 200-204.

The prevalence and impact of dental pain in 8-year-old school children in Harrow, England.  
*British Dental Journal* 10: 38-41.

SIKSIK, M. (2001)  
UNRWA. Jordan Field Office. Personal communication

Prevalence of primary canine hypoplasia of the mandibular teeth.  

The prevalence of dental caries in 3-year-old children: some social differences and a method of assessing pre-school needs at a local level.  
*British Dental Journal* 137:123-128.
Improvements in the dental health of 3-year-old Hertfordshire children after 8 years.

A longitudinal study of infant feeding practice, diet and caries, related to social class in children aged 3 and 8-10 years.
*British Dental Journal* **163**: 296-300.

SILVER, D. H. (1992)
*British Dental Journal* **172**: 191-197.

SILVERSTONE, L. (1990)

Effect of oral hygiene instruction on brushing skills in preschool children.
*Community Dentistry and Oral Epidemiology* **4**: 193-198.

Effect of post brushing water rinsing on caries-like lesions at approximal and buccal sites.
*Caries research* **9**: 337-342.

Intra – oral distribution and impact of caries experience among South Australian school children.

Influence of exposure to fluoridated water on socioeconomic inequalities in children’s caries experience.
*Community Dentistry and Oral Epidemiology* **24**: 89-100.

Baby fruit juices and dental erosion.

Acidogenesis by oral streptococci at different pH values.
*Caries Research* **23**: 14-17.
Differences in cariogenicity between fresh isolates of streptococcus sobrinus and streptococcus mutans. 

SOGNNAES, R.F. (1948) 
Analysis of wartime reduction of dental caries in European children. 
_American Journal of Diseases in Children_ 75: 792-821.

Dental caries experience in the Chiangmai/Lamphun provinces of Thailand. 
_Community Dentistry and Oral Epidemiology_ 17: 131-135.

Caries prevalence of kindergarten children in Salzgitter and Oslo. 
_Caries Research_ 26(3): 201 – 204.

Nursing bottle syndrome in Kuwait. 
_Journal of Dental Research_ 65 (Special Issue IADR): 745.

SPEIRS, R.L. and BEELEY J. A. (1992) 
Food and oral health: Dental caries. 
_Dental Update_ 19(3): 100-104.

SPENCER, A. J. (1997) 
Skewed distributions- new outcome measures. 
_Community Dentistry and Oral Epidemiology_ 25: 52-59.

Sugar availability, sugar consumption and dental caries. 
_Community Dentistry and Oral Epidemiology_ 10: 16-21.

Saliva: Its role in health and disease. 

Epidemiology of gingivitis 

Between-meal eating, toothbrushing frequency and dental caries in 4-year-old children in the north of Sweden. 
STECKSEN-BLICKS, C and BORSSEN, E (1999)
Caries Research 33: 409-414.


STEPHAN, R.M. (1940)
Changes in hydrogen ion concentration on tooth surface and in carious lesions.

de STOPPELAAR, J. D., vanHOUTE, J. and BACKER DIRKS, O. (1970)
The effect of carbohydrate restriction on the presence of streptococcus mutans, streptococcus sanguis and iodophilic polysaccharide-producing bacteria in human dental plaque.
Caries Research 4: 114-123.


SVANBERG, M. and LOESCHE, W.J. (1977)
Salivary concentration of streptococcus mutans and streptococcus sanguis and the colonization of artificial fissures in humans by these organisms.

SVANBERG, M. (1978)
Contamination of toothpaste and toothbrush by streptococcus mutans.

Dental self-efficacy as a determinant to oral health behaviour, oral hygiene and HbA1c level among diabetic patients.
Journal of Clinical Periodontology 26(9): 616-621.

Sugar consumption and caries risk in schoolchildren with low caries experience.
Community Dentistry and Oral Epidemiology 23: 142-146.

TAHAMASSEBI, J.F. and DUGGAL, M. S. (1996)
Comparison of plaque pH response to an acidogenic challenge in children and adults.
Caries Research 30: 342-346.
TAKEUCHI, M. (1961)
Epidemiological study on dental caries in Japanese children before, during and after World War II.

Some characteristics of 5-year-old children with a dmfs of six or more in Gloucestershire, England.
*Community Dental Health* **4**: 121-128.

Caries development in children in relation to the presence of mutans streptococci in dental plaque and serum antibodies against whole cells and protein antigen I/II of streptococcus mutans.
*Caries Research* **24**: 59-64.

THE NEW ENCYCLOPAEDIA BRITANNICA (1974)
Jordan.
Macropaedia (edn.15th ) Volume 10: 270-275

Experimental gingivitis in man II. A longitudinal clinical and bacteriological investigation.

Salivary mutans streptococci and dental caries patterns in pre-school children.
*Community Dentistry and Oral Epidemiology* **24**: 164-168.

Mutans streptococci and caries prevalence in preschool children.

THOMAS, L.F.G. and STARTUP, R. (1992)
Some social correlates with the dental health of young children.
*Community Dental Health* **9**: 11-17.

Longitudinal changes of nutrient intake and caries in Canadian children.
*Journal of Dental Research* (Special Issue): 676 Abstract 241.


TINANOFF, N. (1988)
and Febiger,
Introduction to the early childhood caries conference: initial description and current understanding.  
*Community Dentistry and Oral Epidemiology* 26: (Supplement1): 5-7.

Dietary determinants of dental caries and dietary recommendations for preschool children.  

TODD, J.E. (1975)  


TODD, J. (1988)  

The dental caries experience, oral hygiene and dietary practices of preschool children of factory workers in Phnom Penh, Cambodia.  

Dental caries assessment of Mississippi Head Start children.  

TSUBOUCHI, J., HIGASHI, T., SHIMONO, T., DOMOTO, P.K. and WEINSTEIN, Ph. (1994)  
Baby bottle tooth decay. A study of baby bottle tooth decay and risk factors for 18-month old infants in rural Japan.  

A study of dental caries and risk factors among Native American infants.  

UNITED NATIONS (1997).  
The world economy at the beginning of 1998, economic and social counsel.

Tooth-brushing ability is related to age in children.  
The binding of milk and salivary proteins to hydroxyapatite.
Journal of Dental Research 72 (Special Issue): 394

The effect of milk and casein proteins on the binding of streptococcus mutans to saliva-coated hydroxyapatite.

The effect of milk and Kappa Casein on streptococcal glucosyltransferase.
Caries Research 29: 498-506.

A systematic review of the relationship between breast feeding and early childhood caries.

Assessing risk indicators for dental caries in the primary dentition.
Community Dentistry and Oral Epidemiology 29: 424-434.

Nursing bottle caries: The importance of a developmental perspective.

VERRIPS, G.H. and BEDI, R (1992)

Risk indicators and potential risk factors for caries in 5-year-olds of different ethnic groups in Amsterdam.
Community Dentistry and Oral Epidemiology 20: 256-260.

Ethnicity and maternal education as risk indicators for dental caries and the role of dental behaviour.

Dental caries and dental fluorosis among 4-, 6-, 12-and 15-year-old children in kindergartens and public schools in Kuwait.
Community Dental Health 13: 47-50.
Oral health behaviour of 12-year-old children in Kuwait.

Experimental caries in man.
*Caries research* 4: 131-148.

VON DER FEHR, F. R. (1994)
Caries prevalence in the Nordic countries.

WALDMAN, H.B (1995)
Immigrant children and pediatric dental practice.


Caries prediction and indicators using a pediatric risk assessment teaching tool.

A national survey of infant feeding in Asian families: summary of findings relevant to oral health.
*British Dental Journal* 188:16-20.

Prolonged demand breast-feeding and nursing caries.
*Caries research* 32: 46-50.

Dental caries prevalence and related factors in 5-year-old children in Hong Kong.

WEINSTEIN, Ph., DOMOTO, P., WOHLLERS, K. and KODAY, M. (1992)
Mexican-American parents with children at risk for baby bottle tooth decay: Pilot study at a migrant farm workers clinic.
The effectiveness of pit and fissure sealants.


Oral hygiene in relation to caries development and immigrant status in infants and toddlers.

On oral health in infants and toddlers.

Dietary habits related to caries development and immigrant status in infants and toddlers living in Sweden.

Sucrose retention and colonization by mutans streptococci at different sites of the dentition.
Caries Research 29: 396-401.

Effects of sugar restriction on streptococcus mutans and streptococcus sobrinus in saliva and dental plaque.
Caries Research 29: 54-61.

Streprococcus downei sp. nov. for strains previously described as streptococcus mutans serotype h.

Five-year-old children: changes in their decay experience and dental health related behaviours over four years.
Community Dental Health. 12: 204-207.

WIDSROM, E. and SUKSIS-JANSSON, R. (1985)
Dietary habits and dental health in 6-year-old Finnish immigrant children in Sweden.
Swedish Dental Journal 9: 135-139.
An inquiry into the effects of health related behaviour on dental health among
young Asian children resident in a fluoridated city in Canada.
*Community Dental Health* 7: 413-420.

WINTER, G. B., HAMILTON, M.C. and JAMES, P.M.C. (1966)
Role of the comforter as an aetiological factor in rampant caries of the
deciduous dentition.
*Archives of Disease in childhood* 41: 207-212.

WINTER, G. B., RULE, D.C., MAILER, G. P., JAMES, P.M.C. and GORDON, P. H.
(1971a)
The prevalence of dental caries in preschool children aged 1 to 4 years. part1.
Aetiological factors.
*British Dental Journal* 130: 271-277.

WINTER, G. B., RULE, D.C., MAILER, G. P., JAMES, P.M.C. and GORDON, P. H.
(1971b)
The prevalence of dental caries in preschool children aged 1 to 4 years. part2.
Additional aetiological factors.
*British Dental Journal* 130: 434-436.

Prevalence of dental caries in phenylketonuric children.
*Caries Research* 8: 256-266.

Prediction of high caries risk; diet hygiene and medication.

Clinical trial of a low- fluoride toothpaste for young children.

Patterns of dental caries severity in Chinese kindergarten children.
*Community Dentistry and Oral Epidemiology* 25: 343-347.

WORLD HEALTH ORGANIZATION (1985)
Quintessence Publishing Company.

WORLD HEALTH ORGANIZATION (1987)

*Community Dental Health* 6: 121-130.
Use of sweet snacks, soft drinks and fruit juices, tooth brushing and first dental
visit in high DMFT 4-6 year olds of Riyadh region.

Tooth brushing practices of 2-3-year-old children and their age at first dental
visit: a survey in Adelaide, South Australia.

YAGOT, K., NAZHAT, N.Y. and KUDAR, S.A. (1990)
Prolonged nursing-habit caries index.
*Journal of International Association of Dentistry for Children* 20: 8-10

Management of rampant caries in children.
*Quintessence International* 23(3): 159-168.

The prevalence and patterns of dental caries in Labrador Inuit Youth.

FEATHERSTONE, J.D.B. (1992)
Fluoride concentrations in plaque, whole saliva and ductal saliva after
applications of home use fluoride agents.
*Journal of Dental Research* 71: 1768-1775.

Cariogenic streptococci in infants.
*Archives of Oral Biology* 14: 1429- 1431.

ZOITOPOULOS, L., ATHANASSOULI, T., GELBIER, S and APOSTOLOPOULOS,
A. (1997)
Dental attendance patterns and oral hygiene habits of 5-year-old children in
Athens and South London.

*Community Dental Health* 12: 35-38.
DENTAL CHART 1

Kindergarten
Child Name
Date of Birth
Date of Examination

Geographic Location
Serial Number
Gender

The State of the Teeth

0 = Sound
1 = Caries in dentine, temporary filling, lost restoration
2 = Caries extending to the pulp, or when 2/3rds of the marginal
    ridge of the deciduous molar is carious
3 = Permanent restoration with no secondary caries
   (N.B. restoration with caries is recorded as either 1 or 2
    whichever appropriate)
4 = Missing due to caries (N.B. presence of roots is recorded as code 2)
5 = Missing due to reasons other than caries.
DENTAL CHART 2

Geographic Location
Serial Number
Gender

Plaque and Gingivitis

Plaque

- Labial surfaces of:
  - upper right and lower left central incisors
  - upper right and left second molars.
- Lingual surfaces of lower right and left second molars

Plaque = 0/1

Gingivitis

0 = Normal
1 = Redness
2 = Bleeding on probing
3 = Spontaneous bleeding

2 Plaque and Gingivitis

Gingivitis
Plaque

---

UPPER RIGHT

Gingivitis
Plaque

---

UPPER LEFT

Gingivitis
Plaque

---

LOWER RIGHT

Gingivitis
Plaque

---

LOWER LEFT
Translated from Arabic

Appendix A: Covering letter
Dear child’s mother/father
Greetings
The purpose of this questionnaire is a scientific study regarding the relationship between
the oral health of the child and his/her current food/drink intake and intake during
infancy.
It is very difficult to examine all kindergarten children, so I randomly selected your
child’s kindergarten. Your child was then selected.
Your answers will be treated with complete secrecy. I will be the only one who reads
them, so please do close the envelop properly before returning it to the head teacher.
Being accurate in answering these questions would, in no doubt, fulfill the goal of this
scientific investigation. For this reason I am willing to answer to your queries on
telephone number 4644040.

Thank you for your cooperation
Appendix B: Criteria for the dental examination

Criteria for caries diagnosis
Criteria, as follows, was written on the chart to ensure consistency.
0 - Sound
1 - Caries in dentine, temporary filling, or lost restoration
2 - Caries extending to the pulp, or when 2/3rd of the marginal ridge of a deciduous molar is carious
3 - Permanent restoration without secondary caries
   Restoration with caries is recorded as either 1 or 2, whichever is appropriate
4 - Missing due to caries
5 - Missing due to reasons other than caries

Plaque and gingivitis
Six tooth surfaces are recorded. These surfaces are:
   buccal/labial of \( \text{EA} \) \( \text{E} \) and lingual of \( \text{A} \) \( \text{E} \) \( \text{E} \)

The same surfaces are scored for gingivitis

Plaque Index
A simple prevalence index. The teeth are not dried or stained, and no probe is used
(W.H.O. system (1977)).
Criteria
0 - No visible soft deposit
1 - Any soft deposit on any surface clearly visible to the naked eye

Gingival Index
Scoring of gingivitis is based on the Gingival Index of Loe and Silness (1963)
Criteria
0 - Normal
1 - Redness
2 - Bleeding on probing
3 - Spontaneous bleeding
Translated from Arabic

Appendix C: Questionnaire

Demography and Socio-economic factors

1- Kindergarten
2- Serial number
3- Name
4- Date of birth
5- Gender
6- Birth order
7- Siblings number
8- Residence
9- Home telephone number (neighbour/relative)

10- Level of mother’s education
    No schooling
    Primary
    Preparatory
    Vocational
    Secondary
    Intermediate college
    University

11- Level of father’s education
    No schooling
    Primary
    Preparatory
    Vocational
    Secondary
    Intermediate college
    University

12- Mother’s occupation [Yes] [No]
    If the answer is yes, specify and describe the nature of your job

13- Father’s occupation [Yes] [No]
    If the answer is yes, specify and describe the nature of your job
**Oral Hygiene**

1. Does your child use a tooth brush? [Yes] [No]
2. If the answer is yes, How often?
   - Daily [ ]
   - 2-3 times/week [ ]
   - Occasionally [ ]
3. Does your child use a tooth paste? [Yes] [No]
4. If the answer is yes, How often?
   - Always [ ]
   - Occasionally [ ]
5. Name of tooth paste that is mostly used? ________________________
6. Does the toothpaste contain fluoride? [Yes] [No] [I do not know]
7. What was the age of the child when he/she started to use toothpaste?
   - Less than 6 months [ ]
   - 6 - 12 months [ ]
   - 13 - 24 months [ ]
   - 25 - 36 months [ ]
   - >36 months [ ]
8. How much (amount) toothpaste does your child use every time he/she brushes his/her teeth?
   - Equal to the length of the head of the toothbrush [ ]
   - 1 cm [ ]
   - Size of a pea/ thin layer [ ]
9. Does your child brush his teeth alone? [Yes] [No]
10. At what age has he/she started to brush under supervision?
    - < 12 months [ ]
    - 13 - 24 months [ ]
    - 25 - 36 months [ ]
    - 37 - 48 months [ ]
    - 49 - 60 months [ ]
    - 61 - 72 months [ ]
11. At what age has he/she started to brush alone?
    - < 12 months [ ]
    - 13 - 24 months [ ]
    - 25 - 36 months [ ]
    - 37 - 48 months [ ]
    - 49 - 60 months [ ]
    - 61 - 72 months [ ]
    - Not yet [ ]
Feeding During Infancy

1- What was the method you followed in feeding your child?
   Breast feeding [ ]
   Bottle feeding [ ]
   Breast and Bottle [ ]

2- Did you set time for breast feeding? [Yes] [No]
3- Did he/she sleep with you in the same bed? [Yes] [No]
4- If yes ... when has he/she started to sleep alone? 
   __________________________

5- When was breast feeding terminated?
   < 6 months [ ]
   6 - 12 months [ ]
   13 - 18 months [ ]
   19 - 24 months [ ]
   > 24 months [ ]

6- When did you start using a nursing bottle in feeding your child?
   < 6 months [ ]
   6 - 12 months [ ]
   13 - 18 months [ ]
   19 - 24 months [ ]
   > 24 months [ ]

7- Did you set time for bottle feeding? [Yes] [No]

8- At what time did you bottle-feed your child?
   Nap-time [ ]
   Bed-time [ ]
   Night-time while asleep [ ]
   Day-time while awake [ ]

9- How many times/day had your child been bottle-fed at nap-time, bed-time or during the night?
   Not every day [ ]
   Once/day [ ]
   2 - 3 times /day [ ]
   4 times /day [ ]

10- Did you add sugar/honey to the milk bottle? [Yes] [No]

11- When has bottle feeding been discontinued completely?
   < 6 months [ ]
   6 - 12 months [ ]
   13 - 18 months [ ]
   19 - 24 months [ ]
   > 24 months [ ]
   Not yet [ ]
**Sweetened Liquids in a Nursing Bottle:**

1- Did your child drink liquids other than milk and water from a nursing bottle? [Yes] [No]

2- Which of the following drinks did he/she have most often?
   - Fresh fruit juice
   - Canned fruit juice
   - Fizzy drinks
   - Squash
   - Herbs with sugar
   - Tea with sugar
   - Glucose
   - Others Specify-----------------

3- When did he/she have these drinks?
   - While awake [ ]
   - At nap-time [ ]
   - At bed-time [ ]
   - During the night while asleep [ ]

4- When did he stop using a bottle and started to drink from a cup?
   - < 6 months [ ]
   - 6 - 12 months [ ]
   - 13 - 18 months [ ]
   - 19 - 24 months [ ]
   - > 24 months [ ]
   - Not yet [ ]

5- Did he/she use a dummy dipped in honey/sugar? [Yes] [No]

6- Did you give him/her sweets at bed time? [Yes] [No]

7- When was the dummy discontinued?
   - < 6 months [ ]
   - 6 - 12 months [ ]
   - 13 - 18 months [ ]
   - 19 - 24 months [ ]
   - > 24 months [ ]

**Eating During Childhood**

**Snacks:**

1- What of the following snacks does your child eat most often?
   - Biscuits/cakes [ ]
   - Chewing gum [ ]
   - Candies [ ]
   - Chocolates [ ]
   - Lollipops [ ]
   - Toffee [ ]
   - Ice-cream [ ]
   - Sandwiches with Halawi/honey/jam [ ]
   - Sandwiches with eggs/cheese/labaneh/thyme/olives [ ]
   - Potato chips [ ]
   - Fruits in Syrup [ ]
   - Fresh fruits [ ]
   - Others Specify---------- [ ]
2- What of the following does your child drink most often?
   Fresh fruit juice [ ]
   Canned fruit juice [ ]
   Squash [ ]
   Fizzy drinks [ ]
   Tea with sugar [ ]
   Herbs with sugar [ ]
   Others….. Specify----------------------------------------

**Breakfast/Dinner**

1- Does he/she usually have breakfast? [Yes] [No]
2- What does he/she usually have at breakfast?
   Milk with sugar [ ]
   Tea with sugar [ ]
   Thyme [ ]
   Olives [ ]
   Beans/ Chick-peas [ ]
   Eggs [ ]
   Labanah (Sour cream) [ ]
   Cheese [ ]
   Jam/honey/halawi [ ]

3- Does your child usually have dinner? [Yes] [No]
4- What does he/she usually have?
   Cooked food (vegetable/meat/rice) [ ]
   Milk with sugar [ ]
   Tea with sugar [ ]
   Thyme [ ]
   Olives [ ]
   Labanah (Sour cream) [ ]
   Cheese [ ]
   Eggs [ ]
   Beans/chick-peas [ ]
   Jam/honey/halawi [ ]
Appendix D: List of publications arising from the study

Caries in pre-school children in Amman, Jordan and the relationship to socio-demographic factors.
*International Dental Journal* **52**: 7-10.

Caries prevalence and patterns and their relationship to social class, infant feeding and oral hygiene in 4-5-year-old children in Amman, Jordan.
*Community Dental Health* **19**(3): 144-151.

Food and drink consumption, sociodemographic factors and dental caries in 4-5-year-old children in Amman, Jordan.
*British Dental Journal* July 13, **193**(1): 37-42.

Oral cleanliness, gingivitis, dental caries and oral health behaviour in Jordanian children.
## I. Caries prevalence in the Middle East

### Table 1. Saudi Arabia

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample Description</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salem and Holm, 1985</td>
<td>296 (3-5-year-old) children attending the paediatric clinic at Gizan Hospital</td>
<td>1.2 dmft</td>
<td>With caries 41.5% (d=33.4, m=8.1)</td>
<td>Aim: To gather information about dental caries among preschool children. Findings: 1) One third of the children had one or more teeth with untreated caries, 2) Eight percent of children had lost primary teeth due to caries. 3) None of the children had received any conservative dental treatment.</td>
</tr>
<tr>
<td>Al Sekait and Al Nasser, 1988</td>
<td>7040 primary school children 6-15-years of age in Riyadh District</td>
<td>At age 6 0.8dft, At age 7 0.9dft, At age 8 1.2dft, At age 9 0.8dft, All 1.8dft</td>
<td>With caries All 52%</td>
<td>Aim: To determine the prevalence of dental caries. Findings: 1) Caries experience increases with age till the age of 8, after which it starts to decline, 2) For the whole sample (6-15-year-old), caries is prevalent in middle and upper income groups [no data is presented to confirm this finding], 3) Girls are more affected than boys.</td>
</tr>
<tr>
<td>Al Shammery et al., 1990</td>
<td>2321 (6.9 and 12-year old) children from primary school children in Riyadh Central Province. Of the sample 691 were 6 years old</td>
<td>6-year-old Boys 4.14dmft, Girls 3.43dmft, 9-year-old Boys 3.52dmft, Girls 2.91dmft</td>
<td>Caries free (6-year-old) 23.3%, (9-year-old) -</td>
<td>Aim: To assess prevalence of dental caries in 6, 9 and 12 years. Findings: 1) Caries experience in primary dentition is moderate to high, 2) Boys have higher caries experience than girls. 3) Caries experience is higher in 6-year-old than in 9-year-old, 4) Caries is higher in the urban population.</td>
</tr>
</tbody>
</table>

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Saudi Arabia continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Khateeb et al 1990</td>
<td>1440 (6-12 and 15 years) from three cities with varying concentration of fluoride (480 in each age group)</td>
<td></td>
<td></td>
<td>Aims: 1. To measure the levels of oral health in different communities with varying levels of naturally occurring fluoride in the drinking water. 2. To consider the fluoridation of drinking water as a strategy in the prevention of dental caries in Saudi Arabia. Findings: 1) The caries experience in Jeddah is higher than in Rabigh and Mecca. 2) Percentage of caries-free children gave conflicting results to that of dmft values. 3) Caries experience is higher in males than in females. 4) Caries experience in public schools is higher than in private schools.</td>
</tr>
<tr>
<td></td>
<td>Fluoride concentration</td>
<td></td>
<td></td>
<td>Jeddah 6-year-old 21%</td>
</tr>
<tr>
<td></td>
<td>Jeddah= &lt;0.3ppm</td>
<td></td>
<td></td>
<td>Rabigh= 0.8ppm</td>
</tr>
<tr>
<td></td>
<td>Rabigh= 2.5ppm</td>
<td></td>
<td></td>
<td>Mecca= 2.5ppm</td>
</tr>
<tr>
<td></td>
<td>Of the sample 480 children were 6 years old</td>
<td></td>
<td></td>
<td>Cariess free</td>
</tr>
<tr>
<td></td>
<td>6-year-old</td>
<td>5.0dmft</td>
<td>Jeddah 6-year-old 21%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>4.2dmft</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Females</td>
<td>6.3dmft</td>
<td>Rabigh 6-year-old 40%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public schools</td>
<td>2.9dmft</td>
<td>Mecca 6-year-old 21%</td>
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</tr>
<tr>
<td></td>
<td>Private schools</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Jeddah</td>
<td>4.6dmft</td>
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<td></td>
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<tr>
<td></td>
<td>Rabigh</td>
<td>2.1dmft</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mecca</td>
<td>2.7dmft</td>
<td></td>
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<tr>
<td>Alamoudi et al., 1996</td>
<td>1522 (6-9 year-old) children in Jeddah. Of the sample 272, 299, 492, 459 children were 6, 7, 8 and 9-year-old respectively</td>
<td></td>
<td></td>
<td>Aims: 1. To examine caries experience of different age groups of children with mixed dentition. 2. To determine the most vulnerable group among the child population. Findings: 1) Caries prevalence in Jeddah is high and affects the majority of the child population. 2) Caries prevalence and severity varied according to the age group.</td>
</tr>
<tr>
<td></td>
<td>6-year-old</td>
<td>5.54dmft</td>
<td>6-year-old 26.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-year-old</td>
<td>5.61dmft</td>
<td>7-year-old 13.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8-year-old</td>
<td>4.41dmft</td>
<td>8-year-old 25.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9-year-old</td>
<td>2.93dmft</td>
<td>9-year-old 34.4%</td>
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</tr>
<tr>
<td></td>
<td>Sample mean</td>
<td>4.23dmft</td>
<td>All 26.1%</td>
<td></td>
</tr>
<tr>
<td>Magbool, 1992</td>
<td>1665 (6-17-year-old) pupils from Al-Khobar. Of the sample 279 children were in the 6-7-years age group.</td>
<td></td>
<td></td>
<td>Aims: To collect baseline data on the prevalence of dental caries among school children in Al-Khobar. Findings: The highest total dmft value (5.11) occurred in the 6 and 7 -year-age-group, and the lowest (0.03) in the oldest age group.</td>
</tr>
<tr>
<td></td>
<td>6-7-yr-old</td>
<td>5.1dmft</td>
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<td></td>
<td>8-9-yr-old</td>
<td>4.7dmft</td>
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<tr>
<td></td>
<td>10-11-yr-old</td>
<td>3.2dmft</td>
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<td></td>
<td>12-13-yr-old</td>
<td>0.7dmft</td>
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<td></td>
<td>14-15-yr-old</td>
<td>0.14dmft</td>
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<td></td>
<td>16-17-yr-old</td>
<td>0.03dmft</td>
<td></td>
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</tr>
<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Mean dmft(s)</td>
<td>Prevalence</td>
<td>Comments</td>
</tr>
<tr>
<td>------------</td>
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</tbody>
</table>
| Al Mohammedi et al., 1997 | 390 (2, 4, and 6-year-old) boys examined in three areas (high class, low class and rural area) in Riyadh which has near optimal (0.8ppm) fluoride in drinking water. The sample consisted of 132, 132, 126 children in the three age groups respectively | dmft values  
2-year-old  
High 0.4  
Low 1.7  
Rural 0.2  
4-year-old  
High 0.7  
Low 3.0  
Rural 2.1  
6-year-old  
High 3.7  
Low 5.0  
Rural 2.9 | With caries  
2-year-old  
High 17%  
Low 30%  
Rural 6%  
4-year-old  
High 45%  
Low 55%  
Rural 46%  
6-year-old  
High 62%  
Low 89%  
Rural 61% | Aim: To describe caries experience in young preschool children  
Findings:  
1) Caries prevalence increased with age in the two social classes and the rural area  
2) For all three age groups, mean dmft values were highest in urban low socio-economic group. Only in 6-year-old differences between the low and high social classes reached statistical significance  
3) For all social classes and all ages, most of the caries experience was untreated |
| Paul and Maktabi, 1997 | 103 (5-year-old) children attending the two nurseries in Al-Kharj | Boys 7.11dmft  
Girls 7.12dmft  
Total sample 7.12dmft | Caries free  
All 16.5% | Aim: To study the caries experience in a small military town near Riyadh  
Findings:  
1) Percentage of caries free is relatively low  
2) No significant difference in caries experience between boys and girls |
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murtoomaa et al.,</td>
<td>A random sample of 450 (3-7-year-old) children drawn from students in</td>
<td>Age</td>
<td></td>
<td>Aim: To study caries experience in 3-7-year-old children, to set baseline data for future oral health interventions</td>
</tr>
<tr>
<td>1995</td>
<td>kindergartens and Primary Department of Kuwait English School in Salwa district. The sample consisted of 26, 111, 137, 108, 68 children in the five age groups respectively</td>
<td>3-yr-old</td>
<td>1.7dmft</td>
<td>Findings: 1) Lowest dmft at age 4 and highest at age 6 2) No difference in caries experience between boys and girls</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-yr-old</td>
<td>1.4</td>
<td>3) Proportion of caries free children was highest at 4 and lowest at 6 years of age 4) 26% of the sample belonged to the high caries group (dmft&gt;4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-yr-old</td>
<td>2.9</td>
<td>5) Children with caries had up to 16 dmft 6) Molars and maxillary incisors were most affected by caries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-yr-old</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-yr-old</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total sample</strong></td>
<td><strong>2.9</strong></td>
<td><strong>Total sample</strong></td>
<td>30%</td>
</tr>
<tr>
<td>Al-Duhaibi et al.,</td>
<td>227 18-48-month-old children</td>
<td>Social class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>I= professional &amp; technical</td>
<td>With caries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>II= skilled &amp; semi skilled</td>
<td>Total sample</td>
<td>53%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III= manual</td>
<td>1.2dmft</td>
<td>18-23-month</td>
</tr>
<tr>
<td></td>
<td></td>
<td>no data</td>
<td>24-35-month</td>
<td>54%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>36-48-month</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social class</td>
<td>Caries free</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I= professional &amp; technical</td>
<td>Total sample</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II= skilled &amp; semi skilled</td>
<td>1.2dmft</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III= manual</td>
<td>3.0dmft</td>
<td>42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>no data</td>
<td>42%</td>
<td>4) A higher proportion of children whose mothers have a higher education were caries free</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mother's education</td>
<td>College</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle/secondary</td>
<td>39%</td>
<td></td>
</tr>
</tbody>
</table>

Kuwait continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigild et al., 1996</td>
<td>3500 (4, 6, 12, 15-year-old) students from kindergartens and public schools. Of the sample 1769 were 4 and 6-year-old (547 and 1222 respectively)</td>
<td></td>
<td>Caries free (1993)</td>
<td>Aims:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-years</td>
<td>4.6dmft</td>
<td>1. To describe the occurrence of dental caries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-years</td>
<td>6.2dmft</td>
<td>2. To assess the current need for dental care</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Caries free (1982)</td>
<td>3. To describe dental trend by comparing the present results with data from 1982</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>At 6-years 21%</td>
<td>4. To provide a baseline for the evaluation of preventive oral health programmes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1) dmft values are relatively high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2) Percentage of caries free children is relatively low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3) Percentage of caries free children at 6 years of age decreased from 21% in the first National Health survey (1982) to 9% in 1993. This was partly associated with an increase in the filling component</td>
</tr>
</tbody>
</table>

Table 1.3. Iraq

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean deft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
<th>Aims:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghose et al., 1983</td>
<td>964 (1-4-year-old children) from middle class families in Baghdad (121, 148, 162, 194, 161, 178 children in the 6 age groups respectively)</td>
<td></td>
<td></td>
<td></td>
<td>1. To provide baseline data on dental health status</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13-18-months</td>
<td>0.2deft</td>
<td>13-18-months 93.3%</td>
<td>2. To provide suitable treatment plans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19-24-months</td>
<td>0.62deft</td>
<td>19-24-months 83.8%</td>
<td>3. To allow means of comparison with other countries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-30-months</td>
<td>1.12deft</td>
<td>25-30-months 71.6%</td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31-36-months</td>
<td>2.22deft</td>
<td>31-36-months 49.5%</td>
<td>1) Prevalence and severity increased with age</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37-42-months</td>
<td>3.12deft</td>
<td>37-42-months 37.3%</td>
<td>2) No difference in caries prevalence by gender</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43-48-months</td>
<td>4.42deft</td>
<td>43-48-months 28.7%</td>
<td>3) Decayed teeth constituted most of the dental condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>2.3deft</td>
<td>All 58.1%</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.4. Oman

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>dmft</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Imairy et al., 1997</td>
<td>3114 Grade 1 (6-year-old) children from 11 administrative regions of Oman</td>
<td>Sample dmft</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Examination was confined to canines and molars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Examinations were carried out according to the protocol of the British Association for the Study of Community Dentistry (BASCD) using the criteria defined by Palmer et al., 1984.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Al-Wusta</td>
<td>3.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Batina North</td>
<td>5.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Batina South</td>
<td>3.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dakhliya</td>
<td>4.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dhahiria</td>
<td>6.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dhofar</td>
<td>3.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Musandam</td>
<td>4.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Muscat</td>
<td>4.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sharqya North</td>
<td>5.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sharqya South</td>
<td>3.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aim:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To report the findings of the first Omani National Oral Health Survey of 6-year-old children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Findings:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) dmft is relatively high.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) half of the decayed surfaces deemed beyond restoration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) Large variation between areas in regard to caries free children and severity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4) Caries is related to high social class. Percentage of caries free children in Batina North (an affluent region) is relatively low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5) Occlusal surfaces were most commonly involved, 70.6% were affected by caries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6) First primary molars were the most commonly afflicted teeth</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 1.5. Abu Dhabi

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Mughery et al., 1991</td>
<td>1210 5-year-old children attending city (n= 490) and rural (n= 453) schools within Abu Dhabi administrative area. Three private schools (n= 267) were also examined in order to allow a comparison with the private sector</td>
<td>All: 4.63dmft</td>
<td>Caries free: 28%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>5.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>5.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Private</td>
<td>3.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aim:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To collect information for further development of dental services and adequate planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Findings:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Despite expenditure on dental healthcare, only 28% of 5-year-old are caries free</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) Children from private schools have a lower dmft than both groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) High untreated decay in city and rural schools</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abu Dhabi Continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Hosani and Rugg-Gunn, 1998</td>
<td>Complete data of 640 (2, 4, and 5-year-old) children were obtained from three areas (Abu Dhabi, the capital; Al Ain and Western region). The number of children in various ages were: 217 in 2-year-olds, 204 in 4-year-olds, 219 in 5-year-olds.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2yr 4yr 5yr</td>
<td>Abu Dhabi</td>
<td>1.7</td>
<td>6.2</td>
<td>8.4</td>
</tr>
<tr>
<td>Al Ain</td>
<td>3.2</td>
<td>5.2</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>Western region</td>
<td>2.8</td>
<td>5.1</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td>Parental Education</td>
<td>2yr 4yr 5yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2.9</td>
<td>7.0</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>2.5</td>
<td>2.6</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>2.5</td>
<td>2.6</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>Parental Income</td>
<td>2yr 4yr 5yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2.0</td>
<td>4.3</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>2.0</td>
<td>5.9</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>3.2</td>
<td>5.7</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Locality</td>
<td>2yr 4yr 5yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>2.5</td>
<td>5.2</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>2.4</td>
<td>6.0</td>
<td>8.4</td>
<td></td>
</tr>
</tbody>
</table>

Findings:
1) Caries experience was high to very high.
2) Caries increased with age in the three areas.
3) In the Western region, boys tended to have a higher (3.2, 7.5, 7.2)dmft scores than girls (2.3, 3.5, 4.5). This was not observed consistently in Abu Dhabi or Al Ain.
4) In 4and 5-year-olds, children from rural areas tended to have more caries experience than children from urban areas.
5) Children of parents with high educational level tended to have less caries experience than children of parents of low educational status.
6) Relationship between income and caries experience was less apparent, yet regression analysis revealed its significance together with age and educational status. Locality, gender and ethnicity were not statistically significant.
7) The occurrence of caries was related to a combination of low parental education and high income. Mean dmft was 6.9 in the high income/low education compared with 2.7 in the low income/high education group.
8) Caries experience recorded for 5-year-old living in urban Abu Dhabi (7.1dmft) was higher than that recorded approximately 6 years earlier (5.1dmft).
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raadal et al., 1993</td>
<td>544children (4-5-year-old) and 269 (7-8-year-old), were examined. Children were resident in Khartoum.</td>
<td>Age group</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-5-years 1.68dmft</td>
<td>7-8-years 2.77dmft</td>
<td>Caries free</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibrahim et al, 1997</td>
<td>124 (6-16-year-old) children from two areas with contrasting fluoride content in their drinking water (Treat el Biga = 0.25ppm and Abu Groon=2.5ppm)</td>
<td>Age and area</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-9 2.8dmft</td>
<td>10-12 2.0</td>
<td>Total 2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-9 0.3dmft</td>
<td>10-12 0.8</td>
<td>Total 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1.7. Israel

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Holan et al., 1991   | 210 (5-year-old) children from an Arab village were examined          | dmft 8.04    | Caries free 0.5% | Aim:  
1. To determine the dental caries experience  
2. To examine the effect of parents’ education  
Findings:  
1) Caries experience is extremely high  
2) dmft scores in children of mothers with lower level of education (1,2,3) were significantly higher than in children of mothers with high education (4,5,6)  
3) dmft was significantly lower only in children of fathers with academic degree (level 6)  
4) There were no significant difference in dmft scores between the various combinations of educational levels of the parents |

<table>
<thead>
<tr>
<th></th>
<th>Mother’s education level</th>
<th>dmft</th>
<th>&lt;-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>6.6dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8.53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>9.0 (one child)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caries experience of children of highly educated fathers (5&amp;6) related to mother’s education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2,3</td>
<td>13.33dmft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4,5,6</td>
<td>13.89dmft</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Father’s education level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7.6dmft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>7.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caries experience of children of highly educated mothers (4,5&amp;6) related to father’s education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2,3,4</td>
<td>15.86dmft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,6</td>
<td>13.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                      | 7-year-old                                                            |              |    |
|                      | 1980                                                                  | 3.5dmft      |    |
|                      | 1982                                                                  | 3.4          |    |
|                      | 1994                                                                  | 2.7          |    |
|                      | 7-year-old Caries free                                                |              |    |
|                      | 1980                                                                  | 21%          |    |
|                      | 1982                                                                  | 18%          |    |
|                      | 1994                                                                  | 29%          |    |

Zueman and Crawford, 1995  
A total of 602 (7-year-old) children from three surveys (235 in 1980, 176 in 1982, 191 in 1991) Ashkelon were investigated.  
For the permanent dentition 555 (13-year-old) children from the three surveys were also investigated.  

|                      | 7-year-old                                                            |              |    |
|                      | 1980                                                                  | 3.5dmft      |    |
|                      | 1982                                                                  | 3.4          |    |
|                      | 1994                                                                  | 2.7          |    |

Aim:  
To demonstrate the trend in caries prevalence during the 14 years from 1980 to 1994  
Findings:  
1) A major improvement in both dentitions can be seen  
2) In regard to 7-year-old children  
A- An increase in the percentage of caries free children and a decrease in dmft values  
B- Improvement was mainly due to a fall in disease prevalence: the dm component almost halved, from 2.6 in 1980 to 1.7 in 1994  

Israel continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmfs</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
</table>

**Aim:**
2. To investigate possible associations between caries levels and independent variables.

**Findings:**
1. Reduction of 42% in dmfs values in 6-year-olds and 48% in 9-year-old.
2. Caries level was neither statistically associated with parent's occupation and educational level, nor with children's dental treatment.
Table 1. 8. Jordan

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Mean dmft(s)</th>
<th>Prevalence</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Janson and Fakhouri, 1993 | 255 (6 months-6-year-old) children living in a suburb of Amman. Number of children: <1 year = 32, 12-23-months = 64, 24-35-months = 56, 36-71-months = 103 |              | % with caries  | Aim: To describe dental decay, hygiene and sweet consumption in preschool children.  
                                             |                          |              | Age group | Findings:                                                            |
|                  |                          |              | < 1 year   | 1) Boys had slightly more decay than girls in all age groups.   |
|                  |                          |              | 2-3-years  | 2) Dental decay was not related to the mother’s age or education, fathers profession or the number of living children in the family. |
|                  |                          |              | 3-6-years  | 3) 80% of the sample consumed sweets or biscuits, most often daily. Consumption of sweets started early, 29% of 6-11-month-old children daily consumed sweets. |
|                  |                          |              | 0%         | 4) Only 10% of all children cleaned their teeth. 85% never had their teeth cleaned daily. |
|                  |                          |              | 25%        | 5) Mothers with higher education (Diploma/university) cleaned their children teeth more often (25%) than others (10%). |
|                  |                          |              | 72%        |                                          |
| Hamdan and Rock, 1993 | In both Jordan and England two groups of children were examined aged 6 and 12-years-old. Two hundred were seen in each group giving a total of 800. Data presented is related to 200 Jordanian children | 6-year-old Jordans | Total dmft 2.15 | Aim: 1. To act as a pilot study for the first national survey of dental health in Jordan.  
                                             |                          | Total dmfs 4.64  | 6-year-old Jordans | 2. To compare the data with a sample of English school children. |
|                  |                          | Social class |                | Findings: 1) Caries experience in Tamworth, England was (1.56dmft and 2.5dmfs) less than the Jordanian sample (2.15dmft and 4.64dmfs).  
                                             |                          | High 1.6dmft | 2) Percentage of caries free children in Tamworth (58.5%) is higher than in Amman (37.5%).  
                                             |                          | Middle 2.7dmft | 3) In Jordan  
                                             |                          | Low 2.3dmft    | A- There was more caries in boys than in girls  
                                             |                          |                | B- High social class children had significantly lower caries experience than those from the middle or low classes  
                                             |                          |                | C- There were very few filled teeth in the low social class (7 out of 100 teeth) |
I. Caries Patterns

Table 2.1 Tooth Type

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample Description</th>
<th>Definition</th>
<th>Prevalence 4yr</th>
<th>Prevalence 5yr</th>
<th>Prevalence 6yr</th>
<th>dmft(s)</th>
<th>Comments</th>
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<tr>
<td>Trubman et al., 1989</td>
<td>23 900 Mississippi Head Start children examined during 1987-88 school year, representing a 10% random sample of 3-6-year-old children from 31 of the 313 centres throughout the state</td>
<td>Central incisors</td>
<td>12.9%</td>
<td>21.8%</td>
<td>25.1%</td>
<td>21.3%</td>
<td>Aim: To assess the dental caries status and treatment needs Findings: 1) Dental caries experience increased with age from 1.34 deft in 3-year-olds to 4.32 for 6-year-olds 2) Primary teeth (in all ages) affected in decreasing order were: second molar, first molar, central incisor, lateral incisor and canine.</td>
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<td></td>
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<td>Lateral incisors</td>
<td>5.7%</td>
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<tr>
<td></td>
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<td>Canine</td>
<td>2.9%</td>
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<td>11.1%</td>
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<tr>
<td></td>
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<td>First molars</td>
<td>17.1%</td>
<td>30.7%</td>
<td>41.3%</td>
<td>50.9%</td>
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<tr>
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<td>Second molars</td>
<td>25.7%</td>
<td>44.3%</td>
<td>50.9%</td>
<td>65.7%</td>
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<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample Description</th>
<th>Definition</th>
<th>Prevalence Salzgitter</th>
<th>Prevalence Oslo</th>
<th>Mean dmfs Salzgitter (0.55, 0.1)</th>
<th>Mean dmfs Oslo (0.3, 0.05)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clasen et al., 1992</td>
<td>455 (4-and 5-year-olds) in Salzgitter (FRG) and 171 (4-and 5-year-olds) in Oslo (Norway)</td>
<td>Central incisor</td>
<td></td>
<td></td>
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<td></td>
<td>Aim: To compare the caries prevalence and provision of treatment for kindergarten children in Salzgitter and Oslo Findings: 1) In Oslo very little untreated caries existed. The deciduous molars had all the fillings (0.5 filled surfaces in the first molar and 0.7 in the second molar) and no carious canines 2) In Salzgitter the fillings were also located in molars (0.3 filled surfaces in each) 3) It is postulated that the difference between the two cities is due to the different levels of fluoride exposure, nutritional habits and dental treatment provision.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lateral incisor</td>
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<tr>
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<td></td>
<td>Canine</td>
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<td></td>
<td></td>
<td>First molar</td>
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<td>Second molar</td>
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<table>
<thead>
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<th>Author/Year</th>
<th>Sample Description</th>
<th>Definition</th>
<th>Prevalence</th>
<th>Mean defs</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Grindfjord et al, 1993</td>
<td>832 (2.5-year-old) children living in the southern suburb of Stockholm were examined and the parents answered a structured questionnaire</td>
<td>Incisors Maxillary</td>
<td>72%</td>
<td></td>
<td>Aim: To study caries prevalence in relation to social class and ethnic background, microbiol, dietary, oral hygiene factors and fluoride exposure Findings 1) Initial or manifest caries was present in 11.7%. (non-immigrant 8.4%, immigrant 14.3%) of children 2) Variables most strongly associated with caries were colonization with mutans streptococci and lactobacilli and an immigrant background 3) Of the total number of caries lesions (394) A- 72% were localised to the maxillary incisors. B- Pattern of localisation is similar in the children of non-immigrant and immigrant background</td>
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<td></td>
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<td>Mandibular</td>
<td>1.5%</td>
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<td>Canines Maxillary</td>
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<td></td>
<td>Mandibular</td>
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<td>Molars Maxillary</td>
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<tr>
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<td></td>
<td>Total carious lesions (initial &amp; manifest)</td>
<td>11.7%</td>
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<tr>
<td>Author/Year</td>
<td>Sample</td>
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<td>Prevalence</td>
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<tr>
<td>Peterson et al., 1994</td>
<td>A national sample of 7-year-old Romanian children in Grade one (n=729) and 12-year-old in Grade six (n=660)</td>
<td>7-year-old Molars Upper Lower Canines Upper Lower Incisors Upper Lower</td>
<td>With caries 86%</td>
<td>3.1 defs 5.5 defs 0.2 defs 2.2 defs 0.2 defs</td>
<td>1. To describe prevalence and pattern of dental caries in school children 2. To use data in order to provide a baseline for planning and evaluation of oral health care Findings: In 7-year-old children 1) Prevalence proportion of dental caries was 86%, def score was 11.4 and that of deft was 5.3 2) Caries in the primary teeth was concentrated to molars. In particular, to the mandibular molars 3) Incisors in the maxilla were also affected frequently</td>
</tr>
<tr>
<td>Holt, 1995</td>
<td>1006 5-year-old children</td>
<td>Caries free 63% With caries 31% 19% 3% 7%</td>
<td>1.3 dmft 0.7 0.4 0.1 0.2</td>
<td>Aims: 1. To show the pattern of caries in a cohort of 5-year-old children and in the same cohort at 9 years 2. To compare the pattern seen in children who had used a lower fluoride toothpaste (550ppmF) with those who used a standard control paste (1055ppmF) Findings: 1) Second molars showed the highest caries attack at both ages (31% of children affected at 5 &amp; 44% at 9) 2) Prevalence in first primary molars was 19% &amp; 37% at the two ages respectively 3) No difference in relative pattern of disease in test and control groups but the trend for children who used the lower fluoride paste to have a slightly higher disease level at 5. Also seen at 9 years. (1.0+8+.1=1.9) This discrepancy may be due to the rounding of figures</td>
<td>1006 9-year-old children</td>
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<tr>
<td>Year</td>
<td>Sample</td>
<td>Definition</td>
<td>Percentage of Decayed Teeth</td>
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<td>Lower</td>
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<td>51.1%</td>
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</tbody>
</table>

Aim:
1. To clarify the trends in caries experience in the primary dentition.
2. To describe the types of teeth in which the reduction of caries occurred.

Findings:
1. The percentage of decay in all types of teeth showed a marked reduction until 1977.
2. After 1977, the percentage of decay either remained at the same level, or continued to decrease slowly either steadily or with some fluctuation. An exception to this finding is that the primary maxillary and mandibular second molars in 2-year-olds continued to increase slightly until 1992.
3. The possible causes of most of the decline in caries experience which occurred between 1972 and 1977 might be a combination of dental health education and a slight reduction in overall sugar consumption.
4. The increase in caries experience in general afterwards might be attributed to the change of dental caries or to an increasing rate of restorative treatment.
5. Although the awareness and knowledge of parents and school staff increased in Sendai, yet it has proved to have a short term effect. A reduction in poor food habits and a decline in oral hygiene may have contributed to an increase in the caries experience of the second molar, for the depth of its fissures is difficult to clean.
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinds and</td>
<td>The survey was carried out in 1992/1993. Information on dental health status and on dietary intake was gathered from a total of 1658 (1.5 - 4.5 year-old) from 100 geographic sectors in the United Kingdom</td>
<td>1.5 - 2.5-year-old (n=451) Molars 2%</td>
<td></td>
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<td>Gregory, 1995</td>
<td></td>
<td>Incisors</td>
<td>2%</td>
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<td>Any decay experience</td>
<td>4%</td>
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<td>Incisors</td>
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<td>Any decay experience</td>
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<td>3.5 - 4.5-year-old (n=537) Molars 27%</td>
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<td></td>
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<td>Incisors</td>
<td>13%</td>
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<tr>
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<td>Canines</td>
<td>2%</td>
<td></td>
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<td>Any decay experience</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>All ages (n= 1532) Molars 13%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Incisors</td>
<td>8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Canines</td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any decay experience</td>
<td>17%</td>
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</tr>
</tbody>
</table>

Aim:
1. To collect baseline information about the condition of preschool children’s teeth, by examination to enable future monitoring of the sample.
2. To investigate dental behaviour through an interview
3. To investigate the prevalence of traumas and erosion in the deciduous incisors
4. To enable dental status to be correlated with dietary data

Findings:
1) Overall 17% of children examined were recorded as having some decay experience
2) The proportion varied by age from 4% in children aged 1.5 - 2.5 years to 30% in children aged 3.5 - 4.5 years
3) Caries was most commonly affected primary molars, 13% of the children had decayed molars whereas 8% had caries in incisors and only 1% had caries experience in canines
4) This pattern of disease was age related. Up to 2.5 years of age caries in the incisors and molars was equally prevalent and it was only in the older children (3.5 - 4.5) that it became more observed in the molars especially in the lower molars
5) Most of the decay experience was untreated or "active decay"

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>Mean dmft</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seow et al., 1996</td>
<td>184 (3.5 - 5.9 year-old) Australian aboriginal children who were attending preschools in metropolitan Brisbane, a non-fluoridated state capital city</td>
<td>Mandibular molars</td>
<td>1.3 dmft</td>
<td>1.3</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Maxillary molars</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxillary incisors</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxillary canines</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mandibular canines</td>
<td>0.1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Mandibular incisors</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Aim:
To examine the oral health of a group of Aboriginal preschool children

Findings:
1) Caries was diagnosed in 78% of children
2) 23% of children had maxillary (at least one tooth is affected) anterior labial decay.
3) Children are at higher risk than other Australia children.

Tooth Type Continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dini et al., 1998</td>
<td>1066 3-6-year-old children (903 from fluoridated areas since 1963 and 163 children from a recently fluoridated area)</td>
<td>Results were calculated separately for 3-4-year-old and 5-6-year-old</td>
<td></td>
<td></td>
<td>Aim: 1. To define the pattern of caries in 3-6-year-old children in areas of contrasting fluoridation history using two different indices. Findings: 1) All primary teeth showed less caries in children living in areas where fluoridation had been continued for longer. The difference in percentage prevalence was greatest in A- 3-4-year-old, in the upper incisors B- 5-6-year-old, in the primary first molars. 2) Second primary molars were the most frequently affected in both age groups in fluoridated areas since 1963. 3) Prevalence of caries in the second primary molar was similar to that of the first primary molar in 3-4-year-olds in the recently fluoridated area.</td>
</tr>
<tr>
<td></td>
<td>441 3-4-year-old children (from fluoridated areas since 1963)</td>
<td></td>
<td>Caries free</td>
<td>Total sample 1.1dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second molars</td>
<td></td>
<td>67.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>First molars</td>
<td></td>
<td>20.6%</td>
<td>0.4dmft</td>
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</tr>
<tr>
<td></td>
<td>Canines</td>
<td></td>
<td>17.9%</td>
<td>0.4</td>
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</tr>
<tr>
<td></td>
<td>Upper Incisors</td>
<td></td>
<td>2.5%</td>
<td>0.0</td>
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</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>14.1%</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>0.7%</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>462 5-6-year-old children (from fluoridated areas since 1963)</td>
<td></td>
<td>Caries free</td>
<td>Total sample 2.5dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second molars</td>
<td></td>
<td>43.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>First molars</td>
<td></td>
<td>46.1%</td>
<td>1.2dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canines</td>
<td></td>
<td>37.2%</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Incisors</td>
<td></td>
<td>7.6%</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>18.4%</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>0.9%</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45 3-4-year-old children (from fluoridated area since 1994)</td>
<td></td>
<td>Caries free</td>
<td>Total sample 2.4dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second molars</td>
<td></td>
<td>42.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>First molars</td>
<td></td>
<td>33.3%</td>
<td>0.7dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canines</td>
<td></td>
<td>33.3%</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Incisors</td>
<td></td>
<td>6.7%</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>33.3%</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>118 5-6-year-old children (from fluoridated area since 1994)</td>
<td></td>
<td>Caries free</td>
<td>Total sample 5.3dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second molars</td>
<td></td>
<td>11.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>First molars</td>
<td></td>
<td>77.1%</td>
<td>2.2dmft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canines</td>
<td></td>
<td>71.2%</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Incisors</td>
<td></td>
<td>21.2%</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>44.1%</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Incisors</td>
<td></td>
<td>2.5%</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Author/year</td>
<td>Sample</td>
<td>Definition</td>
<td>Prevalence</td>
<td>dmfs</td>
<td>Comments</td>
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<td>-------------</td>
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</tr>
<tr>
<td>Al-Khateeb et al., 1990</td>
<td>1440 (6- and 12-and 15 year-old) were examined in three cities in Saudi Arabia with varying levels of naturally occurring fluoride in the drinking water; Jeddah (&lt; 0.3ppm), Rabag (0.8ppm), and Mecca (2.5ppm)</td>
<td>6-year-olds</td>
<td>Caries free</td>
<td>Jeddah Rabag Mecca (n=160) (n=160) (n=160) 21% 40% 21%</td>
<td>Jeddah Rabag Mecca</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occlusal</td>
<td>2.6</td>
<td>2.6</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesial/distal</td>
<td>3.8</td>
<td>1.6</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buccal/lingual</td>
<td>1.8</td>
<td>0.8</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total dmfs</td>
<td></td>
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</tr>
</tbody>
</table>

Findings:
1) Occlusal surfaces made the greatest contribution to the total caries in the three age groups and in the three cities.
2) In 6-year-olds, approximal surfaces in Jeddah made greater contribution 46% (3.8 out of 8.2) than Rabag 36% (1.6 out of 4.4) and Mecca 35% (1.9 out of 5.5).
3) In 6-year-olds, caries in free smooth surfaces contributed approximately one fifth of the total experience (Jeddah 22%, Rabag 18% and Mecca 18%).
4) In all age groups, caries in public schools was higher than in private schools. For example, 6-year-old children in Jeddah public schools had a mean dmft of 6.3 compared to 2.9 dmft in private schools.
5) The level of caries in Rabag (with 0.77ppm F) and in Mecca (with 2.44ppm F) is approximately 50% lower than in Jeddah (with 0.3ppm F).
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>Percentage of dmfs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raadal et al., 1993</td>
<td>275 (4-5-year-old) preschool children and 269 7-8-year-old school children. A total of 544 children who were resident in Khartoum, Sudan</td>
<td>4-5-year-old Occlusal Proximal Buccal/lingual Missing</td>
<td>Prevalence</td>
<td>34% 30% 13% 22%</td>
<td>Aim: To investigate the oral health and dietary habits as a part of a larger study Findings: 1) In the preschool group, occlusal caries was most prevalent, but approximal caries was as frequent 2) In the school group approximal caries was most prevalent among the teeth that were not beyond repair 3) There were no statistically significant differences in caries experience (dmfs) between the three socio-economic groups</td>
</tr>
<tr>
<td>Peterson et al., 1994</td>
<td>A national sample of 7 and 12-year-old Romanian children</td>
<td>7-year-old children Occlusal Mesial/distal Facial/lingual</td>
<td>Prevalence</td>
<td>3.6 4.9 3.0</td>
<td>Aim: To describe prevalence and pattern of dental caries in school children Findings: 1) Prevalence proportion of dental caries was 86% in 7-year-old 2) Caries in the primary teeth was concentrated in the molars with the approximal surfaces having a higher (4.9 df) than the occlusal and facial/lingual</td>
</tr>
<tr>
<td>Holt, 1995</td>
<td>Data were drawn from records made at two clinical examinations for caries. The first had been carried out at the end of a 3-year clinical trial of a fluoride toothpaste formulated for young children. The second, four years later, as part of a follow up study of the children who had taken part. Of the children, 1006 were re-examined at the age of 9 years, 516 from the test group and 490 from the control</td>
<td>5-year-old Occlusal Proximal Buccal (labial)/Lingual (palatal)</td>
<td>Prevalence</td>
<td>34% 17% 13%</td>
<td>Aims: 1. To show the pattern of caries in a cohort of 5-year-old children and in the same cohort at 9 years of age 2. To compare the pattern seen in children who had used a lower fluoride toothpaste (550ppmF) and those who used a standard control paste (1055ppmF) Findings: 1) At 5-years of age, most disease occurred in occlusal surfaces of primary molars, especially second molars. Mandibular molars were affected more often than maxillary. 2) Between the ages of 5 and 9 years, new caries came to affect a greater proportion of approximal surfaces 3) At 9-years of age, approximal dmfs (1.8 per child) exceeded that for occlusal surfaces (1.6 per child). 4) When the clinical trial ended, there had been a statistically insignificant trend for children in the test group to have slightly higher caries. This was still apparent four years later.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9-year-old Occlusal Proximal Buccal (labial)/Lingual (palatal)</td>
<td></td>
<td></td>
<td>Surface Type Continued</td>
</tr>
<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Definition</td>
<td>Prevalence</td>
<td>Percentage of dmfs</td>
<td>Comments</td>
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<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Slade et al., 1996</td>
<td>9690 subjects were selected from a stratified random sample of 5-15-year-old-children enrolled with South Australian School Service. 977(5-year-old children) participated in the study</td>
<td>Pit and Fissure surfaces</td>
<td></td>
<td>45.4%</td>
<td>Aims:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Free smooth surfaces</td>
<td></td>
<td>16.2%</td>
<td>1. To describe the intra oral distribution of caries experience with respect to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesio-distal surfaces</td>
<td></td>
<td>38.3%</td>
<td>A- Components of caries experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>B- Site within the tooth</td>
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<td></td>
<td></td>
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<td>C- Type of tooth</td>
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<td></td>
<td></td>
<td></td>
<td>D- Number of surfaces affected per tooth</td>
</tr>
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<td></td>
<td></td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1) Caries experience was distributed predominantly between pit/fissure surfaces and mesio-distal surfaces with 16.2% of caries experience observed in the free smooth surfaces</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>2) The majority of caries(75%) occurred in molars and the proportion increased in older ages</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>3) 63.6% of the teeth were affected on a single surface, 12% had three or more surfaces while the rest of the teeth were affected on two surfaces (24.4%)</td>
</tr>
</tbody>
</table>

**Surface Type Continued**
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Mean dfs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Third National Health</td>
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</tr>
<tr>
<td></td>
<td>and Nutrition Examination Survey-phase I, conducted from 1988 to</td>
<td></td>
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</tr>
<tr>
<td>Kaste et al., 1996</td>
<td>1991 in the United States. The sample assessed for dental caries</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>provides estimates for over</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>58 million children and</td>
<td>Occlusal</td>
<td>1.1 dfs</td>
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<tr>
<td></td>
<td>adolescents in the US ages</td>
<td>Buccal</td>
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<tr>
<td></td>
<td>1-17 years</td>
<td>Mesiodental</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>1.1 dfs</td>
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<tr>
<td></td>
<td></td>
<td>Occlusal</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buccal</td>
<td>0.7</td>
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</tr>
<tr>
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<td></td>
<td>Mesiodental</td>
<td>1.0</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Black</td>
<td>1.0 dfs</td>
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<td>Occlusal</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buccal</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesiodental</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non Hispanic Whites</td>
<td>1.0 dfs</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>Occlusal</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buccal</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesiodental</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non Hispanic Blacks</td>
<td>1.0 dfs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occlusal</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buccal</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesiodental</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mexican American</td>
<td>1.6 dfs</td>
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</tr>
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<td>Occlusal</td>
<td>1.4</td>
<td></td>
</tr>
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<td>Buccal</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesiodental</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

**Aims:**
1. To assess dental caries in US children and adolescents
2. To assess differences in dental caries status in relation to age, sex, race and race-ethnicity

**Findings:**
1) For all the sample
   A: No difference by surface types was observed in 2-4 year-old children
   B: Occlusal and mesiodistal dfs scores (1.6 & 1.4, respectively) were greater than the bucco-lingual scores (1.0) in 5-9 years old children
2) The mean dfs scores for occlusal, buccolingual and mesiodistal surfaces for the non-Hispanic white and non-Hispanic black subpopulation appeared to be lower than those observed for Mexican Americans for all ages
Table 2.3.1. Tooth Type Pattern - *Rampant Caries*

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter et al., 1971</td>
<td>602 (12-60-month-old) children were examined. Information, usually from the mother, was obtained in regard with the factors determining the presence of the disease</td>
<td>Caries affecting the labial or palatal surfaces of 2 or more upper incisor teeth</td>
<td>Age</td>
<td>dmft(s)</td>
<td>Aim: To investigate preschool children attending child welfare centres in the London Borough of Camden</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Age</td>
<td>dmft(s)</td>
<td>1. Prevalence of rampant caries for the total sample was 8%. The highest prevalence (15%) was recorded for the age group 48-60-month-olds</td>
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<td></td>
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<td></td>
<td>12-23-month-old</td>
<td>0.6%</td>
<td>2. In regard to social class, there was a significant social gradient, the lower the social group the more the caries</td>
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<td></td>
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<td>24-35-month-old</td>
<td>10%</td>
<td>3. A significant relationship between sweetened comforters and the prevalence of rampant caries in young children had been confirmed, where 83% of the parents of children with rampant caries admitted to pacify their children using sweet comforters</td>
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<td></td>
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<td>36-47-month-old</td>
<td>10%</td>
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<td></td>
<td>48-60-month-old</td>
<td>15%</td>
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<tr>
<td></td>
<td></td>
<td><strong>Total sample</strong></td>
<td>8%</td>
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<td></td>
<td><strong>Social class</strong></td>
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<td><strong>Registrar General's Classification</strong></td>
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<td></td>
<td></td>
<td><strong>I</strong></td>
<td>3%</td>
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<td><strong>II</strong></td>
<td>5%</td>
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<td></td>
<td><strong>III</strong></td>
<td>8%</td>
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<td></td>
<td></td>
<td><strong>IV</strong></td>
<td>18%</td>
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<td></td>
<td></td>
<td><strong>V</strong></td>
<td>17%</td>
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<td><strong>Comforters</strong></td>
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<tr>
<td></td>
<td></td>
<td>Children with sweetened comforter</td>
<td>83%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Children without sweetened comforter</td>
<td>17%</td>
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</table>

*Rampant caries Continued*
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghose et al., 1983</td>
<td>964 (1-4-year-old) nursery school children in Baghdad. Children were from the middle class families which constitute the majority of the population</td>
<td>A minimum of 5deft value of which at least two anterior teeth with smooth surface caries</td>
<td>Age</td>
<td>13-18-month-old: 0%</td>
<td>Aims: 1. To provide baseline data on the dental health status of school children in order to provide suitable treatment plans and preventive measures 2. To allow means of comparison with other countries Findings: 1) Frequency of children with rampant caries A- was 12% B- it increased with age 2) Rampant caries is higher than in other studies. It was due to inappropriate use of feeding bottle containing milk adulterated with teaspoon sugar.</td>
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<td>19-24-month-old: 4.1%</td>
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<td>25-30-month-old: 4.9%</td>
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<td>31-36-month-old: 13.9%</td>
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<td>37-42-month-old: 18.6%</td>
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<td>43-48-month-old: 25.8%</td>
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<td>All ages: 12.1%</td>
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<tr>
<td>Kelly &amp; Bruerd, 1987</td>
<td>514 (3-5-year-old) Native American Head Start children in Alaska and Oklahoma</td>
<td>At least three decayed maxillary incisors</td>
<td></td>
<td></td>
<td>Aim: To describe the prevalence of Baby Bottle Tooth Decay (BBTD) in specific populations so as to identify the extent of the problem. Findings: 1) High prevalence of BBTD that warrants comprehensive and culturally appropriate educational programme, for its prevalence ranged between 17-85% with a mean of 53%</td>
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<td></td>
<td></td>
<td></td>
<td>53%</td>
<td></td>
<td>Rampant Caries Continued</td>
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<tr>
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<td>Prevalence</td>
<td>dmft(s)</td>
<td>Comments</td>
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<tr>
<td>Holt et al., 1988</td>
<td>565 12-60-month-old children were examined and their parents, most often their mother, interviewed. The sample was drawn from the population attending Maternal and Child Welfare clinic- Camden</td>
<td>Caries involving labial or palatal surfaces of two or more maxillary incisor teeth</td>
<td>Age</td>
<td>1986</td>
<td>1980</td>
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<td></td>
<td></td>
<td></td>
<td>12-23-month-old</td>
<td>0%</td>
<td>2%</td>
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<td></td>
<td>24-35-month-old</td>
<td>9%</td>
<td>3%</td>
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<td></td>
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<td></td>
<td>36-47-month-old</td>
<td>10%</td>
<td>4%</td>
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<td></td>
<td>48-59-month-old</td>
<td>16%</td>
<td>4%</td>
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<td>Social class</td>
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<td>Registrar General’s Classification</td>
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<td>I-IIIN</td>
<td>3%</td>
<td>4%</td>
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<td></td>
<td>IIIM-V</td>
<td>10%</td>
<td>3%</td>
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<td></td>
<td></td>
<td></td>
<td>Not classified</td>
<td>9%</td>
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<td></td>
<td></td>
<td>Ethnicity</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>European</td>
<td>6%</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Asian</td>
<td>14%</td>
<td></td>
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<td></td>
<td></td>
<td>African or Afro-Caribbean</td>
<td>5%</td>
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<td></td>
<td></td>
<td></td>
<td>Other origin</td>
<td>9%</td>
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<td></td>
<td></td>
<td></td>
<td>Feeding method</td>
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<td></td>
<td></td>
<td></td>
<td>Breast-fed</td>
<td>5%</td>
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<td></td>
<td></td>
<td>Bottle-fed</td>
<td>9%</td>
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<td></td>
<td>Both</td>
<td>7%</td>
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<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Definition</td>
<td>Prevalence</td>
<td>dmft(s)</td>
<td>Comments</td>
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</table>
| Louie et al., 1990  | Data of 1796 (3-5-year-old) Head Start children from low-income families. The survey was conducted in 1986-1987 in fluoridated and non-fluoridated communities in California, Hawaii and Micronesia | Caries in three or four of the maxillary incisors                           | California                  |         | **Aims:**<br>1. To determine caries prevalence in Head Start children  
2. To determine the prevalence of BBTD  

**Findings:**<br>1) Prevalence of BBTD ranged from 13% in fluoridated community to 18% in non-fluoridated community - California. The highest prevalence was in Micronesia (36%) followed by Hawaii (29%).  
2) A need for counseling parents about the importance of early detection of BBTD and about prolonged and inappropriate feeding practice. |
|                     |                                                                        |                                                                            | Monterey Co.                | 17.9%   |                                                                                                                                         |
|                     |                                                                        |                                                                            | San Bernadino Co.           | 12.7%   |                                                                                                                                         |
|                     |                                                                        |                                                                            | Hawaii State                | 28.8%   |                                                                                                                                         |
|                     |                                                                        |                                                                            | Micronesia                  | 36.2%   |                                                                                                                                         |
|                     |                                                                        |                                                                            | Total                       | 28.5%   |                                                                                                                                         |
| Williams & Hargreaves, 1990 | 64 (36-72-month-old) Asian children in Edmonton residing within the Milbourne Health District, a relatively underprivileged residential area | One or more smooth surface lesion on maxillary primary incisor teeth        | Lesions sited labially or buccally | 14% | 8% | **Aims:**<br>1. To inquire into infant feeding practices, social characteristics and dentally related awareness and behaviour among Asians in Edmonton  
2. To determine whether and to what extent such factors are associated with caries experience  
3. To compare findings in low fluoride Leeds, UK with fluoridated Edmonton, Canada  

**Findings:**<br>1) No clear significant differences were observed between children with incisor caries and without in relation to the following:  
A. Length of time that the parents had been resident in Canada  
B. Mother's educational level  
C. Breast or bottle feeding commenced after birth  
D. Use of sweetened milk  
E. Age at which bottle feeding stopped  
F. Age when tooth brushing began  
G. Dental attendance |

*Rampant Caries Continued*
<table>
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<tr>
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<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
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</thead>
</table>
| Kaste et al., 1992  | 142 Head Start children with mean age 4.4 years obtained from a chart audit of dental records for the 1977-78 Head Start dental examination. Dental examination for the same children was carried out in 1988. The final study group comprised 88 children with a mean age of 15.2 years | Buccal/lingual of maxillary incisors | 45%        |         | 1. To assess retrospectively the caries experience  
2. To compare the prevalence rates of nursing caries obtained by using different nursing caries classification schemes.  
3. To study the relationship of prior nursing caries to high caries level determined by clinical examination in the same children approximately ten years later  
Findings  
1) Different classification schemes yielded different prevalence rates  
2) Caries defined as existing on buccal or lingual surfaces of the maxillary incisors showed no increased risk of 5 or more DMFT at the age of 15  
3) Caries defined as 2 or more, or 3 or more, decayed maxillary anterior teeth had relative risk of 1.6 and 1.4  
4) Relative risk for children with a dmft of 5 or more was 2.4  
5) The classification of nursing caries by carious maxillary incisors appears to depict the overall caries experience in the primary dentition of Native American Head Start children  
6) The maxillary anterior classifications demonstrated a positive relationship to the presentation of high caries in the permanent dentition which was not found when nursing caries was measured by buccal or lingual caries of the maxillary incisors |
<table>
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<tr>
<th>Author/Year</th>
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<th>Definition</th>
<th>Prevalence</th>
<th>dmfs</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Mateo et al., 1992b</td>
<td>442 (1.0 - 2.5-year-old) children who attended maternal and Child Health clinics in Mwanza and Morogoro regions in Tanzania were examined and feeding pattern were also obtained, mainly from the mother, in case the child experienced rampant caries</td>
<td>At least two maxillary incisors exhibit caries</td>
<td></td>
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<td>Aims:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age</td>
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<td></td>
<td>1. To assess prevalence of rampant caries</td>
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<tr>
<td></td>
<td></td>
<td>1.0-1.5-year-old</td>
<td>6.3%</td>
<td>3.3dmfs</td>
<td>2. To investigate the characteristics of rampant caries and its</td>
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<tr>
<td></td>
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<td>1.5-2.0-year-old</td>
<td>9.2%</td>
<td>5.2</td>
<td>associated factors</td>
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<td>2.0-2.5-year-old</td>
<td>13.2%</td>
<td>11.8</td>
<td>Findings:</td>
</tr>
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<td></td>
<td></td>
<td>Total</td>
<td>10.6%</td>
<td></td>
<td>1) Children with rampant caries were not evenly distributed over the</td>
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<td>five studied areas</td>
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<td>2) Children exhibited rampant caries almost exclusively on the labial,</td>
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<td>proximal and lingual surfaces of maxillary incisors</td>
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<td>3) Severity, expressed as dmfs scores, (but not the prevalence)</td>
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<td></td>
<td></td>
<td>appeared to increase significantly with age. This may indicate that the</td>
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<td>onset of rampant caries, in most of the cases, occurred in</td>
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<td>1-1.5-year-olds.</td>
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<td>4) Linear hypoplasia may predispose to caries since the carious lesions</td>
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<td>occurred on the labial surfaces of incisors between the neonatal line</td>
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<td>and gingival margin</td>
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<td>5) Extreme forms of breast feeding may predispose to rampant caries. All</td>
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<td>the 6 infants with rampant caries in the 1.0-1.5-age period were still</td>
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<td>breast-fed with a mean frequency of 14 times a day</td>
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**Rampant Caries Continued**
<table>
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<tr>
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</thead>
</table>
| Weinstein et al., 1992 | Subjects for this pilot study were parents/caretakers who enrolled a child less than 4-year-old in a woman Infant Children (WIC) or Maternal Child Health (MCH) programmes for migrant families in Yakima Valley of Central Washington. 125 8-47-month-old children and their parents participated | BBTD (Two or more decayed anterior teeth) | 29.6%      |         | Aim:  
1. To study a targeted sample of individuals from high risk population  
2. To understand risk factors  
3. To formulate acceptable intervention  
Findings:  
1) Prevalence of BBTD was high (29.6%)  
2) Age was related to disease status, BBTD babies being older (33 months) than non-BBTD babies (25.3 months)  
3) BBTD babies had mothers with more education, a greater percentage having completed high school (16.2% vs. 11.6%)  
4) When Mexican-American mothers received more help in child care (41 hours vs. 23 hours), their babies had less BBTD  
5) When the baby was fed in the evening by someone other than the mother or the father, the baby was less likely to have BBTD  
6) Giving the bottle to aid sleep and propping up the bottle were related to BBTD  
7) Not weaning at an early age was related to BBTD  
8) Babies with BBTD were easy going and less strong willed than those children with no BBTD. On the other hand they were viewed as reacting more strongly in disagreeable situations  
9) BBTD parents indicated the need for more help to stick to diet than non-BBTD parents  
10) BBTD parents visited a dentist on average 2.8 years earlier, while non-BBTD parents reported a period of 1.4 years between visits  
11) BBTD parents were less likely than non-BBTD parents to substitute immediately the cup for the bottle for all feedings  
12) Future intervention should include effective professionally supervised therapy (topical fluoride and chlorhexidine application. Parents should be allowed to choose one or more behavioural approaches which they would be willing to initiate within their household. |
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<tbody>
<tr>
<td>Schwartz et al., 1993</td>
<td>A study was conducted in a private paediatric dental practice in an urban community with a water supply fluoridated to 1ppm. Questionnaires were distributed to the two hundred consecutive new patients at the initial visit Data of 156 (14 months-5years) who have a complete set of maxillary incisors and a completed questionnaire were collected</td>
<td>“Nursing caries” = a child having caries on any primary teeth with the exclusion of children who have solely two occlusal carious lesions on their lower first primary molars</td>
<td></td>
<td></td>
<td>Aim: To determine whether there were any feeding practices by infants that would favour development of nursing caries</td>
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<td></td>
<td></td>
<td>Children given the bottle</td>
<td>37%</td>
<td></td>
<td>Findings:</td>
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<td></td>
<td></td>
<td>Children not given the bottle</td>
<td>0%</td>
<td></td>
<td>1) Children given the bottle at bed time experience significantly more cases of nursing caries than those who did not go to bed with the bottle</td>
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<td></td>
<td></td>
<td>Discarded the bottle before falling asleep</td>
<td>27%</td>
<td></td>
<td>2) Children who fell asleep with the nipple of the bottle in the mouth had more caries than those discarded the bottle and then fell asleep</td>
</tr>
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<td></td>
<td></td>
<td>Fell asleep with bottle</td>
<td>62%</td>
<td></td>
<td>3) The contents of the bottle (milk, juice, formula, other), the age at which the child stopped sleeping with the bottle as well as the age at which the child started brushing his/her teeth had an insignificant impact on the incidence of nursing caries.</td>
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<td></td>
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<td>Age stopped sleeping with bottle</td>
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<td>4) Age at which the child stopped sleeping with the bottle showed an increase in the percentage of caries till 24 months, after which a decrease was apparent. Anyhow, not all the parents were able to answer this question</td>
</tr>
</tbody>
</table>

Rampant Caries Continued
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</table>
| Tsubouchi et al., 1994 | 638 children who participated at 18 months in dental health screening in Okayama Prefecture, Japan. All communities were nonfluoridated | BBTD (maxillary incisors and frequently the maxillary and mandibular molars are affected) | 13.7%      | 0.27dft | Aim: To investigate BBTD and caries risk factors in infants in rural Japan communities  
Findings: 1) Caries prevalence in rural Japan is less than in earlier reports  
2) Weaning from breast had strong correlation with caries status. The have not weaned yet group had approximately twice the prevalence of caries than the have already weaned group (21.3% vs. 12.4%)  
3) For children who stopped using a bottle, the "have not weaned" group had significantly higher caries prevalence than the "have already weaned" group (22.2% vs. 12.1%). For children who were using a bottle results were not significantly different for weaned and not weaned yet groups (13.8% vs. 17.6%)  
4) Children who were bottle-fed only, results were not significantly different for stopped using and not stopped yet groups (13.8% vs. 14.3%)  
5) The most important risk factor was weaning from breast. Other important factors were regularity of snacking, brushing the child's teeth and snacking while playing.  

**Rampant Caries Continued**
### Table:

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<tbody>
<tr>
<td>Holt et al., 1996</td>
<td>406 (12-59-months-old) children were examined and their parents (often their mother) were interviewed.</td>
<td>Caries affecting labial or palatal surfaces of two or more maxillary incisors</td>
<td>Age groups</td>
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<td></td>
<td></td>
<td></td>
<td>12-23 months</td>
<td>2%</td>
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<td></td>
<td></td>
<td></td>
<td>24-35 months</td>
<td>6%</td>
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<td></td>
<td></td>
<td></td>
<td>36-47 months</td>
<td>14%</td>
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<td></td>
<td>48-59 months</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social class</td>
<td>I-IIID</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III-V</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not classified</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ethnic group</td>
<td>Caucasian (UK &amp; North European)</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>African &amp; Afro-Caribbean</td>
<td>3%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Asian</td>
<td>18%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comforters</td>
<td>Using sweet comforter</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not using sweet comforter</td>
<td>48%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Breast feeding</td>
<td>Stopping within 1st 12 weeks</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stopping between 12-36 weeks</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continued longer</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sweet drink in a feeding bottle</td>
<td>Having sweet drink</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not having sweet drink</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stopping by 2 years</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continued after 2 years</td>
<td>19%</td>
<td></td>
</tr>
</tbody>
</table>

**Aims:**
1. To establish the current prevalence of caries in preschool children in Camden
2. To investigate the relationship between prevalence of disease and social class, ethnic origin, infant feeding practices and use of comforters
3. To investigate the extent of dental care that has been received by children taking part in the study

**Findings:**
1) Caries affected 11% of 2-year-old children and 29% of 3-year-olds. Rampant caries affected 6% and 14% respectively
2) A higher proportion of children in the lower classes had experienced caries at all and more had rampant caries
3) More children of Asian origin had caries and more had rampant caries than did those from other ethnic groups
4) In multivariate analysis, social class failed to contribute significantly to the variation seen while being of Asian origin contributed significantly to the risk of both caries and rampant caries.
5) Although the use of comforter contributed to the risk of caries, it failed to reach statistically significant level in multivariate analysis
6) Children who were breast-fed for longer than 36 weeks had more caries
7) 9% of children who were having sweet drinks in a bottle had rampant caries compared to 4% for those who were not having drinks. 19% of children who continued having a bottle after 2 years had rampant caries compared to 6% for those who had stopped drinking from a bottle before 2 years.
8) 61% of children with caries experience were reported to have visited a dentist, yet 37% of them had received treatment.

Rampant Caries Continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmfs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doshi et al., 1995</td>
<td>227 18-48-old children were examined in two centres in Kuwait, the Kuwait Maternity Hospital and the Bayan Health Centre. Mothers were also interviewed.</td>
<td>Caries affecting labial surfaces of two or more maxillary incisors.</td>
<td>All</td>
<td>19%</td>
<td>Breast fed at least 12 months 3.7 dmfs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dmfs in anterior teeth</td>
<td>Boys</td>
<td>15%</td>
<td>Bottle fed at least 12 months 4.7 dmfs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Girls</td>
<td>23%</td>
<td>Bottle fed for less than 12 months 2.6 dmfs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Breast fed at -will &gt; 6 months 26%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaste et al., 1996</td>
<td>The Third National Health and Nutrition Examination Survey Phase I conducted from 1988-1991 in the USA to assess dental caries in 1-17-year-old 654 12 through 23 months of age received a brief “lift the lip” visual inspection for early childhood caries</td>
<td>At least one maxillary incisor showed visual evidence of caries or restoration on a labial or proximal surface</td>
<td><em>Weighted estimate for US population of infants</em> 0.8%</td>
<td>Unclassified 1.1%</td>
<td>Aims: 1. To assess dental caries in US children and adolescent 2. To assess differences in dental caries status in relation to age, sex, race and race-ethnicity Findings: 1) Fourteen children were scored positive for caries. Of these, ten were Mexican-American. Eight additional children could not be classified 2) There are limitations of the “Lift-the-lip” examination The uncertainty about calling some teeth carious (for example stained anterior teeth which the examiner was unable to score). A more appropriate estimate of prevalence would be by combining the caries positive and the unclassified Rampant Caries Continued</td>
</tr>
<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Definition</td>
<td>Prevalence</td>
<td>dmft(s)</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------</td>
<td>---------</td>
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</tr>
<tr>
<td>Ramos-Gomez et al., 1996</td>
<td>362 (186 boys &amp; 176 girls) who visited the paediatric clinic at the University of California San Francisco Medical Centre (UCSF) Most lived in the optimally fluoridated San Francisco Bay Area and most came from low-socio-economic-status families. 72% were Medi-Cal patients (a state funded health insurance)</td>
<td>Infant caries: 1- Labiolingual lesion on maxillary incisor 2- At least 2 carious maxillary incisors 3- At least 3 carious maxillary incisors 4- ≥5 dmft</td>
<td>27%</td>
<td>37%</td>
<td>A. Boys showed a higher prevalence rate than girls (37% vs. 27%) B. Ages 3-4 demonstrated a higher prevalence rate (43%) than any other age group 3) The youngest child observed with infant caries was 14-months-old 4) The high prevalence of infant caries indicates that aetiological or risk factors may eclipse the benefits of fluoridation 5) Treatment costs were high and proportional to the number of teeth involved 6) Restorative treatment was based upon the severity of the carious lesion 7) Non-compliance was due to the high cost of treatment.</td>
</tr>
</tbody>
</table>
### Table 2.3.2. Tooth Type Pattern - Anteriors/ Posteriors /Both

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmfs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>O’ Sullivan and Timooff, 1993</td>
<td>Caries data and mutans streptococci levels were collected from 481 (3-and 4 year-old) Head Start children as well as psychological information from their parents</td>
<td>Only anterior teeth</td>
<td>4.2%</td>
<td>4.0dmfs</td>
<td>Aims: 1. To define caries prevalence and patterns in anterior teeth 2. Contrast the anterior pattern with the other caries patterns in the child’s mouth 3. Compare patterns in anterior teeth with mutans streptococci levels 4. Correlate the maxillary caries with information from their parents Findings: 1) 44% of children had caries 2) Among children with both anterior and posterior caries, the mean dmfs was 14.4 more than double the combined mean dmfs of children with only one caries pattern 3) Of the children with maxillary anterior caries, 68(87%) had also posterior caries 4) All but one child with maxillary caries had recoverable mutans streptococci 5) The majority of children with both patterns (anterior and posterior) had the highest mutans infection 6) 70% of the children reported to have taken a bottle to bed did not develop the anterior caries pattern 7) 90% of parents of children with maxillary anterior caries knew the harm of taking a bottle to bed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only posterior teeth</td>
<td>26.8%</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both anterior and posterior</td>
<td>12.1%</td>
<td>14.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>mean dmft</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjarnason et al., 1995</td>
<td>631 (3-4-year-old) Latvian children (576 from the Metropolitan area and 55 from a rural area)</td>
<td>Entire dentition</td>
<td>3.2</td>
<td></td>
<td>Aim: To assess dental health in a group of Latvian nursery school children after a decline in organized preventive programmes since 1989 Findings: 1) Molar decay (2.1dmft) accounted for 66% of the total decay experience (3.2dmft) 2) The mean dmft for the total sample was 3.2 (2.2 and 3.8 in the 3 and 4-year-olds respectively) 3) A comparison between 3-and 4-year-olds indicated a mean annual increase of 73% in dmft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incisors and cuspids</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Definition</td>
<td>Prevalence</td>
<td>dmft(s)</td>
<td>Comments</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
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<td>---------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Dini et al., 1998</td>
<td>1066 (3-6-year-old) children (903 from fluoridated areas since 1963  and 163 children from a recently fluoridated area) Results were calculated separately for 3-4-year-old and 5-6-year-old</td>
<td>441 (3-4-year-old) children fluoridated areas since 1963</td>
<td>Caries free</td>
<td>67%</td>
<td>With caries 18%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars only</td>
<td></td>
<td></td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars, incisors and Canines</td>
<td></td>
<td></td>
<td>Incisors and canines only 6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 (3-4-year-old) children fluoridated since 1994</td>
<td>Caries free</td>
<td>42%</td>
<td>With caries 24%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars only</td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars, incisors and Canines</td>
<td></td>
<td></td>
<td>Incisors and canines only 13%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>462 (5-6-year-old) children fluoridated areas since 1963</td>
<td>Caries free</td>
<td>43%</td>
<td>With caries 36%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars only</td>
<td></td>
<td></td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars, incisors and Canines</td>
<td></td>
<td></td>
<td>Incisors and canines only 4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>118 (5-6-year-old) children fluoridated since 1994</td>
<td>Caries free</td>
<td>11%</td>
<td>With caries 40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars only</td>
<td></td>
<td></td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molars, incisors and Canines</td>
<td></td>
<td></td>
<td>Incisors and canines only 5%</td>
</tr>
</tbody>
</table>

Aims:
1. To define the pattern of caries in 3-6-year-old children in areas of contrasting fluoridation history using two different indices.

Findings:
1) In both areas, the majority of 3-4-year-olds had disease confined to molars
2) In areas fluoridated for more than 10 years, the highest proportion of 5-6-year-olds with caries also had the disease confined to primary molars (36%)
3) In the more recently fluoridated area, similar proportions of children had caries in primary molars alone as had caries in both primary molars and incisors (24% & 20% in 4-year-olds and 40% & 44% in 5-year-olds)
### Table 2.4. Severity Zone System

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition*</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poulsen &amp; Horowitz, 1974</td>
<td>Data from 2123 individuals 6-17-year-olds examined in three previous studies</td>
<td></td>
<td></td>
<td></td>
<td>Aim:</td>
</tr>
<tr>
<td></td>
<td>Hawaii data</td>
<td>Zone5  10.3%</td>
<td></td>
<td></td>
<td>1. To examine whether the assumption of Cumulative Zone Membership is correct</td>
</tr>
<tr>
<td></td>
<td>consists of the third year follow up examination findings of 199 children 13-15 years who comprised the controls in a clinical trial on the reducing effect of acidulated phosphate fluoride</td>
<td>Zone4  3.0%</td>
<td></td>
<td></td>
<td>2. To evaluate the accuracy of Craigie’s Method in describing the prevalence of dental caries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone3  34.8%</td>
<td></td>
<td></td>
<td>3. To determine the value of Craigie’s Method in describing the results of a caries preventive programme with an established caries reducing effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone2  25.8%</td>
<td></td>
<td></td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone1  22.7%</td>
<td></td>
<td></td>
<td>1) The basic assumption of hierarchical zone membership is not fulfilled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone0  3.0%</td>
<td></td>
<td></td>
<td>2) To fulfil the assumption, it is suggested that zones 2 and 3, and 4 and 5 to be combined</td>
</tr>
<tr>
<td></td>
<td>Brazil data</td>
<td></td>
<td></td>
<td></td>
<td>3) The reducing effect of water fluoridation is demonstrated, which shows that the biggest preventive effect is obtained in Severity Zone 2-3</td>
</tr>
<tr>
<td></td>
<td>consists of baseline examination findings of 811 children 12-16 years old who participated in a clinical trial on supervised tooth brushing with acidulated phosphate fluoride.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Zone5  9.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seagrove data</td>
<td>Zone4  3.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>consists of 766 children 6-17-year olds who were examined before school water fluoridation was started</td>
<td>Zone3  39.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone2  31.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone1  14.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone0  1.5%</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>A subset of Seagrove data consists of 322 children (7-10-year-olds) at baseline examination to be compared with 348 children 7-10-year-olds at the 4th year follow up examination representing children who had continuous exposure to school water fluoridation</td>
<td></td>
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<tr>
<td></td>
<td>Baseline examination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone5 and Zone4</td>
<td>Zone5  7.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone3 and Zone2</td>
<td>Zone4  4.7%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Zone3  12.0%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Zone2  32.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone1  22.9%</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Zone0  14.2%</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>4th year examination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone5 and Zone4</td>
<td>7yr    2.5%</td>
<td>8yr    3.3%</td>
<td>10yr  5.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone3 and Zone2</td>
<td>9.2%   25.3%</td>
<td>34.9%   53.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>44.7%  46.8%</td>
<td>50.6%   50.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>44.7%  25.3%</td>
<td>11.2%   10.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone5 and Zone4</td>
<td>1.3%   4.0%</td>
<td>2.3%    6.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone3 and Zone2</td>
<td>2.3%   15.1%</td>
<td>18.6%   29.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38.3%  40.4%</td>
<td>58.1%   51.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>58.0%  40.4%</td>
<td>20.9%   13.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Zone5: Proximal surfaces of mandibular anterior
Zone4: Labial surfaces of maxillary and mandibular anterior
Zone3: Proximal surfaces of maxillary anterior
Zone2: Proximal surfaces of posterior teeth
Zone1: Pits and fissures of posterior teeth
Zone 0: None of the above
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition*</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Wong et al., 1997 | As part of the baseline examinations of a longitudinal caries prevention trial, dental caries data were collected from 452 (3-6-year-old) Chinese preschool children in Conghua, Southern China. | Zone 0      | 10.2%      |         | Aims: 1. To analyse caries data according to hierarchical caries pattern system  
2. To assess the hierarchical assumptions of the system  
3. To evaluate the usefulness of the system as an additional caries descriptor  
Findings 1) Very low percentage (10%) of children were caries-free and a higher percentage (15% and 25%) in severity zones 4 and 5 respectively  
2) Assessing the fit of hierarchical assumption using the original severity zone criteria seem to be unsatisfactory for only 61% of children were correctly classified  
3) A cariologically most acceptable model which merged zones 2 & 3 and zones 4 & 5 correctly classified 83% of the children  
4) The hierarchical severity zone system as originally proposed must be subjected to minor modifications in order to improve the fulfillment of the basic assumptions underlying the method. The model of 4 zones instead of the original one can be used for descriptive purposes to give clinically meaningful information. Thus adding positively to the information gained from dmfs values alone. |
|                  | Zone 1                                                                 | 2.7%        |            |         |                                                                                                                                          |
|                  | Zone 2                                                                 | 5.1%        |            |         |                                                                                                                                          |
|                  | Zone 3                                                                 | 41.8%       |            |         |                                                                                                                                          |
|                  | Zone 4                                                                 | 15.3%       |            |         |                                                                                                                                          |
|                  | Zone 5                                                                 | 25.0%       |            |         |                                                                                                                                          |
|                  | Zone 0                                                                 | 10.2%       |            |         |                                                                                                                                          |
|                  | Zone 1                                                                 | 2.7%        |            |         |                                                                                                                                          |
|                  | Zone 2 & 3                                                            | 46.9%       |            |         |                                                                                                                                          |
|                  | Zone 4 & 5                                                            | 40.3%       |            |         |                                                                                                                                          |

*Zone5: Proximal surfaces of mandibular anteriors  
Zone4: Labial surfaces of maxillary and mandibular anterior  
Zone3: Proximal surfaces of maxillary anteriors  
Zone2: Proximal surfaces of posterior teeth  
Zone1: Pit and fissures of posterior teeth  
Zone 0: None of the above  

Severity Zone System Continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition*</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schwartz and Hansen, 1979</td>
<td>The study is based on epidemiologic data collected in the school year 1977-1978 from 507,485 (2-15-years) children being treated in accordance with the Child Dental Care Act. A sample of about 159,000 (2-7-year-olds) are presented</td>
<td>Zone 1</td>
<td>2yr 3yr 4yr 5yr 6yr 7yr</td>
<td>77% 63% 43% 27% 18% 14%</td>
<td>Aim: To describe certain features of the child dental care in Denmark. Findings: 1) Caries experience in primary teeth increases up to the age of 8 and then decreases sharply with the natural shedding of primary teeth. 2) With age A- A decreasing proportion of children remain caries free B- An increasing proportion of children develop a more severe type (e.g., increasing percentage of children in Zone 4 and decreasing percentage in Zone 1) C- An increasing proportion of children move simultaneously into caries groups with more tooth surfaces involved</td>
</tr>
<tr>
<td>Zone 2</td>
<td>12% 20% 24% 20% 17% 14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>2% 4% 14% 25% 36% 45%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 4</td>
<td>9% 13% 19% 28% 29% 27%</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Zone 1 No tooth surfaces have caries
Zone 2 Caries in pits and fissures in premolars and/or molars
Zone 3 Caries in proximal surfaces of canines and/or premolars and/or molars
Zone 4 Caries in incisors and/or smooth surfaces

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition*</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petersen and Guang., 1994</td>
<td>The study comprised 119 grade one children (6-year-olds) and 113 grade six children (12-year-olds) in two districts (one urban and one periurban) in Wuhan City, China. The drinking water contained 0.25ppmF. Data for the permanent dentition is not shown.</td>
<td>Zone 1</td>
<td>Primary dentition 6-yr-old 12-yr-old</td>
<td>14.3% 80.5%</td>
<td>Aims: 1. To describe the prevalence and the pattern of dental caries 2. To provide baseline data of relevance for planning and education of a school based preventive programme Findings: 1) In 6-year-olds A- The prevalence proportion of dental caries was 85.7 and for the primary teeth the mean dmft was 5.7 B- Approximal caries was prominent (22.7% were affected at the level of zone 4 and about 60% were affected at the level of zone 3) and about 60% were affected at the level of zone 4 (Incisors and/or smooth surfaces) 2) Results showed that school based oral health promotion programmes are urgently needed</td>
</tr>
<tr>
<td>Zone 2</td>
<td>3.4% 4.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>22.7% 10.6%</td>
<td></td>
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</tr>
<tr>
<td>Zone 4</td>
<td>59.6% 4.5%</td>
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</tr>
</tbody>
</table>

*Zone 1 No tooth surfaces have caries
Zone 2 Caries in pits and fissures in premolars and/or molars
Zone 3 Caries in proximal surfaces of canines and/or premolars and/or molars
Zone 4 Caries in incisors and/or smooth surfaces

Severity Zone System Continued
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition*</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td></td>
<td>A national sample of Romanian children at grade 1 (n=729) and grade 6 (n=660) was chosen consistent with the WHO pathfinder principle</td>
<td></td>
<td></td>
<td></td>
<td>Aims:</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1. To describe the prevalence and the pattern of dental caries in school children.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. To provide baseline data for planning and evaluation of oral health care</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1) At grade 1, 61% had a very severe caries in their primary dentition (i.e. caries in pits and fissures, proximal surfaces, smooth surfaces and incisors).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2) Data indicates that oral health promotion and prevention at the community level is urgently needed.</td>
</tr>
<tr>
<td>Zone1</td>
<td>No tooth surfaces have caries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone2</td>
<td>Caries in pits and fissures in premolars and/or molars</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Zone3</td>
<td>Caries in proximal surfaces of canines and/or premolars and/or molars</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone4</td>
<td>Caries in incisors and/or smooth surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigild et al., 1995</td>
<td>The study population comprised 350(4-6-12 and 15-year-old) children in kindergartens and public schools in Kuwait, selected by stratified cluster sampling. Of the study population 547 children were 4-year-old</td>
<td></td>
<td></td>
<td></td>
<td>Aims:</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1. To describe the occurrence of dental caries and fluorosis</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>2. To record the severity of decay</td>
</tr>
<tr>
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<td></td>
<td>3. To assess the current need of the study population for dental health care</td>
</tr>
<tr>
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<td></td>
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<td></td>
<td>4. To describe the trend in dental caries experience by comparing the present results with data from 1982</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5. To provide a baseline for the evaluation of preventive oral health programmes commencing in the school year 1994-1995</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1) Dental caries is a dominant oral health problem</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>A) Among the 4-year-old, caries prevalence was 81% with a mean deft of 4.6</td>
</tr>
<tr>
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<td>B) Caries experience and prevalence had increased since 1982</td>
</tr>
<tr>
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<td>2) With respect to the location of decay, 47% of 4-year-old children had decay in the front teeth, and 21% had caries in the proximal surfaces.</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td>3) Preventative activities should start in kindergartens together with health education of mothers and teachers</td>
</tr>
</tbody>
</table>
Table 2. 5. 1. Aetiology Based System – Caries Patterns

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson et al., 1984</td>
<td>200 3 ½ -5-year-old children from two Head Start Programmes in two optimally fluoridated cities (Elyria and Lorain) in Ohio</td>
<td>Caries free</td>
<td>39%</td>
<td>0defi</td>
<td>1. To classify dental caries patterns in the primary dentition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pit and fissure</td>
<td>32%</td>
<td>4</td>
<td>2. To determine the prevalence of each pattern</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;minimal&quot;</td>
<td>20%</td>
<td>5</td>
<td>3. To assess the relationship between specific life style variables and specific caries pattern</td>
</tr>
</tbody>
</table>
|                      |                                                                        | "Extensive"        | 6%         |         | Findings:
<p>|                      |                                                                        | Hypoplasia          | 6.5%      |         | 1) More children had carious lesions associated with tooth defects (38.5%) than with smooth surface lesions (22.5%) |
|                      |                                                                        | minimal            | 5%         |         | 2) For three of the four patterns, more children were classified in the &quot;minimal&quot; categories than in the &quot;extensive&quot; categories |
|                      |                                                                        | Facial-lingual      | 11%        |         | 3) For the facial-lingual category, more children were classified in the &quot;extensive&quot; category than in the &quot;minimal&quot; category |
|                      |                                                                        | minimal            | 2.5%       |         | 4) Children in the &quot;pit and fissure&quot; category were more likely to have defects of 4.0 or less than children in either the facial-lingual or the proximal |
|                      |                                                                        | &quot;Extensive&quot;        | 8.5%       |         | 5) No statistically significant differences or trends were found when comparing the questionnaire responses for caries free children and children with lesions associated with tooth defects |
|                      |                                                                        | Molar approximal    | 11.5%      |         | 6) Data for children with smooth-surface lesions differed from data for children who were caries free in the following: |
|                      |                                                                        | minimal            | 8.7%       |         | A- Mothers of caries free children were more likely to have completed high school than mothers of children with smooth-surface lesions. |
|                      |                                                                        | &quot;Extensive&quot;        | 2.8%       |         | B- Children with smooth surface caries were more likely to spend time frequently with grand parents than were caries free children. |
|                      |                                                                        | &quot;Extensive&quot;        | 0%         |         | C- Mothers of caries free children were less likely to permit the child to eat sweets without restriction than were mothers of children with smooth-surface lesions. |
|                      |                                                                        | &quot;Extensive&quot;        | 0%         |         | D- Mothers of caries free children were more likely to believe that &quot;difficulties in brushing&quot; is the main reason for cavities than mothers of children with smooth-surface caries. |
|                      | Frequent together time with parent |                      |            |         |                                              |
|                      | Caries free               | 19%                  |            |         |                                                                                             |
|                      | Fissures only             | 29.5%                |            |         |                                                                                             |
|                      | Smooth surfaces           | 42%                  |            |         |                                                                                             |
|                      | Mother completed high school |                      |            |         |                                                                                             |
|                      | Caries free               | 65%                  |            |         |                                                                                             |
|                      | Fissures only             | 62.5%                |            |         |                                                                                             |
|                      | Smooth surfaces           | 38%                  |            |         |                                                                                             |
|                      | Difficulties in brushing main reason for cavities |                    |            |         |                                                                                             |
|                      | Caries free               | 15%                  |            |         |                                                                                             |
|                      | Fissures only             | 22%                  |            |         |                                                                                             |
|                      | Smooth surfaces           | 25%                  |            |         |                                                                                             |
|                      | Mother predicts most of own teeth lost before 40 |                    |            |         |                                                                                             |
|                      | Caries free               | 17%                  |            |         |                                                                                             |
|                      | Fissures only             | 13%                  |            |         |                                                                                             |
|                      | Smooth surfaces           | 29%                  |            |         |                                                                                             |
|                      | Child permitted to eat sweets without restriction |                    |            |         |                                                                                             |
|                      | Caries free               | 45%                  |            |         |                                                                                             |
|                      | Fissures only             | 47.5%                |            |         |                                                                                             |
|                      | Smooth surfaces           | 69%                  |            |         |                                                                                             |</p>
<table>
<thead>
<tr>
<th>Author/ Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence and dmft (s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson et al., 1986</td>
<td>1310 (3 ½-5-year old) children enrolled in Project Head Start from four sites (urban fluoridated &amp; non-fluoridated, non-urban optimally fluoridated and sub-optimally fluoridated) in Ohio, USA</td>
<td>Mean dmft</td>
<td>Urban fluoridated (n=505)</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean dmfs</td>
<td>Urban non-fluoridated (n=395)</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Caries free</td>
<td>Optimal fluoride (n=183)</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lesions associated with developmental defects</td>
<td>Suboptimal fluoride (n=227)</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Pit &amp; fissure defects</td>
<td></td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Hypoplasia*</td>
<td></td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Smooth surface lesions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Facial-lingual lesions</td>
<td></td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Approximal molar lesions</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Facial-lingual plus Molar approximal</td>
<td></td>
<td>4%</td>
</tr>
</tbody>
</table>

**Aim:**
1. To determine caries levels
2. To determine percentages of children with specific caries patterns associated with different aetiologies
3. To determine the frequency distribution by severity for groups of children with carious lesions limited to tooth defects and with lesions of smooth surfaces

**Findings**
1) Scores of defs & def were (respectively) higher for the non-fluoridated sites than for the fluoridated sites in both the urban and non-urban areas
2) Respective defs & def scores were almost identical for urban and non-urban fluoridated. Likewise, scores were almost identical for urban and non-urban unfluoridated sites
3) Percentages of caries free children is higher in the urban and nonurban fluoridated sites compared with urban and nonurban unfluoridated sites.
4) Percentages of children with defects associated lesions (fissure & hypoplasia) were similar for all four study sites.
5) Percentages of children with the facial-lingual caries pattern were
   A- Similar for the urban and nonurban unfluoridated sites
   B- Higher in non-fluoridated sites than in the fluoridated sites
6) Percentages of children with the facial-lingual plus molar approximal pattern was higher in the non-fluoridated sites than in the fluoridated sites were
7) Frequency distribution by severity
   A- over half of the children with tooth defects had one or two carious surfaces.
   B- more children with smooth surface lesions had six or more carious surfaces than those with defect associated lesions.
   C- children with smooth surface lesions from fluoridated sites tended to have fewer carious surfaces than those from non-fluoridated sites.
   D- total number of lesions for children in the non-fluoridated sites with facio-lingual plus molar approximal pattern was greater than for children with the molar approximal pattern

**Caries Patterns Continued**
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Percentage distribution</th>
<th>defs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson et al., 1987</td>
<td>Dental charting of 438 2-5-year-old children (209 at a paediatric dentistry clinic in a city teaching hospital and from 229 at a suburban private paediatric dentistry practice), both sites were in fluoridated communities</td>
<td><strong>City Clinic</strong></td>
<td>&lt;2 1/2</td>
<td>2 1/2-3</td>
<td>3-3 1/2</td>
</tr>
<tr>
<td></td>
<td>Caries free</td>
<td>31%</td>
<td>18%</td>
<td>18%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Fissure</td>
<td>3%</td>
<td>6%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>Hypoplasia</td>
<td>6%</td>
<td>12%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Facial-lingual</td>
<td>60%</td>
<td>52%</td>
<td>47%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Molar approximal</td>
<td>0%</td>
<td>0%</td>
<td>9%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Facial/lingual/Molar approximal</td>
<td>0%</td>
<td>12%</td>
<td>10%</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td><strong>Private clinic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caries free</td>
<td>57%</td>
<td>66%</td>
<td>34%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>Fissure</td>
<td>6%</td>
<td>6%</td>
<td>19%</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Hypoplasia</td>
<td>6%</td>
<td>3%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Facial-lingual</td>
<td>31%</td>
<td>22%</td>
<td>22%</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>Molar approximal</td>
<td>0%</td>
<td>3%</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Facial/lingual/Molar approximal</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>19%</td>
</tr>
</tbody>
</table>

**Caries Patterns Continued**
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zammit et al., 1994</td>
<td>343 (5-22-year-old) students selected from two Inuit communities (Nain and Hopedale) to study the need for orthodontic care. Of those, 51 (5-6-year-old) were with a complete primary dentition</td>
<td>Caries free</td>
<td>Primary 5-6-year-old</td>
<td>dmft + DMFT = 6.85</td>
<td>Aim: 1. To record dental caries patterns and relate these caries patterns to traditional dmft (DMF) index values. 2. To examine the cross-sectional data on caries patterns for characteristics of caries progression from primary to the early adult dentition. 3. To determine the preventive need.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pit and fissure</td>
<td>Permanent 15-22-year-old</td>
<td>dmfs + DMFS = 15.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypoplasia</td>
<td>4% 2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FAC/def</td>
<td>4% 38%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>smooth surfaces*</td>
<td>- 3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molar proximal</td>
<td>7% 8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facial/maxillary with molar proximal</td>
<td>17% 22%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>68% 26%</td>
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</table>

* (including approximal surfaces of incisors and the mesial surface of the canine)
Table 2.5.2. Aetiology Based System- Caries Analysis System.

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
</table>
| O'Sullivan & Tinanoff 1993a | 217 3-5-year-old African-American, Hispanic and Caucasian children enrolled in two different Head Start programmes in Connecticut 130 (59.9%) of the sample were caries positive after one year. | **Children with maxillary anterior pattern**  
Pit/fissure pattern  
posterior proximal  
posterior buccal/lingual | 89.2%  
40.5%  
32.4% |         | **Aims:**  
1. To quantify the association between maxillary anterior pattern and other patterns in primary teeth  
2. To determine caries risk factors in children participating in a one-year study  
**Findings:**  
1) In one year, larger percentage of children with maxillary anterior pattern were affected by posterior proximal and buccal/lingual than were (caries positive) children who did not have the maxillary anterior pattern. |
<table>
<thead>
<tr>
<th>Author/Year</th>
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<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglass et al., 1994</td>
<td>A total of 625 (3-4-year-old) children (426 from Connecticut Head Start programmes (80 White, 226 Black, 120 Hispanic) and 199 Chinese from Beijing nursery schools)</td>
<td>White</td>
<td>3-year-old (n=58) 4-year-old (n=22)</td>
<td>Fissure 22.4% 31.4% Maxillary anterior 13.8% 22.7% Posterior proximal 5.2% 9.1% Posterior Buccal/lingual (smooth) 3.4% 9.1% Caries Positive 27.6% 31.8%</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>38.9% 44% Maxillary anterior 17.5% 20% Posterior proximal 2.2% 12% Posterior Buccal/lingual (smooth) 3.2% 7% Caries Positive 47.6% 49%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>(n=69) (n=51)</td>
<td>Fissure 52.2% 35.3% Maxillary anterior 12% 11.8% Posterior proximal 7.2% 11.8% Posterior Buccal/lingual (smooth) 2.9% 5.9% Caries Positive 51.1% 43.1%</td>
<td></td>
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</tr>
<tr>
<td>Chinese</td>
<td>(n=95) (n=104)</td>
<td>Fissure 62.1% 72.1% Maxillary anterior 43.2% 45.2% Posterior proximal 14.7% 46.2% Posterior Buccal/lingual Caries Positive 8.4% 11.5% 67.4% 74%</td>
<td></td>
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</tbody>
</table>

**Aim:**
1. To demonstrate the application of the Caries Analysis System by comparing prevalence and pattern between a developed (Connecticut/USA) and a developing (Beijing/China) population.

**Findings**
1. There are differences in prevalence among the racial/ethnic groups:
   - A. Higher among Chinese
   - B. Lower in White than in Black
   - C. Similar in Hispanic and Black
2. Prevalence increases with age, with the lowest increases in fissure and maxillary anterior caries.
3. Fissure caries is the most common pattern.
4. The caries analysis system provides a more complete and detailed profile of the caries experience than the traditional dmft(s) index by using the descriptors of prevalence, severity and distribution.
   - A. Severity of maxillary anterior caries in Hispanic children is low (15%) and it is lower than the other racial/ethnic groups.
   - B. Chinese children although experiencing a high prevalence of all caries patterns are no more severe than those seen in Connecticut children.
   - C. Hispanics have the greatest distribution of fissure caries.

**Caries Analysis System Continued**
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Definition</th>
<th>Prevalence</th>
<th>dmft(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglass et al., 1995</td>
<td>400 3-6-year-old children from Beijing nursery schools</td>
<td>Fissure</td>
<td>3-year-old</td>
<td>62%</td>
<td>Aim: To employ a surface-specific, etiologically based caries analysis system in Chinese children with high levels of caries to further understand caries prevalence, patterns and progression in developing countries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxillary anterior</td>
<td>4-year-old</td>
<td>72%</td>
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<tr>
<td></td>
<td></td>
<td>Posterior proximal</td>
<td>62%</td>
<td>42%</td>
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<tr>
<td></td>
<td></td>
<td>Posterior buccal/lingual</td>
<td>43%</td>
<td>14%</td>
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<tr>
<td></td>
<td></td>
<td>(smooth)</td>
<td>11%</td>
<td>9%</td>
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<tr>
<td></td>
<td></td>
<td>Fissure</td>
<td>6-year-old</td>
<td>81%</td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxillary anterior</td>
<td>6-year-old</td>
<td>82%</td>
<td>1) In 3-year-old the most prevalent caries patterns were fissure caries (62%) and maxillary anterior (42%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior proximal</td>
<td>82%</td>
<td>42%</td>
<td>2) No significant change in maxillary anterior pattern with age</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior buccal/lingual</td>
<td>30%</td>
<td>62%</td>
<td>3) An increase in the fissure pattern with successive age groups reaching a maximum of 82% in the 6-year-olds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(smooth)</td>
<td>68%</td>
<td>25%</td>
<td>4) A greater increase in the posterior proximal pattern with a prevalence of 14% in the 3-year-olds and 68% in the 6-year-olds</td>
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<td>24%</td>
<td>Caries Analysis System Continued</td>
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<td>Author/Year</td>
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<td>Prevalence</td>
<td>dmft(s)</td>
<td>Comments</td>
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<tr>
<td>O'Sullivan et al., 1994</td>
<td>2003 (3-5-year-old) Navajo children who were participant in Head Start Programme from more than 100 centres located in Arizona and New Mexico. A convenience sample of 115 children younger than three years of age who were enrolled in the WIC (Women, Infants, and Children programme.</td>
<td>&lt;2-year-old</td>
<td>Maxillary pattern: 11%</td>
<td>Fissure: 20%</td>
<td>Posterior proximal: 8%</td>
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<tr>
<td></td>
<td></td>
<td>2-year-old</td>
<td>Maxillary pattern: 36%</td>
<td>Fissure: 20%</td>
<td>Posterior proximal: 8%</td>
</tr>
<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Definition</td>
<td>Prevalence</td>
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<tr>
<td>Douglass et al., 1996</td>
<td>127 (4-year-old) Apache children from White river Head Start programmes examined in 1993</td>
<td>Maxillary anterior</td>
<td>73%</td>
<td>8.33dmft 19.15dmfs</td>
<td>Aims: 1. To assess dental caries and levels of salivary mutans streptococci in a contemporary Apache preschool population</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fissure caries</td>
<td>92%</td>
<td>10.59 ds</td>
<td>2. To compare caries levels and patterns in this population with similar information from data collected 15 years earlier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior proximal</td>
<td>68%</td>
<td>2.20 ms</td>
<td>Additional aim: 3. To determine the impact of nursing (2 or more carious teeth in the maxillary anterior pattern) on dental health of the 1993 cohort</td>
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<tr>
<td></td>
<td></td>
<td>Posterior Buccal/lingual</td>
<td>49%</td>
<td>6.35 fs</td>
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<td></td>
<td></td>
<td>(smooth)</td>
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<td></td>
<td></td>
<td>Caries positive</td>
<td>95%</td>
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<td>Information on 113 (4-year-old) from the same location was obtained from a chart audit of the 1978-79 Head Start dental examination</td>
<td>Maxillary anterior</td>
<td>79%</td>
<td>9.15dmft 19.78 dmfs</td>
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<td></td>
<td></td>
<td>Fissure caries</td>
<td>92%</td>
<td>14.59 ds</td>
<td></td>
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<td></td>
<td></td>
<td>Posterior proximal</td>
<td>71%</td>
<td>3.89 ms</td>
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<td></td>
<td></td>
<td>Posterior Buccal/lingual</td>
<td>39%</td>
<td>1.29 fs</td>
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<td></td>
<td></td>
<td>(smooth)</td>
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<td></td>
<td></td>
<td>Caries positive</td>
<td>95%</td>
<td></td>
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<tr>
<td>Children with nursing caries</td>
<td>Fissure</td>
<td>97%</td>
<td></td>
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<tr>
<td></td>
<td>Posterior proximal</td>
<td>78%</td>
<td></td>
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<tr>
<td></td>
<td>Posterior Buccal/lingual</td>
<td>60%</td>
<td></td>
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<tr>
<td></td>
<td>(smooth)</td>
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</tr>
<tr>
<td>Children without nursing caries</td>
<td>Fissure</td>
<td>97%</td>
<td></td>
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<tr>
<td></td>
<td>Posterior proximal</td>
<td>58%</td>
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<tr>
<td></td>
<td>Posterior Buccal/lingual</td>
<td>32%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(smooth)</td>
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<th>Prevalence</th>
<th>dmfs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>O'Sullivan and Tinsmoff 1996</td>
<td>142 Head Start children from several centers located in an inner-city environment in Hartford, Connecticut, an optimally fluoridated city were examined once annually for 2 years. The children had a mean age of 3.8 years at baseline examination.</td>
<td>Baseline examination Caries-free</td>
<td>59%</td>
<td>0.0 dmfs</td>
<td>Aim: To report on the association between baseline caries patterns and further caries development in preschool children after two years of study</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pit and fissure Maxillary anterior caries with or without posterior caries</td>
<td>28%</td>
<td>3.02</td>
<td>Findings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After two years Caries-free Pit and fissure Maxillary anterior caries with or without posterior caries</td>
<td>10%</td>
<td>5.0</td>
<td>1) After two years, children with maxillary anterior caries or pit/fissure caries had a mean posterior dmfs of greater than 7 and 4 times, respectively than mean dmfs of children who were caries-free at baseline</td>
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<td></td>
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<td>2) When specific type of posterior tooth surface affected was analysed by baseline caries pattern, the pit and fissure pattern had the largest number of carious surfaces per child in all three baseline caries</td>
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<td>3) In the group that presented with pit and fissure caries at baseline, a change in dmfs for the proximal posterior and buccal/lingual patterns were 4 and 3 times greater, respectively than change for those in the caries-free group</td>
</tr>
<tr>
<td></td>
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<td>4) In the group presented with the maxillary caries at baseline A- Children in this group not only began the study with a greater level of pit/fissure caries than children categorized with the pit/fissure pattern without maxillary anterior caries, but the two-year incidence of pit/fissure caries was also greater in those with the maxillary anterior pattern than those with the pit/fissure pattern</td>
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<td>B- A change in the proximal posterior pattern was 8 times greater than those of children who began caries-free</td>
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<td>5) Not only the maxillary anterior pattern but also the pit and fissure pattern had a hierarchical relationship with continued decay.</td>
</tr>
</tbody>
</table>

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<tbody>
<tr>
<td>Thibodeau and O'Sullivan, 1996</td>
<td>146 children of low socioeconomic status, initial mean age 3.8 years, were examined for dental caries at baseline and once annually for 2 years. This cohort represented all children who completed a 2 year longitudinal study that initially started with 462 subjects</td>
<td></td>
<td>Baseline</td>
<td>dmft(s)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Low (0CFU)</td>
<td>Moderate (1-50 CFU)</td>
<td>High (&gt;50CFU)</td>
</tr>
<tr>
<td></td>
<td>Pit and fissure</td>
<td>12%</td>
<td>28%</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maxillary anterior</td>
<td>-</td>
<td>8%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posterior proximal</td>
<td>-</td>
<td>6%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posterior smooth (Buccal/lingual)</td>
<td>-</td>
<td>2%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After 2 years</td>
<td>Low (0CFU)</td>
<td>Moderate (1-50CFU)</td>
<td>High (&gt;50CFU)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pit and fissure</td>
<td>36%</td>
<td>50%</td>
<td>81%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maxillary anterior</td>
<td>-</td>
<td>13%</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posterior proximal</td>
<td>8%</td>
<td>12%</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posterior smooth (Buccal/lingual)</td>
<td>6%</td>
<td>5%</td>
<td>19%</td>
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</tr>
</tbody>
</table>

**Aim:**
To assess the association between levels of salivary mutans streptococci and the prevalence, incidence and distribution of caries patterns in primary dentition.

**Findings**
1. Children with low baseline salivary mutans streptococci levels are more likely to be caries free (87.9%) and have a lower dmft (3.17) after 2 years than children with moderate (6.52) and high (9.15) baseline levels.
2. There is a positive association between salivary mutans streptococci levels and the prevalence of caries patterns. Children in the high SMS group had the highest prevalence of each pattern and vice versa.
3. Of all the children in the Maxillary anterior pattern at the second examination, none had a low baseline salivary mutans streptococci level. Conversely no children with low baseline SMS level developed the Maxillary pattern.
4. SMS levels are proportional to the severity of Pit and fissure caries for both cross-sectional and longitudinal data.
5. The incidence of the MA, PP, and BL patterns (i.e., increase in the number of children with these patterns) was greater in the high than the low SMS group.

**Caries Analysis System Continued**
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<th>dmft(s)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Dini et al., 1998</td>
<td>1066 (3-6-year-old) children (903 from fluoridated areas since 1963 and 163 children from a recently fluoridated area) Results were calculated separately for 3-4-year-old and 5-6-year-old</td>
<td>Fissure</td>
<td>25%</td>
<td></td>
<td>Aim: To define the pattern of caries in 3-6-year-old children in areas of contrasting fluoridation history using two different indices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxillary/mandibular anteriors</td>
<td>15%</td>
<td></td>
<td>Findings:</td>
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<tr>
<td></td>
<td></td>
<td>Posterior proximal</td>
<td>12%</td>
<td></td>
<td>1) In both areas, the prevalence of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior buccal/lingual (smooth)</td>
<td>5%</td>
<td></td>
<td>A- Fissure caries and posterior buccolingual surface pattern in 3-6-year-olds were twice as great as those observed in 3-4-year-olds</td>
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<td>B- Posterior proximal pattern showed a 2.5 times increase in prevalence between the two age groups</td>
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<td>2) For both posterior proximal and posterior buccolingual, the prevalence in the most recently fluoridated area were three times those in the areas fluoridated since 1963</td>
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<td>3) The prevalence of maxillary/mandibular anteriors in 3-4-year-olds in the area fluoridated in 1994 was twice that in the areas fluoridated in 1963</td>
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<tr>
<td></td>
<td>441 (3-4-year-old) children fluoridated areas since 1963</td>
<td>Fissure</td>
<td>42%</td>
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<tr>
<td></td>
<td></td>
<td>Maxillary/mandibular anteriors</td>
<td>33%</td>
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<tr>
<td></td>
<td></td>
<td>Posterior proximal</td>
<td>29%</td>
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<tr>
<td></td>
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<td>Posterior buccal/lingual (smooth)</td>
<td>16%</td>
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<td></td>
<td>45 (3-4-year-old) children fluoridated since 1994</td>
<td>Fissure</td>
<td>49%</td>
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<tr>
<td></td>
<td></td>
<td>Maxillary/mandibular anteriors</td>
<td>20%</td>
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<td></td>
<td></td>
<td>Posterior proximal</td>
<td>30%</td>
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<td></td>
<td>Posterior buccal/lingual (smooth)</td>
<td>11%</td>
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<td></td>
<td>462 (5-6-year-old) children fluoridated areas since 1963</td>
<td>Fissure</td>
<td>76%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Maxillary/mandibular anteriors</td>
<td>47%</td>
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<td></td>
<td></td>
<td>Posterior proximal</td>
<td>72%</td>
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<tr>
<td></td>
<td></td>
<td>Posterior buccal/lingual (smooth)</td>
<td>47%</td>
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