CHAPTER 2: LITERATURE REVIEW

2.1 A new perspective for nutrition: the oral health connection

Nutrition and the oral health connection is a relatively new area being explored. Nutrition is a complex science involves not only food and diets, but also makes use of principles from biochemistry, genetics, immunology, physiology and molecular biology to deal with the process of incorporating into the body essential compounds from the trophic environment that cannot be synthesized by human tissues. These disciplines are useful in dealing with the nutrition process at the level of the individual and its tissues. Beyond tissues and organs, nutrition also includes concepts from behavioral science, sociology, economics, agriculture and marketing. These disciplines enter into the expanded domain of nutrition and contribute to the determination of the process by which foods and nutrients are brought to the table of individuals and eventually are incorporated into tissues (Navia, 1995).

Many scientists regard the 1940's and 50's as the "Golden Era of Nutrition", when the role of protein, amino acids, vitamins and minerals (particularly new essential trace elements) in the eradication of nutritional deficiencies were discovered. Twenty years later, new contributions from biochemistry and genetics led to the development of molecular biology and its impact on nutrition.

In the late 1970s, new scientific evidence gave support to the concept that nutrients were not only essential to growth, development and maintenance of tissues but were also linked to the expression of gene information, the effectiveness of the immune system, the prevention of cell damage and in general to increase resistance to many chronic diseases and even some infectious diseases. The relevance of health maintenance and disease prevention resulted in a renewed interest in nutrition that expanded beyond the domain of classical nutritional deficiencies.

Diet and its nutritional consequences have a profound influence on the control and prevention of many chronic conditions such as osteoporosis, cardiovascular disease, high blood pressure, cancer as well as play an important role in many oral diseases and pathoses such as dental caries, periodontal disease, salivary gland dysfunction and soft tissues lesions. In addition, the effect of specific nutrients such as vitamin A and carotene may contribute to the prevention of many intestinal and respiratory infections (Underwood, 1990). Thus morbidity can be reduced and the quality of life improved through nutrition and modification of our daily diet. .

Most countries have formulated specific national dietary intake guidelines for healthy populations related to specific age cohorts. These are recommended dietary allowance (RDA) which specify the amount of nutrients to be consumed daily by healthy individuals of different sexes and ages living in the specific country (Food and Nutrition Board, 1989).

In Malaysia the reference standards of nutrient intake was compiled in 1975 based on WHO technical report series published between 1962 and 1973 (http://nutriweb.org.my/publications/mjn0010_2/preliminaries.pdf). New scientific knowledge over the past three decades has prompted the Technical Working Group (TWG) on Nutritional Guidelines under the support of the National Coordinating Committee on Food and Nutrition (NCCFN), Ministry of Health Malaysia, to revise the RDI. The main task of the sub-committee was to review the "state of art" of current dietary recommendations and to update the current RDI. The new Recommended Nutrient Intake for Malaysia (RNI) was launch in year 2005.

The science of nutrition is concerned with maintenance of health and prevention of diseases, particularly chronic diseases (including dental caries), which are responsible for the high rate of morbidity and mortality in developed countries (Navia, 1994). Many research were conducted to understand the role of nutrition and diet in the reduction of

risk for chronic diseases. The stakeholders involved nutritionists, public health professionals, clinicians, food manufacturers, consumer representatives and policy makers in attempts to determine amounts, combination, functional properties (Pomeranz, 1985), and consequence of foods in the diet, as well as the interactions of nutrients that could reduce the risk factors associated with specific disease conditions (National Research Council Diet and Health,1989).

Further, the US Department of Agriculture (USDA, 1990), noted the link between nutrition and prevention of chronic diseases, including related to oral health. Navia (1994) stated that nutrition has 2 roles of oral health. First, there were systemic effects mediated by absorbed nutrients to fulfill the biological function important to the development and maintenance of oral tissues and the natural protective mechanism in the oral cavity. Secondly, the local influence of foods, their organoleptic properties and nutrient composition on the implantation, colonization and metabolism of pathogenic bacteria in dental plaque and stimulation of salivary flow.

Many studies on association between food intake and dental health had been done in humans (Rugg-Gunn, 1983; Scheinin, 1975; Scheinin, 1985) and animals (Michalek, 1977; Firestone, 1984). They identified carbohydrates (including starch) and sugars as the most important caries promoting components of foods. Consequently, during the past 40 years, research and health education have focused on decreasing sugar in the diet and fluoride to prevent caries. Extensive research has reaffirmed the importance of these two actions in the control of caries. It has also contributed additional information and understanding about the role of diet, foods, nutrients, and nutrition in general that needs to be considered when the relation between sugars, carbohydrates and dental caries is being evaluated.

Thus in conclusion, we have shown that past research have established that diet and to a lesser extent, nutrition, affects oral health status, especially dental caries.

However, the present study will attempt to explore a new perspective ie.whether intervention efforts aimed at controlling dental caries, can have a collateral impact in improving nutritional status as evidenced by changes in anthropometric measures such as BMI. This may provide evidence that the Common Risk Factor Approach (Sheiham & Watt, 2000) in health promotion is a practical and pragmatic strategy or otherwise.

In order to have effective intervention of dental caries and nutrition in an integrated manner, young children must be targeted as early in life as possible. The following section will discuss the classification of young children in the context of the situation in Malaysia.

2.2 Vital Statistics of young children and households in Malaysia.

Children are a valuable asset to the country. The progress of the country is dependent on the health status of children today to enable them to become healthy and productive adults. The Malaysian Pediatric Association (2003) divided young children into three categories: infants (0-1year old), toddlers (1-4 years old) and preschool (5-6 years old). The present study will use this age-linked definition henceforth when referring to the terms infants, toddlers and preschoolers.

In Malaysia, the rate of population growth from 2000-2010 was 2.17% which was lower compared to 1991-2000 period (2.64%). This resulted in a reduction of population aged less than 15 years old which was 27.7 in 2009 to 27.2 in 2010. The population decline was probably due to the decrease in the crude birth rate from 18.1 in 2007 to 17.8 in 2008. The infant mortality rate also increased slightly from 6.2 in 2007 to 6.4 in 2008. The average household size showed a shrinking trend, from 4.62 in 2000 which dropped to 4.31 in 2010 (Department of Statistic, 2010).

However, three states ie. Sabah, Kelantan and Terengganu recorded the highest household size compared to other states in Malaysia, with each state having an average

of 5.88, 4.86 and 4.78, respectively (Department of Statistic, 2010). The implications of this trend is that these poorer states tend to have higher population growth, poorer health (and oral health) status indicators and thus need more urgent health promotion intervention programs. This is one of the reasons why Kelantan was chosen for the present intervention study. The following section will discuss what types of malnutrition problems can exist in young children.

2.3 Malnutrition problems among children - global and local scenario

Eating disorders or excess food problems exist in tandem with each other (Abu Bakar and Tee, 1998). For children, it is essential to receive foods in the appropriate amounts for them to grow well and stay healthy. Nutrition in the early years of life plays a big role in physical, mental and emotional development. Poor and inadequate nutrition leads to malnutrition, morbidity and mortality among preschool children (Vaid & Vaid, 2005). During the preschool age, children have special nutritional needs because of their extensive growth and development (WHO, 1995; Blossner, de Onis & Uauy, 2006). Malnutrition, especially among preschool children, is a huge obstacle to overall national development (Bishnol *et al*, 2004).

2.3.1 Over-nutrition/Obesity problems

Obesity is the most common nutritional problem among children in developed countries (Sorof and Daniels, 2002). It is a complex, multifactorial and chronic condition resulting from interplay between environment and genetics (Segal & Sanchez, 2001). The prevalence of obesity has been growing at an alarming rate for decades in both children and adults (Giammattei *et al*., 2003). Obesity prevalence is between 14 – 20% in industrialized countries, but the fastest increases, particularly in childhood obesity, are seen in developing countries such as Chile and China (Finer, 2003).

Worldwide, about 22 million children under the age of five are overweight (Finer, 2003).

In Thailand, the prevalence of obesity in 5 -12 years old children increased from 12.2% to 15.6% in just two years (WHO, 2003). The prevalence rate of childhood obesity in China reached 7.1% in Beijing and 8.3% in Shanghai in the year 2000 (WHO, 2000a).The rate rose with age, from 3.7% among 3-year-olds to 11.7% among 6-year-olds (WHO, 2000b).

In Malaysia, obesity among children also increased with increasing age: 6.6% among 7-year-olds, rising to 13.8% among 10-year-olds. Obesity among these 7 to 10 years-olds was higher among boys (12.5%) than girls (5%). Ethnic differences were also found, especially among boys, with 16.8% of Malays being obese compared to about 11.0% of Chinese and Indians (Ismail and Tan, 1998). The Third National Health and Morbidity Survey III (NHMS, 2006), found that the prevalence of overweight based on BMI-for-age for the children below 5 years for both sexes increased to 6.4% (Khor *et al*., 2009) compared to same cohort survey done by the Ministry of Health Malaysia and UNICEF in 1999-2000, where the prevalence of overweight was 3.3% for both boys and girls (MOH, 2000).

The increasing prevalence of obesity among children occurred due to adoption of industrialized society lifestyles such as urbanization, western foods, increased sedentariness and car ownership (Sherina and Rozali, 2004). The shift towards a "westernized" dietary pattern has brought about a new nutrition scenario in many developing countries (Tee, 1999). In Malaysia, rapid and marked socio-economic advancement over the past two decades has brought about significant changes in the lifestyles of communities. Significant changes in dietary patterns include for e.g. an increase in consumption of fats, oils and refined carbohydrate and a decreased intake of complex carbohydrates, while an increase in the percentage contribution of fat has been

observed (Tee, 1999). Changes in a meal patterns also contributed to this problem. More families eat out, busy executives skip meals, and the younger generation miss breakfast and rely too much on fast foods (Tee, 1999).

2.3.2 Under-nutrition

At the other end of the spectrum, hunger and malnutrition are devastating to developing countries, particularly for the poor and under-privileged groups. Despite impressive advances in health sector technology in recent decades, many in developing countries remain vulnerable to food insecurity, under-nutrition and ill health (World Bank, 2001). Malnutrition remains one of the most common causes of morbidity and mortality among children throughout the world. About 60% of 10.9 million children under-five deaths every year and over two-thirds of these deaths are associated with inappropriate feeding practices during the first year of life (WHO, 2002; WHO, 2003). Based on the 388 national surveys from 139 countries, it was estimated that maternal and child under-nutrition was the underlying cause of 3.5 million deaths and 35% of the disease among children younger than 5 years (Black *et al*, 2008).

In Asia, about 128 million (70%) children under five years were stunted (Allen and Gillespie, 2001). In India, 61.6% of preschool children were underweight (below 2SD), 51.6% were stunting, and 32.9% were wasting (Rao *et al*., 2005). In Bangladesh, the prevalence of underweight among children aged below five has been reduced from 69.3% in 1985 to 47.0% over 20 years. For the same period, the proportion of stunted children reduced from 55.7% to 30.8% (Faraque *et al*., 2008). However, a more recent study in Bangladesh on 5242 children aged 0-59 months, found that the trend of stunted had increased to 43% (Mostafa *et al*., 2010).

In Malaysia, under-nutrition from 1984 to 2006 had shown a decrease. Chong *et al*. (1984) in a survey of 14 impoverished villages in Peninsular Malaysia involving

3600 subjects found stunting in 43% of the preschool children. A decade later, another large scale study in low income rural communities, including rice-growing, coconut and rubber smallholdings and fishing villages in Peninsular Malaysia was carried out. A total of 2415 subjects aged 18 years and below were assessed. The result showed that, in children 1-6 years, 32.6% of boys and 35.9% of girls were underweight, while the prevalence of stunting was 28.0% among boys and 28.8% in girls.

The National survey involving 5383 children below 5 reported the prevalence of 19.8% underweight boys was and 18.5% girls. For stunting the prevalence were 17.5 % boys and 15.5% girls (MOH, 2000). In the Third National Health and Morbidity Survey in 2006, (NHMS III, 2006) on 21,000 children aged 0-17.9 years the overall prevalence of underweight children was 12.9% and stunting, 17.2% (Khor *et al*., 2009).

The NHMS III recommended that in order to prevent malnutrition problems, there was a need for more innovative intervention programs to further improve the nutritional status of young children, especially in reducing stunting. Specific strategies to improve household food security, promote optimal breastfeeding and young child feeding practices and preventing macro and micro-nutrient deficiency should be re-assessed and followed up with culturally appropriate interventions. This is particularly relevant in the current climate of economic uncertainties culminating in rising costs of food and services. The challenge of providing quality food and health care for the young, especially from poor households, becomes increasingly complex and formidable (Khor *et al*, 2009). Hence, the present study concurred that diverse and innovative approaches that integrates and involve multisectoral agencies are needed to overcome malnutrition.

2.4 Early Childhood Caries (ECC)

2.4.1 Early childhood caries, its causes and impact

Caries is a Latin word meaning decay. Dental caries is the most common chronic disease of childhood. It is five times more frequent than asthma, which are the second most common chronic diseases. Among 2 to 5-year olds, 19% have untreated caries and 45% of school-aged children have caries in their permanent teeth (DePaola, 2002). Carious teeth may cause pain, chewing difficulties, speech problems, general health disorders and psychological problems (Mattos-Graner *et al*, 1998; Berkowits, 2003). Treatment of ECC is expensive; it may require general anaesthesia and new caries tend to occur (Tinanoff *et al*, 1998; Almeida *et al*, 2000). In the UK, ECC affects one in 10 of all 3 – 4 year old children. ECC is a serious public health problem especially in disadvantaged communities in both developing and industrialized countries (Davies, 1998).

ECC has a unique pattern of decay involving primary maxillary incisors followed by the maxillary molars and rarely the mandibular molars (Shelton *et al*, 1977; Ripa, 1988). This is thought to be related to the protective effect of the tongue during suckling. This type of rampant decay has been associated with prolonged bottle feeding beyond 12 months of age. History usually reveals that the child takes the bottle to bed at night and nap times. Lactose can be metabolized by plaque bacteria, resulting in potential acid demineralization of enamel (Jenkins *et al*, 1966). The cariogenic potential of milk supplemented with sucrose or the substitution of milk with beverages high in refined sugar content is a precursor of this disease.

The disease process is due to repeated exposure to acids produced during bacterial fermentation of carbohydrates that erodes the enamel. The erosion is progressive and can lead to cavitation of the enamel and thereafter of the dentin. The dietary component of the disease process is difficult to quantify. Sugars, modified

starches and starches are subject to fermentation; sugared soda-pop, confections and starched baked with sugars are considered highly cariogenic (Campain *et al*, 2003; Marshall *et al*, 2003). Dietary habits, that is, when and how the beverage or food is consumed, can modify this risk. Frequent consumption of sugars is thought to increase the risk (Marshall *et al*, 2005).

Sucrose is well known to facilitate implantation of cariogenic streptococci as well as an excellent substrate of acid production (Scherp, 1971). The cariogenic potential of milk in ECC probably reflects a situation of increased exposure time to a substrate which when conventionally consumed causes no harm. The decreased salivary flow rate during sleep renders the dentition more susceptibility to acid production by plaque bacteria. These two factors, namely increased exposure time and decrease in salivary flow, seem to be critical in etiology and pathogenesis of this condition. Iida *et al.,* (2007) identified four factors associated with ECC: prolonged breast and /or bottle feeding, sugar containing liquids in the bottle, falling asleep while feeding and genetic predisposition. ECC in infants and preschool children appears to be related to feeding behaviors after prolonged bottle-feeding (Garcia-Godoy *et al*., 1995).

Several studies stated that, human milk is more cariogenic than cows milk. It is clear from case reports and case series that breast-feeding, even exclusive breast-feeding, can cause caries in the maxillary incisors or nursing bottle caries (Runn-Gunn *et al*., 1985; Thomson *et al*., 1996; Bowen & Lawrence, 2005). Thus patterns in the introduction of foods, when eating behaviors are being established, may be influential in the prevention and treatment of ECC (Tinanoff and Palmer, 2000). This includes promotion of healthy diet and hygiene practices and provision of fluoridated water (Ismail *et al*, 1998). According to Allen (1994), a healthy diet has been shown to promote child growth as well as development (Granthan-Mc Gregor and Powel, 1991). It also prevents other diseases in early childhood related to malnutrition (WHO, 1995).

2.4.2 Definition of early childhood caries (ECC)

Many terms has been used to describe caries in children aged 0 to 5. This shows that confusion exists in the literature. According to Faine (2001), ECC which occurs in about 10% of 2-year olds has been called nursing caries, nursing bottle caries and baby bottle tooth decay. The following expressions are used interchangeably: *baby bottle tooth decay, early childhood caries, early childhood dental decay, early childhood tooth decay, comforter caries, nursing caries, maxillary anterior caries, rampant caries*, and many more (Ismail *et al.*, 1999; Dilley *et al*., 1980; Lacroix *et al*., 1997; Tinanoff *et al.,* 1997). Some were used specifically to illustrate the causes of tooth decay in preschool children (Ismail *et al.*, (1999). Baby bottle tooth decay is used in the literature to identify inappropriate baby bottle use as the main cause of caries disease (Lacroix *et al.*, (1997).

Most of the researchers prefer the term *nursing caries* because it designates inappropriate bottle use and nursing practices as the causal factors (Dilley 1980; Ripa 1988). However, the term of early childhood caries is becoming increasingly popular with dentists and dental researchers a like (Drury *et al.*, 1999; Ismail 1999; Tinanoff 1997). This broader term encompasses other, less understood, practices as etiological factors, such as malnutrition, cariogenic childhood foods, and bacterial transmission from mothers or caregivers to children (Tinanoff, 1997).

According to American Academy of Pediatric Dentistry, (2007) and Drury *et al.*, (1999), the disease of early childhood caries (ECC) is the presence of one or more decayed (noncavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger. In children younger than 3 years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC). From ages 3 through 5, one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth, or a

decayed, missing, or filled score of >4 (age 3), >5 (age 4), or >6 (age 5) surfaces constitutes S-ECC.

A group of experts designated by the National Institutes of Health USA to develop and adopt a consensus regarding a clinical definition and diagnostic criteria for these types of caries has also adopted the term **early childhood caries** to describe caries in preschool-age children (Drury, 1999). The following clinical definition of early childhood caries (ECC) has been proposed. The presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces in any primary tooth in a preschool-age child between birth and 71 months of age. More specifically, experts recommend using the term of ***Severe*** Early Childhood Caries (SECC) to designate all caries considered atypical, progressive, acute or rampant. This category thus includes baby bottle tooth decay, nursing caries, maxillary anterior caries, labial caries, comforter caries, and rampant caries. Gagnon (1984), considers that SECC are merely an incidence of ECC under special or specific conditions. A simpler version by Ismail (1998), defined ECC as the occurrence of any sign of dental caries on any tooth surfaces during the first 3 years of life.

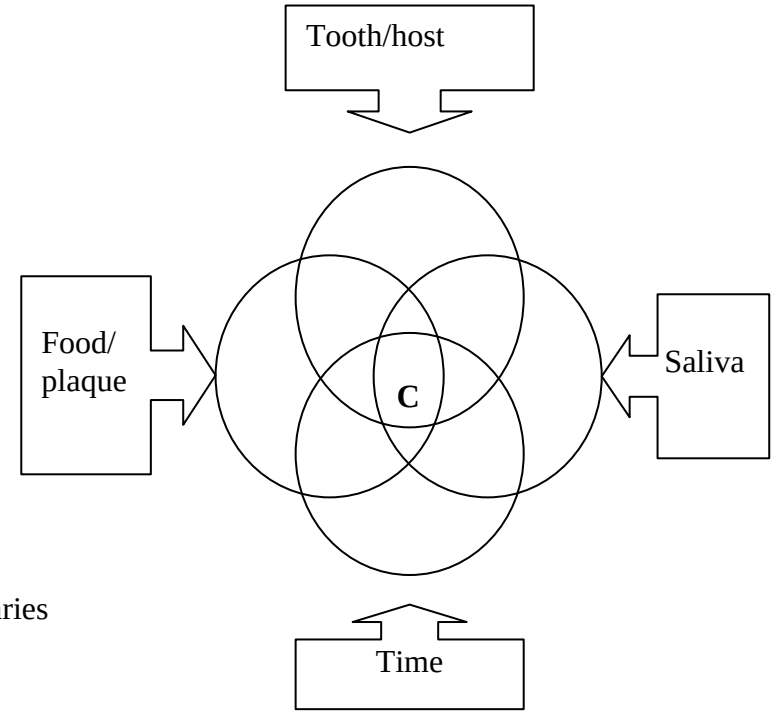
2.4.3 Etiology of early childhood caries (ECC).

Early childhood caries (ECC) is considered a multifactoral disease, where the model by Parkin (1991), is the best explanation of the cause. It is generally accepted that ECC occurs when all four factors are present: susceptible tooth, caries potential micro flora, suitable substrate and time. All these factors such as bacteria plaque (microorganisms or flora), tooth (as the host) and food (as the oral cavity environment/substrate/sugar/diet) and time (the duration of cariogenic exposure) must act concurrently for caries to occur. Saliva has also been introduced as another circle

instead of time or as one part of the environment of the oral cavity (Thylstrup and Fejerskov, 1994).

Oral bacteria live in an environment with poor basic supply of nutrients but, from time to time, become exposed to high levels of nutrients. The condition of high concentrations of dietary sugars can represent a hazard to the oral bacteria because sugars rapidly enter to the bacteria cells and toxic levels of glycolytic intermediates will accumulate. However, the oral bacteria have their own protective mechanisms from the effect of acidic environment for survival or replaced by others (Thylstrup and Fejerskov, 1994).

Figure 2.1 Risk factors of early childhood caries (ECC) by (Parkin, 1991)



C= Caries

The cariogenic bacteria metabolize sugars to produce energy required for their growth and development. The energy sources may be exogenous (from immediate food sources) or endogenous (from stored polysaccharide). Cariogenic bacteria can metabolize any monosaccharides or disaccharides for energy. Once within the cell, glucose as the end product will enter the glycolytic pathway and result in the formation of two 3-carbon pyruvate molecules from each 6-carbon glucose molecule, along with generation of two molecules of adenosine triphosphate (ATP). Pyruvate can be converted to lactic acid or other end products depending on a number of factors including substrate concentrations. The result of this sugar catabolism is the production of organic acids in the dental plaque fluid, which lowers the plaque pH. As the pH decreases to around 5.2 to 5.5, the intermediate tooth environment is no longer saturated with calcium and phosphate ions, and the tooth starts to demineralization. Repeated occurrence of demineralization will lead to caries formation if remineralization does not occur to counteract in a relatively equal length of time. Once the decalcification reaches the dentin to enamel junction, acid decalcification of the dentin can progress and the bacteria can invade the protein of the dentin and destroy it through a process called proteolysis (Mobley and Dodds, 2003).

The complex composition has been secretions from various salivary glands mix in the oral cavity to form whole saliva or ‘oral fluids’. The organic component consists of proteins, carbohydrates, enzymes etc., which play important roles in controlling the oral environment. Inorganic components such as calcium and phosphates determine the relative saturation of fluid. Severe reduction of salivary flow rate predisposes teeth to caries. The buffer capacity of the saliva also has generally been thought to vary with caries activity (Thylstrup and Fejerskov, 1994).

Recently, it was found that the fluoride content in the hard dental tissue is less important than a moderate increase of fluoride concentration in the oral fluids. Thus, the

modern concept on mechanism of action of fluoride emphasizes a daily supply of fluoride in significant concentrations in saliva and plaque fluid to control enamel dissolution (Thylstrup and Fejerskov, 1994). This is currently the prevailing view advocating fluorides in caries prevention.

2.4.4 Factors influencing early childhood caries

Oral health status is influenced by many factors, directly or indirectly. Children with caries before the age of two years have significant problems in dietary habits compared to those without caries (Chellapah *et al.,* 1990). Diet and nutrition intake in the first year of life affect caries formation in two ways:

i) Pre-eruptive malnutrition causes hypoplastic enamel, thus increasing caries susceptibility.

ii) The greater post-eruptive effect is on the first erupted teeth through frequent and long exposure of sugary foods, such as sucrose added to milk, use of reservoir feeder, sweetened juice and confectioneries (Thylstrup and Fejerskov, 1994).

Practices such as infant bottle-feeding have been proven to cause ECC (Davies, 1998; Tinanoff, 1998; Roberts *et al.,* 1993). Changes in food intake patterns resulted in increased prevalence of overweight and obesity among children, not only in urban, but also in rural areas and had negative effect to oral health status of children. The common risk factors are sugar intake (Ismail, 2002; Ebrahim, 1982).

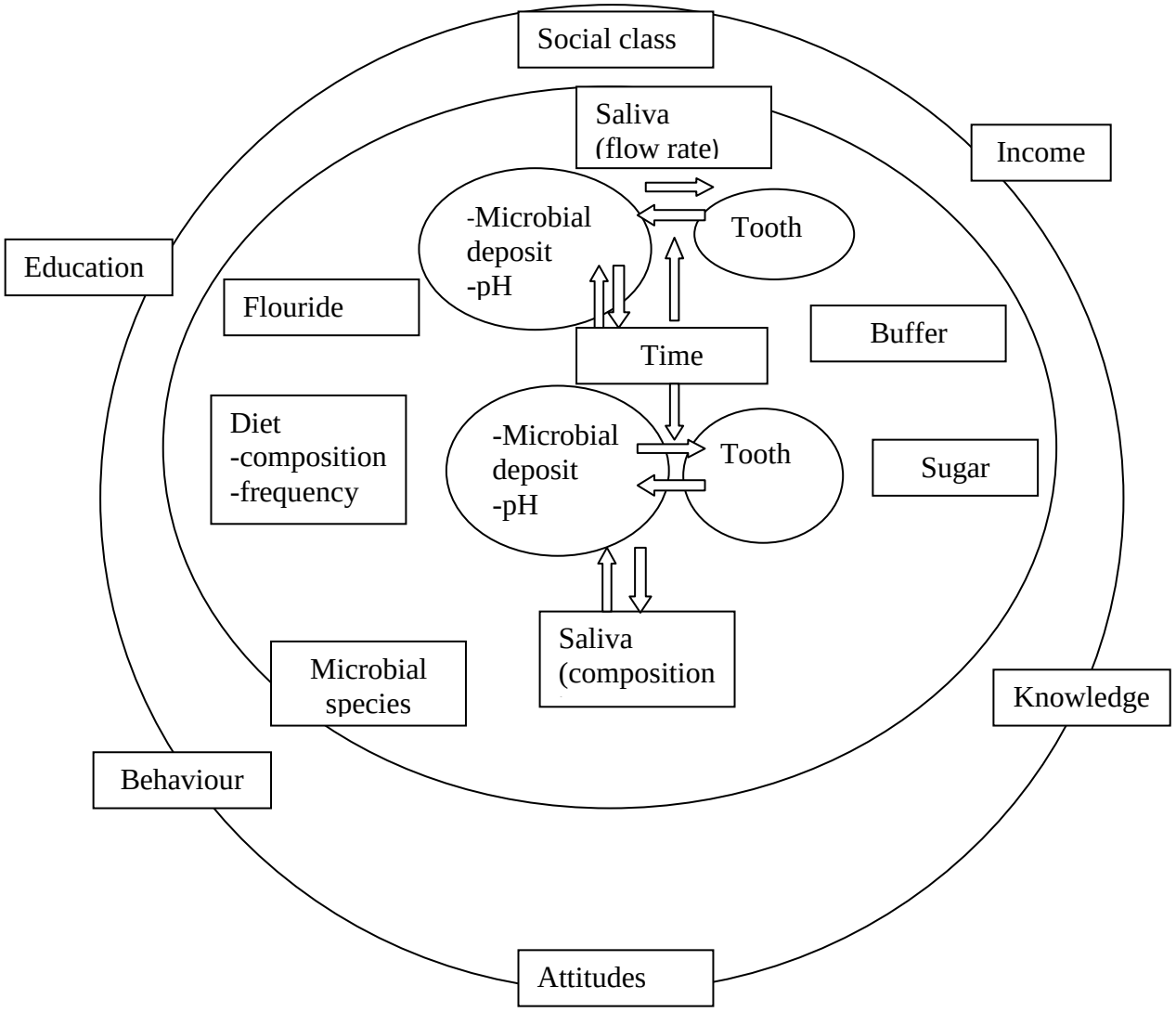
Knowledge, attitude and practices were correlated with the occurrence of ECC (Reisine & Douglas, 1998). Reduction of dental caries and changing oral disease patterns in the past decades were parallel with significant improvements in oral health awareness, dental knowledge and attitudes of children and parents (Zhu *et al.,* 2003). Verrips *et al.,* (1993) highlighted that maternal education is a risk factor for dental

caries and dental behaviors were related to caries experience as well as ethnicity and maternal education. For attitudes of dental care among parents, Arnrup *et al.,* (2002) found that parent's knowledge and child's oral health behavior are significantly related, whereby parents with lower dental knowledge influenced negative behaviors such as taking more sweets and exhibit greater dental fear and high treatment refusals.

Many studies showed that socio-economic status is an important indicator of oral health (Sampaio *et al*., 2000; Rugg-Gunn, 1993; Rugg-Gunn and Nunn, 1999; Pine, 1997; Locker, 2000; Lalloo *et al.,* 1999; Freira *et al*., 1996 and Dunlop *et al.,* 2000). The relationship between socio-economic status and health (incidence and prevalence of disease) showed that when socioeconomic status increases, disease, illness and their impact decreases (Reisine and Psoter, 2001). Studies have demonstrated that the health of individuals from the lower end of socio-economic status scale is markedly worse than that of individuals from the upper end (Locker, 2000).

Figure 2.2 A schemic illustration of relationship between the etiological factors and determinants and confounders in dental caries.

(Source: Fejerskov and Manji, 1990; cited from Thylstrup and Fejerskov, 1994).



2.5 Diet and Early Childhood Caries.

Nutritional status and nutrients intake are critical to good oral health. However the pre-eruptive influence is much less important than the post-eruptive local effect of diet on the teeth (Rugg-Gunn, 1993). Inadequate intake of energy and protein can delay tooth eruption, effect tooth size and enamel solubility and can cause salivary gland dysfunction. Calcium and vitamin D intake are important to the mineral process and deficiencies can lead to compromised tooth integrity and delayed eruption patterns. Fluoride is important to enamel formation, inhibits demineralization, stimulates remineralization and inhibits bacteria growth. Others nutrients including vitamin A, ascorbic acid (Vitamin C), iodine and iron are also involved in the development and maintenance of teeth and other oral structures (Faine 2001; Palmer, 2003).

Deficiencies in vitamin A and D and protein-energy malnutrition (PEM) have been associated with enamel hypoplasia and salivary gland atrophy. This reduces the mouth's ability to buffer plaque acids, which makes the teeth more susceptible to decay (WHO, 2003). Foods consist mostly of carbohydrates, fats, protein and minerals and the eating patterns can enhance or promote the caries process or interfere with and depress the caries activity (Mobley *et al*., 2003).

Dental caries occurs because of demineralization of enamel and dentin by organic acids formed by bacteria in dental plaque through the anaerobic metabolism of sugars derived from the diet (Arens, 1999). Organic acids increase the solubility of calcium hydroxyapatite in the dental hard tissues and demineralization occurs. Saliva is super-saturated with calcium and phosphate at pH 7 which promotes remineralization. If the oral pH remains high enough for sufficient time then complete remineralization of enamel may occur. If the acid challenge is too great, however, demineralization dominates and the enamel becomes more porous until finally a carious lesion forms (Arend *et al.*, 1986). Thus, the development of caries requires the presence of sugars

and bacteria, but is influenced by the susceptibility of the tooth, the bacteria profile and the quantity and quality of the saliva.

Fermentable carbohydrates play an important role in caries by providing the plaque bacteria with the substrate for acid production and the synthesis of extracellular polysaccharides. This helps the bacteria to stick to each other and to the tooth surface and by thickening the layer of plaque, prevents saliva from neutralizing plaque acid (Kidd and Joyston-Bechal, 1997). Repeated exposure to reduced plaque pH results in sub-surface softening of the enamel (white spot lesion) and the lesion can progress to form a carious cavity (Scottish Intercollegiate Guidelines, 2000).

There is strong evidence to show the role of dietary sugars in the aetiology of dental caries (Bjarnason *et al.,* 1989; Beighton *et al*., 1996). The dietary factors include the amount of sugar consumed, sugar concentration of food, physical form of carbohydrate, frequency of eating meals and snacks, length of interval in between and sequence of food consumption (Scottish Intercollegiate Guidelines, 2000).

Sucrose is the most cariogenic sugar because the synthesis of extracellular polysaccharides from sucrose is more rapid compared to glucose, fructose and lactose (Kidd and Joyston-Bechal, 1997; Brambilla *et al.,* 2000). Sucrose is also eaten most commonly and most widely available, it is a very important cause of dental caries (Kidd and Joyston-Bechal, 1997; Rugg-Gunn & Nunn, 1999) and has been labeled as “the arch criminal of dental caries” (Rugg-Gunn and Nunn, 1999).

A cross-sectional study by Garcia-Closas *et al.,* (1997) found a positive association between frequency of intake of foods containing a mixture of starch and sugars with high dental caries prevalence. Moynihan (2002) proposed that it should be a public health policy to reduce the amount of sugar consumed, but at individual level, it is easier to quantify the frequency of sugar intake and it is more practical in dietary advice.

2.5.1 Sugars issues.

Yudkin (1972) has labeled sugar as “pure, white and deadly” because of its association with many health problems such as obesity, heart disease, hyperactivity, diabetes and dental caries. There are various types of sugar categorization such as “total sugar”, “added sugar” and “non-milk” extrinsic sugars (NMES) (Committee on Medical Aspects of Food Policy, Department of Health, 1989). The role of added sugars in human diet has gained prominence with the introduction of modern food processing methods. Introduction of new foods with high sugar such as soft drinks, sweets, cakes and chocolates encourages consumption of sugar in homes, fast food restaurants and vending machines in schools or universities.

The Dietary Guidelines for Americans provide authoritative advice on what Americans should eat to be healthy and form the basis of federal nutrition policy (ABARE, 2005; Archer *et al.*, 1998). They advised Americans to moderate intake of sugars, a recommendation that has been consistently offered, with only slight changes in wording, since the first publication of the guidelines in 1980 (Barakatun Nisak, 2009).

The US Dietary Guidelines do not quantify recommended intake of sugars. However, the US Department of Agriculture (USDA) Food Guide, popularly known as the Food Guide Pyramid (Bowmen, 1999), offers food-based advice for a diet based on the principles of the US Dietary Guidelines that is, a varied, nutritionally adequate diet moderate in total fat, saturated fat, cholesterol, sugars, and sodium (Committee on Medical Aspects of Food Policy, Department of Health, 1989; Cunningham, 1998).

To achieve variety and nutritional adequacy, servings from 5 major food groups are recommended: bread, cereal, rice, grains; vegetables; fruits; milk, milk products; and meat, poultry, fish, dried beans, eggs, nuts, seeds. Minimum energy levels for sample diets are calculated using foods from each group in their lowest fat-containing form and without added sweeteners (ABARE, 2005).

The scientific evidence on sugar guideline in relation to health revolves around three main health issues. First, sugar is the main cause of dental caries and that a lower absolute sugar intake would result in an appreciable decrease in caries incidence. Second, sugar could contribute to obesity, either by contributing towards excess energy or by accentuating appetite leading to overconsumption. Finally, sugar intake in excess of recommendations could displace micronutrient-dense foods from the diet, resulting in a greater risk of vitamin and mineral deficiency (MOH, 2010).

Thus, awareness of high intake of sugar content is crucial to encourage more moderate consumption. One of the main concerns for health is that sugar content for example in soft drinks and foods contain no other vitamins and minerals apart from calories which may lead to adverse effects if taken excessively (empty calories).

The amount and frequency of consumption of non-milk extrinsic sugars (NMES) was also considered to be the major cause of dental caries (Department of Health, 1989). NMES are those sugars which are not located within the cellular structure of a food, but exclude the sugars in milk (almost all lactose) which is not thought to contribute to dental caries (Department of Health, 1989). NMES include all sugars in fruit juices as well as table sugar, honey and sucrose, glucose and glucose syrups added to food. Thus the primary target of public health interventions to reduce empty calories should be the reduction in intake of NME sugars.

2.5.2 Dietary sugar and dental caries

Numerous evidence from human studies, animal experiments and experimental studies in vivo and in vitro showed the role of dietary sugars in relation to dental caries (Rugg-Gunn, 1993). Worldwide epidemiological studies have compared sugar consumption and levels of dental caries between countries. Sreebny & Sreebny (1982) correlated dental caries experience (DMFT) of 12-year-olds with data on sugar supply

of 47 countries and found a significant correlation with 52% of the variation in the level of caries explained by per capita availability of sugar. In countries with consumption of sugar less than <18 kg per person per year, caries experience was consistently lower than < DMFT 3. However, 23 countries with per capita sugar availability of less < 50g per day had a mean of DMFT score <3, whereas only half of the countries with sugar availability above this level had achieved a DMFT score was <3. Caries experienced also decreased during the Second World War because of reduction of sugar availability but increased again when the restriction of sugars was lifted (Marthaler, 1967; Takeuchi, 1961).

People with high exposure to sugars have level of caries higher than the population average. Children with chronic diseases who required long-term sugar containing medicines (Roberts *et al*., 1979), and confectionery workers (Masalin *et al.*, 1990; Petersen, 1983; Katayama, 1979; Anaise, 1978), had level of caries higher compared to normal populations.

A famous classical human intervention study (The Vipeholm Study), conducted in an adult mental institution in Sweden between 1945 and 1953 (Gustafsson, 1954), investigated the effect of consuming sugary foods of varying stickiness and at different times throughout the day on the development of caries. They found that sugar even when consumed in large amounts, had little effect on caries increment if it was ingested up to a maximum of four times a day and at mealtimes only. However, increased frequency of consumption of sugar between meals was associated with marked increase in dental caries and withdrawal of sugar rich foods decreased the problem.

Another intervention study (The Turku Study), was carried out on adults in Finland in the 1970s to control dietary sugary intake. The results showed that almost total substitution of sucrose in the diet with xylitol (a non-cariogenic sweetener) resulted in an 85% reduction in dental caries over a 2 year period of study (Scheinin *et al.*,

1976). Granath (1978), showed that sugar intake was the most important factor associated with caries in the primary dentition of preschool children in Sweden. When the effects of oral hygiene and fluoride were kept constant, the children with a low intake of sugars between meals had up to 86% less caries than those with high intake of sugars. Others studies have found that fluoride exposure and oral hygiene to be more strongly associated with caries than sugars consumption (Schroder and Aranath, 1983; Hausen *et al.*, (1981).

In addition, many cross-sectional studies have shown a relationship between sugars consumption and levels of caries in the primary and permanent dentition in countries or throughout the world, including China (Peng, 1992), Denmark (Petersen, 1992), Madagascar (Petersen *et al*., 1996; Petersen, 1991), Saudi Arabia (Al-Tamimi *et al*., 1998), Sweden (Persson., 1985; Stecksen-Blicks and Holm., 1995), Thailand (Petersen, 2001), Malaysia (Zahara *et al*., 2010) and United Kingdom (Hinds K. and Gregory J., 1995).

However, modern diets of industrial countries contain a mix of sugars and other carbohydrates including sucrose, glucose, lactose, fructose, glucose syrups, high fructose corn syrups and other synthetic oligosaccharides and highly processed starches that are fermentable in the mouth (Moynihan, 2004). Oral bacteria metabolized all mono- and disaccharides to produce acids which tend to develop dental caries.

2.5.3 Frequency and amount of sugar consumption

The important of frequency versus the total amount of sugar intake is difficult to evaluate as the two variables are hard to distinguish from each other. However, evidence from numerous studies suggested that caries rates in humans are related to the amount of sugar consumed and the frequency of eating between meal sugary products. COMA (1991), stated that "in free-living people these three variables: mass, concentration and frequency, were closely and positively related to each other". The WHO (1990), expert committee on Diet, Nutrition & Prevention of Chronic Diseases concluded that "numerous epidemiological studies conducted at the population level suggest that there is a direct relationship between the quantity and frequency of sucrose consumption and the development of caries. Many studies indicated that as more sugars were consumed, the frequency increased.

The Vipeholm study showed that caries experience increased when the frequency of sugar intake exceeds four times a day (Gustafsson, 1954; Holbrook, 1995; Holt, 1991;Holbrook, 1989). Data from human studies also showed that the frequency of sugars intake is an important etiological factor for caries development (Karlsbeek and Verrips., 1994). Animals studies have also indicated the importance frequency of sugars intake in the development of dental caries (Firestone *et al*.,1984; Konig *et al*., 1968). Many studies have related frequency of sugars or sugars-rich food intake to caries development but have not concurrently investigated the relationship between amount of sugars consumed and dental caries, therefore no conclusion regarding the relative importance of this two variables can be drawn (Sundin *et al*., 1992; Bjarnason *et al*., 1989; Hankin *et al*., 1973).

Some animal studies have shown a relationship between amount of sugars consumed and the development of dental caries (Hefti and Schmid, 1979; Mikx, 1975; Guggenheim, 1966 Gustafsson, 1953). Several longitudinal studies in human have

indicated that the amount of sugars consumption is more important than the frequency (Burt, 1988; Rugg-Gunn, 1984; Szpunar *et al*., 1995; Kleemola-Kujala and Rasanen, 1982), while Jamal *et al.,* (1997) found that both the frequency and the amount of sugars intake are important.

The correlation between frequency of sugary foods of intake per day and weight consumed per day, by children aged 12 to 14 years was high (r=+0.77) (Sheiham, 2001). All the correlations for a number of food groups were above +0.75, showing that as the amount of the sugary food consumed per day increased, the frequency of intake also increased (Table 2.1). The correlation was higher for the amount and frequency of all sugared drinks (0.86). Similarly high correlations for amount and frequency of drinks between meals (+0.97) was reported by Ismail *et al.*, (1984) for American children and for frequency and total sucrose intake for South Africa Black people, Indians and Whites (Cleaton *et al*., 1987). The correlations ranged between +0.78 and +0.84.

A similar trend of correlations between frequencies of sugars was reported by Rodrigues (1997). There was a highly significant relationship between daily frequency of sugar intake and the daily weight of intake and caries increment. In addition, children with a frequency of sugar consumption of 4-5 times per day at nursery were 6 times more likely to develop high level of caries over one year, compared to those having lowest frequency (Mikx, 1975); Guggenheim, 1966). Daily frequency of sugar intake at nursery showed an increased risk of having high caries development.

Table 2.1 Correlation between frequency and weight of intake of dietary items which are high in sugars, observed in 405 English children aged 11-14 years. All correlations are positive and significant.

Types of foods	**Correlations**
Sweets	0.74
Confectionery	0.77
Chocolate	0.85
Biscuits and cake	0.80
Biscuits, cake and puddings	0.71
Sweet puddings	0.86
Sugared tea	0.98
Other hot drinks	0.93
Sugared drinks	0.86
Sugared cordials	0.79
All foods and drinks	0.32
All foods with >10% sugars	0.59

Finally, the strong correlation between both the amount and frequency of sugars consumptions has been demonstrated by several investigators in different countries (Rugg-Gunn, 1984; Rodrigues *et al.*, 1999; Cleaton-Jones., 1984; Ismail *et al*., 1984). Thus it was concluded that, in caries development, both variables ie. amount and frequency of sugars intake are very important.

WHO (2003), recommended that countries with a low intake of free sugar do not increase intake and those with higher intake (>15-20kg per year) aim to reduce intake of free sugar to less than 10% of total energy intake (which equates to <15-20 kg per year) or about 12 teaspoons per day. The consumption of extrinsic sugars levels above 60kg per person per year for teenagers and adults increases the risk of dental caries.

It has been recommended that for pre-school and young children, the intake should be limited to 30g per person per day (Sheiham, 2001) or 6 teaspoons per day. The UK National Diet and Nutrition Surveys recommended that added sugars should

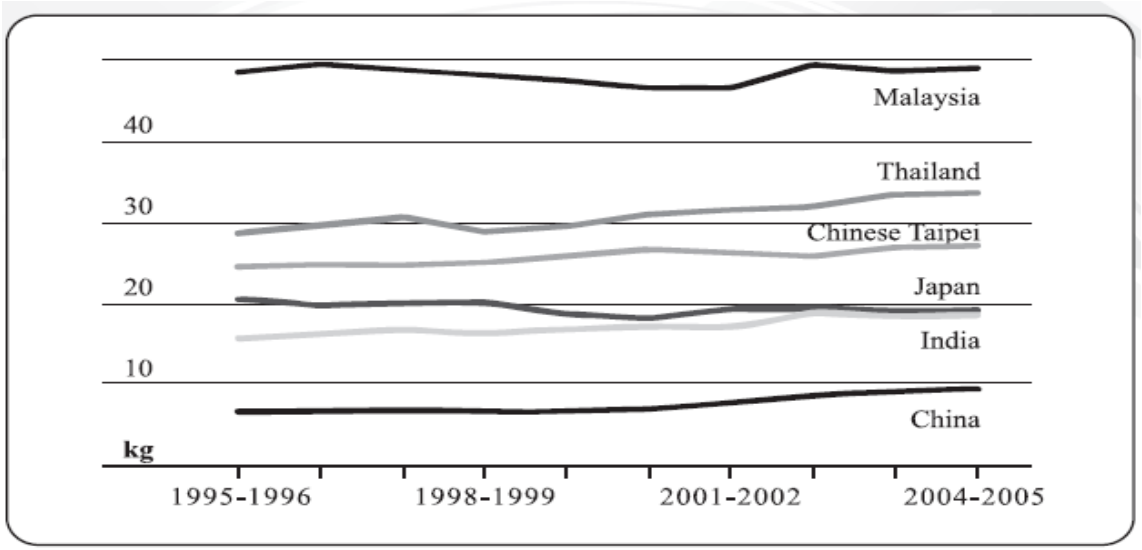
comprise no more than 10% of total daily calories. For example, an estimated calorie consumption of 900-1000 calories for children aged 1-3 year-old, the added sugar intake should be 100 calories (Gidding *et al*., 2005).

2.5.4 Current Status in Malaysia and global sugar intake.

According to the GAIN report, (2006), Malaysia is only 5% self-sufficient in domestic sugar production. Malaysia imported raw sugar from Thailand, Brazil and Australia, and exported refined sugar mainly to Indonesia, Philippines, Singapore and Taiwan. The Malaysian sugar consumption per capita basis showed an increase from 37.6 kg in 1985 to 51.2 kg in 1995, which is among the highest in the Asia Pacific region (FAO, 1997). However, Figure 2.3 (ABARE, 2005) showed the consumption of sugars per person in Asia seems to reach a plateau at around 50kg compared to Thailand, Chinese Taipei, Japan, India and China. Based on the food balance sheet data for Malaysia, the available sugars in the country was estimated to be about 86g/day or 39% of total energy in 1985 which then rose to 104g/day or 14% of total energy in 2002 (NCCFN, 2005; FAO, 2008).

In 2009, based on the Malaysian population of 28.31 million and domestic sugar distribution of 806,381.88 metric tons, sugar consumption per capita per day was 78 gram or 16 teaspoons a day or 16% of daily energy requirements for adults. If domestic sugar and industry sugar was added, ie. 1,281,183.04 metric tons in 2009, sugar consumption per capita per day was 124 gram or 25 teaspoons per day or 25% of daily energy requirements for adults (Berita Harian, June 20, 2011). The trend showed an increase in sugar intake for the Malaysian population.

Figure 2.3: Sugar Consumption per person in Asia



According to the Malaysian Adults Nutrition Survey 2003 (MOH, 2006) report, about 59% of the Malaysian population consumed sugar daily. The mean sugar intake was about 4 teaspoons per day which is about 21 grams. This study also reported that consumption of sugar was higher in rural areas (69.1% consumed daily, 2.1 times per day) as compared to urban population (51.4% consumed daily, 1.8 times per day) (Norimah *et al*., 2008). The finding reported that sugar is usually added to beverages such as tea, coffee and chocolate-based drinks (Table 2.2). Sugar content of selected local foods and beverages are listed in Table 2.3 and 2.4. According to the *Berita Harian* report (Monday, June 20, 2011) sugar intake for adults were 7 tea spoons per day (51g) consisting 4 tea spoons (21g) of granulated sugar and 3 tea spoons (30g) of sweetened condensed milk which were added to beverages.

Table 2.2 Mean intake of selected beverages and foods among Malaysians

Type of food	**Estimated mean intake (g/day)**	**Household measurement**
Condensed milk	30	6 teaspoons
Tea	247	1 ¼ cups
Coffee	171	¾ cup
Chocolate drinks	128	½ cup
Cordial syrup	102	½ glass
Carbonated drinks	57	1/5 can
Local *kuih*	22	¾ piece
ABC ice	26	1/8 bowl
Jam	6	½ teaspoons
Sugar	21	3 teaspoons

Source: Ministry of Health Malaysia (2006).

Table 2.3 Example of sugar content in some local beverages and snacks

Food (g/ml)	**Sugar content (g)**	**Household measurement equivalent (teaspoon)**
Chocolate bar (19 gram)	5-10	1-2
Cookies (29 gram)	5-10	1-2
Cereals, sweetened (29 gram)	10	2
Ice cream (60 gram)	5-15	1-3
Energy drinks (250ml)	20-40	4-8
Carbonated drinks (240 ml)	15-30	3-6

Source: MOH (2004).

Table 2.4 Sugar content in local *kuih*

Local *Kuih*	**Weight (g) per piece**	**Sugar content (g) per piece**	**Teaspoon Equivalent 1 tsp (5g)**
Bingka ubi kayu	70-90	18-25	4 ¼
Kuih koci	40-50	10-13	2 ¼
Kuih keria	55-65	10-13	2 ¼
Lepat pisang	65-75	10-13	2 ¼
Kuih kosui	70-80	10-13	2 ¼
Kuih seri muka	110-120	10-13	2 ¼
Onde-onde	25-45	8-10	2
Kuih kasturi	120-135	8-10	2
Doughnut (plain)	45-55	7-10	1 ¾
Puding jagung	70-80	7-10	1 ¾
Apam	40-50	6-8	1 ½
Kuih lapis	120-140	5-7	1 ¼

Source: NCCFN (2005).

According to Kiple and Omelas, (2000), sugar consumption in the UK in packet or table sugar form, was estimated at around 60 kg per person per year (the equivalent of 30 bags of sugar). However, oral health surveys carried out every 10 years using the DMFT index (decay, missing and filled teeth) showed a gradual reduction in caries in children aged between 5 to 12 years (Office for National Statistics, 2004). The reductions were attributed to improved oral health and dietary education of parents and children, wider availability and use of fluoride toothpaste and regular dental check-up to identify early problems.

2.6 Starches and dental caries

Epidemiological studies showed that starch contributes low risk to dental caries. People who consumed high-starch/low-starch diets generally have low level of caries, whereas those who consume low-starch/high-sugars diets have high level of caries (Newbrun, 1980; Scheinin *et al.*, 1976; Rugg-Gunn, 1984). The heterogeneous nature of starch (degree of refinement, botanical origin, raw or cooked) is particularly relevant when assessing its potential cariogenicity (Brudevold, 1985; Grenby, 1970). Cooked starch is about one-third to one-half as cariogenic as sucrose (Bowen, 1980). According to Firestone *et al*., (1982), intake of mixtures between starch and sucrose was potentially more cariogenic than starch alone.

Plaque pH studies using an indwelling oral electrode, showed that starch-containing foods reduced plaque pH to below 5.5, but starches are less acidogenic than sucrose. Plaque pH studies measure acid production from substrate rather than caries development, and take no account of the protective factors in some starch-containing foods or of the effects of foods on stimulation of salivary flow.

Currently, glucose polymers and pre-biotics have been extensively used as food additives. Evidence on the cariogenicity of these carbohydrates was limited. From animal, plaque and in vitro studies, it was suggested that maltodextrins and glucose syrups were cariogenic (Grenby *et al*., 2000; Moynihan, 1996). In plaque pH studies and in-vitro experiments, isomalto-oligosaccharides and gluco-oligosaccharides was less cariogenic than sucrose (Koga, 1988; Ooshima 1988; Roberts *et al*., 1980). However, fructo-oligosaccharides were as acidogenic as sucrose (Moynihan, 2001; Hartemink, 1995).

2.7 Fruits and dental caries

According to the Malaysian Food Pyramid, fruits were placed at level 2 with a suggested 2 servings per day for example: 2 whole apples, 2 whole bananas, 1 whole guava/ pear per day (MOH , 2009). However, there was a little evidence that showed fruits intake was one of factors in caries development (Rugg-Gunn, 1984; Clancy, 1977; Martinsson, 1972).

A few plaque pH studies have shown that fruits were acidogenic but less so than sucrose (Hussein *et al*., 1996; Imfeld, 1983). Animal studies showed that very high frequency of fruits intake (up to 17 times a day), can cause caries (Imfeld, 1991). Evidence on association between fruits consumption and DMFT showed that high fruits intake (8 apples or 3 bunches of grapes per day), was associated with higher DMFT in farm workers compared with grain farm workers, especially in differences in numbers of the missing teeth (Grobler *et al*., 1989).

However, dried fruit may potentially be more cariogenic since the drying process breaks down the cellular structure of the fruit, releasing free sugars and dried fruits tend to have a longer oral clearance (Moynihan, 2004). Rugg-Nunn (1993) concluded that "as eaten by humans, fresh fruit appears to be low cariogenicity and citrus fruits have not been associated with dental caries". However a more recent study by Issa *et al*, (2011) which compared the effects of whole fruits and fruit juices in situ found no difference in demineralizing potential between sugars present intrinsically and free sugars and thus neither could not be considered less cariogenic. In other words, sugars in whatever form should not be taken excessively as they are cariogenic, acidogenic and obesity inducing.

2.8 Fluoride in diet and dental caries

One of the elements present in the diet which is important to teeth development and caries prevention is fluoride (WHO, 1994). Fluoride can be ingested from water, tea and a range of foods (Rugg-Gunn, 1993). A common non-dietary source of fluoride in industrialized countries is toothpaste. Fluoride in toothpaste is considered to be the most important reason for decline in caries in Europe (Peterson & Razanamihaja, 1996). For children, fluoride reduces caries by about 20% to 40% but does not eliminate dental caries altogether.

Many controlled trials of the effect of fluoride on dental caries have been conducted and demonstrated that fluoride is the most effective agent against dental caries (WHO, 1994). However, several studies also indicated that a relationship between sugars intake and caries development still exists even in the presence of adequate fluoride exposure (Holt, 1991; Kunzel and Fischer,1997; Beighton *et al*.,1996). In longitudinal studies in children, the relationship between sugars intake and development of dental caries remained after controlling use of fluoride and oral hygiene practices (Burt, 1988; Rugg-Gunn, 1984).

Further, according to Marthaler, (1990), even when preventive measures such as use of fluoride are employed, a relationship between sugars intake and dental caries still exists. He stated that in industrialized countries where there is adequate exposure to fluoride, no reduction in the prevalence and severity of dental caries will be achieved unless the intake of sugars is reduced.

Burt and Pai, (2001), in their review that investigated the importance of sugars intake in caries etiology in populations exposed to fluoride concluded that where there is adequate exposure to fluoride, sugars consumptions is a moderate risk factors for caries in most people. Moreover, sugars consumption appears to be a more powerful indicator for risk of caries in persons who do not have regular exposure to fluoride.

Thus, restricting sugars consumption is important in the prevention of caries in situations where there is widespread use of fluoride but this is not as strong as it is without exposure to fluoride.

However, on the other hand, excess ingestion of fluoride during enamel formation can lead to dental fluorosis. This condition is observed particularly in countries that have high level of fluoride in their water supplies (WHO, 1994).

2.9 Other dietary factors which protect against dental caries

Some dietary components do protect against dental caries WHO (2003). These "cariostatic foods" refers to foods which inhibit the acid attack on the teeth (Ehrlich, 1994). Cheese is one of the cariostatic foods and has been demonstrated in experimental studies (Moynihan, 1999), and in human observational studies (Rugg-Gunn, 1984) and in intervention studies (Gedalia, 1994).

Milk is an essential aspect for growth and development of children. Cow's milk contains calcium, phosphorus and casein. All of these nutrients are thought to inhibit caries. Several studies have shown that the fall of plaque pH because of milk consumption is negligible (Rugg-Nunn, 1985). The cariostatic nature of milk has been demonstrated in animal studies (Bowen, 1991; Reynolds and Johnson, 1981).

Wholegrain foods have protective properties in the way of requiring more mastication thereby stimulating increased saliva flow. Other foods which are good as mechanicals stimulants to increase salivary flow include peanuts, hard cheese and chewing gum. Both organic and inorganic phosphates (found in unrefined plant foods) have been found to be cariostatic in animal studies (Nizel and Harris, 1995). Both animal studies and experimental investigations in humans showed that black tea extract increases plaque fluoride concentration and reduces the cariogenicity of sugars rich diet (Lingstrom *et al*., 2000; Linke, 2000).

2.10 Diet and Dental Erosion

Dental erosion is the progressive irreversible loss of dental hard tissues that is chemically etched from the tooth surface by extrinsic and/or intrinsic acids by a process that does not involve bacteria. Extrinsic dietary acids include citric acid, phosphoric acid, ascorbic acid, malic acid, tartaric acid and carbonic acid. All of these acids can be found in fruits and fruits juice, soft drinks and vinegar (WHO, 2003). Intrinsic acids come from vomiting and regurgitation. Poor salivary flow or salivary deficiencies are thought to make individuals more susceptible to acids challenges. Low salivary flow rate or inadequate buffering capacities are factors that exacerbate erosion (Zero & Lussi, 2000; Distler *et al.*, 1993). Erosion reduces the size of the teeth and in severe cases leads to total tooth destruction (Meurman and Ten-Cate, 1996).

Human observational studies have shown an association between dental erosion and a consumption of a number of acidic foods and drinks, including frequent consumption of fruit juice, soft drinks (including sport drinks), pickles (containing vinegar), and citrus fruits. (Millward 1994; Jarvinen *et al*., 1991; Linkosalo and Markka, 1985; Stabhoiz 1983). Experimental clinical studies have shown that consumption of acidic beverages significantly lowers the pH of the oral fluids (Imfeld, 1983). Enamel is softened within one hour of exposure to coca-cola but this may be reversed by exposure to milk or cheese (Gedalia, 1991). Animal studies have shown that fruit and soft drinks cause dental erosion (Stephan, 1966), although fruit juices are significantly more destructive than whole fruits (Grenby *et al*., 1990).

2.11. Official recommendations to reduce sugar intake and ECC

The Malaysian Dietary Guidelines 2010, (MOH, 2010), recommended two ways to reduce sugar intake which may help to reduce risk for dental caries (Table 2.5).

Table 2.5 Malaysian Dietary Guidelines (2010) recommendations to reduce sugar intake.

Main objective	**How to achieve:**
1. Eat foods low in sugar	▪ Choose or prepare "kuih" and cakes with less sugar ▪ Replace sweet desserts such as "kuih" and cakes with healthier options such as fruits. ▪ Consume foods containing sugar less frequently ▪ Avoid consuming sugary foods in between meals and close to bedtime. ▪ Check food labels for sugar content focusing on the position on sugar on the ingredient list. If sugar is listed at the beginning of the list, it indicates that sugar constitutes one of the main components of the ingredients.
2.Drink beverages low in sugar	▪ Choose plain water rather than carbonated and non-carbonated sugary drinks (such as soft drink, syrup and cordial). ▪ Limit intake of table sugar or sweetened condensed milk or sweetened condensed filled milk to one tea spoon per cup of drink. ▪ When ordering drinks, ask for less sugar or less sweetened condensed milk or sweetened condensed filled milk. ▪ Check nutrition information panel on labels of beverages for sugar content. ▪ Reduce consumption of beverages containing sugar such as carbonated drinks, cordial, "cendol" and "air batu campur" (ABC). ▪ Avoid consuming sugary drinks in between meals or close to bedtime.

WHO (2003), recommended that consumption of free sugars should be below 15-20kg per person per year. This is equivalent to a daily intake of 40 -55 g per person and the value equated to 6-10% of energy intake. Regarding intake of the amount of free sugars, the frequency of free sugars also important. Foods or drinks containing free sugars should be limited to a maximum of four times per day. The implementation of fluoride exposure to the community should be encouraged to reduce caries. To minimize the occurrence of the dental erosion, the amount and frequency of intake of

soft drinks and juices should be limited. Many of these recommendations take into consideration the dietary habits of Malaysian consumers. The present intervention study adopted these recommendations in educating the parents to control their diet and sugar intake.

2.12 Health promotion models used in this study

Most health promotion models come from evidences obtained from behavioral and social sciences. The various disciplines involved include psychology, sociology, management, consumer behavior and marketing. The diversity of those disciplines shows that health promotion practice is not only concerned with the behavior of individuals but also with the ways in which society is organized and the role of policy and organizational structures in promoting health.

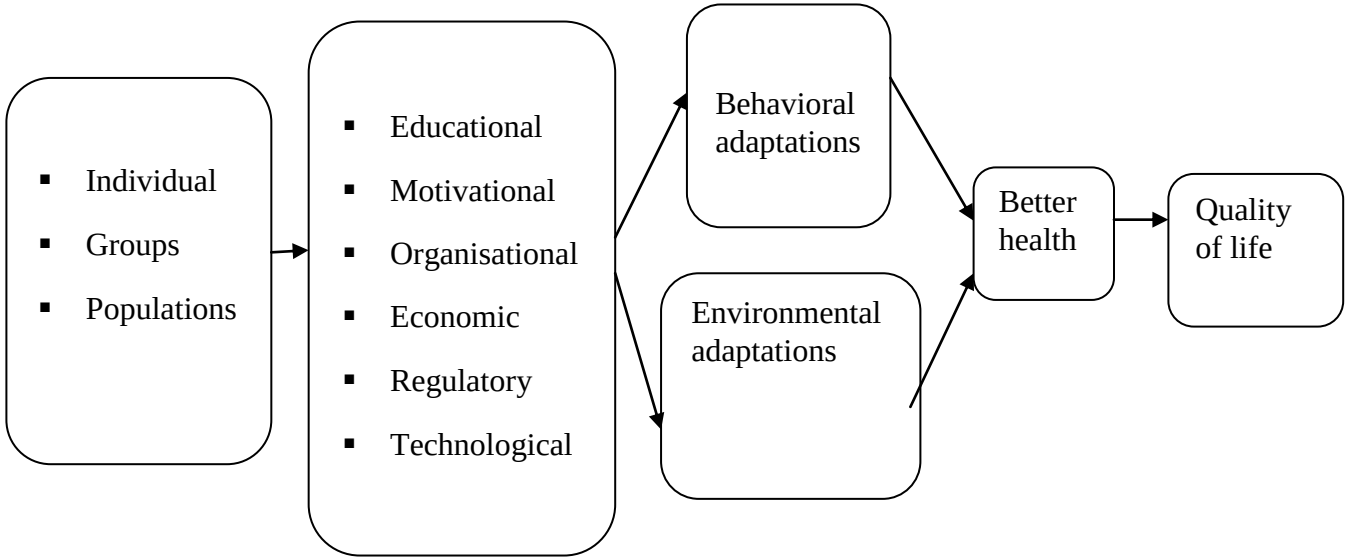
Health promotion is defined as "the process of enabling individuals and communities to increase control over the determinants of health and thereby improve their health. It represents a mediating strategy between people and their environment, combining personal choice and social responsibility for health to create a healthier future" (WHO, 1994). Green and Kreuter (1991), considered health promotion as a combination of educational and environmental supports for actions and conditions of living conducive to health. Cottrell *et al*., (2002) defined health promotion as " any planned combination of educational, political, environmental, regulatory, or organizational mechanism that support actions and conditions of living conducive to the health of individuals, groups and communities".

The definition of health promotion evolved with appearance of chronic diseases that are no longer a single predisposing cause, but a hierarchy of associated factors with a behavioral, social and politico-economic base.

Another guiding principle used in designing an intervention program for the present study is the Primary Health Care principles. These principles listed in the Declaration of Alma Ata 1978 at (http:www.paho.org/ alma_ata_declaration), was the dominant philosophy influencing health promotion with the strategy to achieve "Health for All by the year 2000". The principles are (i) Equitable Distribution, ie. Governments must endeavour to equitably distribute those variables which influence health. (ii) Community Participation ie. Individuals and communities should participate in all decisions which affect their health. (iii)Focus on prevention ie. The focus on health planners and funding must shift from medical/dental care prevention and health promotion. (iv) Use of Appropriate Technology ie. Emphasis should be on the most appropriate technology and personnel to deal with problems. (v) A Multi-sectoral Approach ie. Solutions to ill-health cannot be solved only by the health sector. Social, economic, agriculture, education sectors must co-ordinate policies that affect health.

The Ottawa Charter for health promotion (WHO, 1986), was a milestone in international acceptance outlined in five specific goal for health promotion action under the new public health. These were: building healthy public health policy, creating supportive environments, strengthening community action, developing personal skills and reorienting health services. It encompassed health education, public policy change, environmentalism and community action. It included all those activities intended to prevent disease, improve health and enhance well-being (Naidoo and Wills, 1998). Research in health promotion indicated that health promotion interventions were more likely to be effective where combinations of strategies were employed (Steckler, *et al*., 1995). The framework for health promotion is shown in Figure 2.4.

Figure 2.4 A Framework for Health Promotion



2.12.1 The PRECEDE-PROCEED framework

The PRECEDE-PROCEED framework was a comprehensive planning system that starts with extensive research to assess needs at multiple levels with an ecological perspective (Green and Kreuter, 1999). As suggested by the name, there are two predominant stages; assessment (PRECEED) and intervention (PROCEED). The PRECEDE stage focused on identifying preliminary information necessary before developing the intervention. There are five types of assessment or diagnosis in this stage; social, epidemiologic, behavior/environmental, educational/organizational and administrative/policy.

The social diagnosis involves a broad assessment of the community's perception of its own needs. The epidemiologic diagnosis involves determining which health problems are of greatest important to which groups in the community. The behavior/ environmental diagnosis include determining the factors that contribute to the occurrence or severity of the health problem and how easy it could be change. The educational/organizational diagnosis includes identifying the predisposing (ie: knowledge, attitude, belief), reinforcing (ie: continual reward, photo record) and enabling factors (facilitators) that would support change. The administrative/policy diagnosis involve identifying policies, regulations and resources that could either enhance or hinder the implementation of interventions (Green and Kreuter, 1999; Gielen and McDonald, 2002).

The PROCEED stage focuses on implementation, process evaluation, impact evaluation and outcome evaluation. Based on the goals and objectives set, the implementation of the programs are carried out and followed up by the continuous process evaluation which aims to monitor the progress of the program, rectify problems faced and implement corrective measures if necessary. The evaluation of the impact or outcome of the program will be carried out to assess the effectiveness of the program as

to how much of the goals were being achieved. The present study referred to the precede-proceed model of planning to come up with the design of the intervention phase that is appropriate and fits the current oral health care delivery situation for toddlers and preschoolers in Malaysia.

2.13 Model that explain health behavior change by focusing on the individual.

2.13.1 Health belief model.

The health belief model is one of the models designed to explain health behavior by better understanding belief about health with emphasis on the explanation of preventive health behavior. It was developed by Hochbaum, Kegeles, Leventhal and Rosenstock from the U.S. Public Health Services in the 1950s in an effort to explain the widespread failure of people to participate in programs to prevent or to detect disease (Rosenstock *et al*., 1974).

This model has four major components: perceived susceptibility, perceived severity, perceived benefits and perceived barriers (Glanz *et al*., 1997). Perceived susceptibility refers to a person's subjective estimation of his or her own risk of developing a particular health condition. Perceived severity is a personal judgment of the seriousness of that condition. For the person to feel threatened (or vulnerable), both perceived susceptibility and perceived severity must be high. According to this model, the higher the perceived threat, the more motivated the person is to take action to reduce the treat.

The other two dimensions are in reference to a specific health recommendation (eg: to reduce sugar intake, to quit smoking etc). Perceived benefits or sometimes referred to as perceived costs is a subject's estimation of the effectiveness of that recommendation in removing the threat and perceived barriers are any negative aspects or consequences of following the recommendation. If the perceived threat is high

enough and if the anticipated benefits outweigh the anticipated costs, the recommended action is likely to occur.

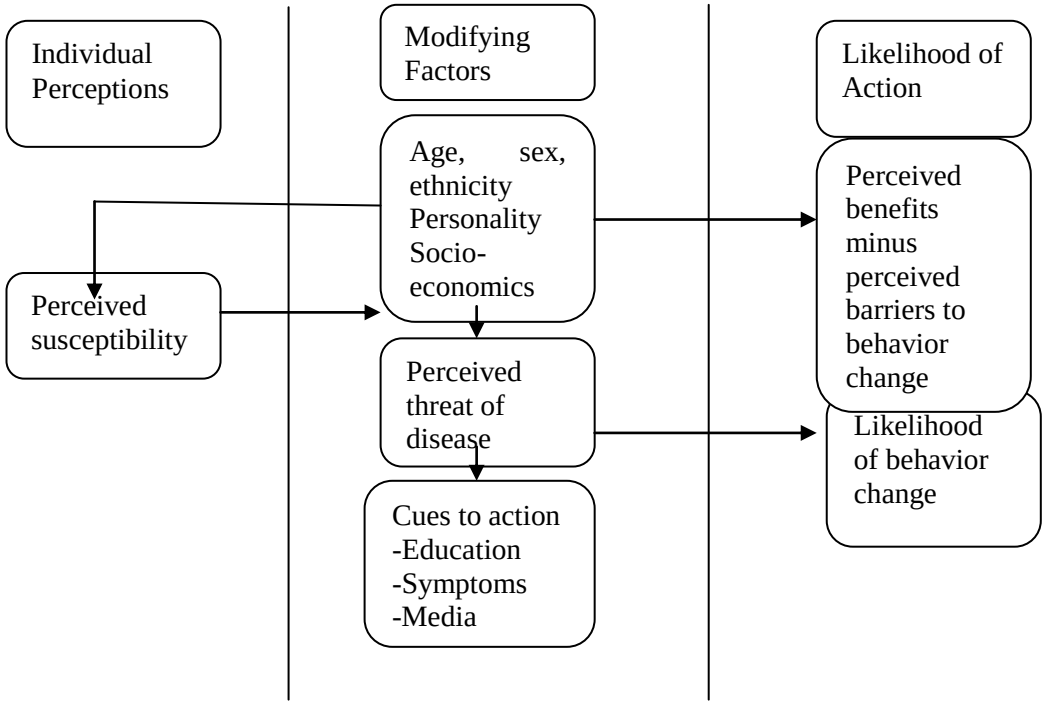
Self-efficacy, which is defined as "the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1977), was added in to the Health Belief Model subsequently as recommended by Rosenstock, Stretcher and Becker as a separate construct (Rosenstock *et al*., 1988). It measures an individual's belief that he can apply the behavior in order to achieve good health outcomes. If a smoker doesn't believe he can quit smoking, there is little likelihood he will attempt to quit even he believes that his smoking behavior is responsible for his poor health status. When the self-efficacy is greater, there will be higher motivation in facing obstacles or barriers and better chances of persisting over time outside a situation of formal supervision. Three strategies to increase self-efficacy are: 1). Setting small and increment goals, 2). Behavioral contracting, and 3) Monitoring reinforcement.

If the goal set is small and achievable, the individual will have better motivation and greater persistence for the new behavior learnt. Behavioral contracting is a formalized process to establish goals and specify rewards (reinforcement) so that the individual can receive feedback about performance, praise and a tangible reward. Self monitoring and reinforcement through record keeping can reduce anxiety about one's ability to achieve a behavior change, thus increasing self-efficacy (Glanz *et al*., 1997).

Further, for behavior change to succeed, one must feel threatened by their current behavior patterns (perceived susceptibility and severity) and believe that change of a specific kind will result in a valued outcome at acceptance cost. They also must feel themselves competent (self-efficacious) to overcome the perceived barriers to taking action. Figure 2.5 shows the Health Belief Model and its linkage. Many of literature support the importance of self-efficacy in accounting for initiation and maintenance the behavior change (Bandura, 1995; Bandura, 1997). The present study incorporated

elements of the health belief model to convince the stakeholders to accept and change their risky oral health and dietary behaviours through gradual change and tangible rewards.

Figure 2.5 Health Belief Model components and linkages (Janz *et al*., 2002)



2.13.2 The Stages of Change Model

This model was developed by Prochaska and DiClamente (1984), to describe and explain different stages of change which appear to be common to most behavior change processes. The model has two basic dimensions which describe both the different stages of change and process of change relevant to the different stages. It is based on the premise that behavior change was a process, not an event and that individuals have varying levels of motivation or readiness to change.

Table 2.6 Stages of Change

Stage	Meaning	Implications
1. Precontemplation	No thought or intention to change	Provide balance, meaningful information about issues and leave alone for now.
2. Contemplation	Plans to change in near future, but may be ambivalent	Help reinforce pros over cons.
3. Readiness	Sincere desire to change	Provide specific information and guidance via nondirective counseling
4. Action	Has started to change	Reinforce new habits, help intervene in problems areas.
5. Maintenance	Has put change in place	Positive reinforcement, give self monitoring strategies.
6. Relapse	Has neglected changes	Provide relapse prevention strategies before relapse occur. Indicate that these are normal

Adapted from Christen and Katz, 1999.

For this model, people appear to move in a predictable way through these stages, although some move more quickly than others, and some get "stuck" at a particular stage. The model is circular rather than linear, as people can enter or exit at any point. It's applies equally to people who self-initiate change, and those who are responding to advice from health professionals or to health campaigns. The present study incorporated individual support for changes in behaviour at various stages by identifying at which stage the client was progressing through positive reinforcement and diet counseling.

2.13.3 Communication-Behavior Change Model

The communication-behavior change model was developed by McGuire (1989) to design and guide public education campaign. In this model, five communication inputs are described:

1). Source: the person, group or organization from whom a message to have come. The source can influence the credibility, clarity and relevance of message.

2). Message: the messages explain what is said and how it is said. All the content and form of message can influence subject response. For example the use of fear and humour to communicate the same message may provoke different responses from the target subjects. Practical considerations such as length of message, form of language and tone of voice are also important.

3). Channel: the medium through which a message is delivered. These media include television, radio, newspapers, direct email and electronic communication eg. SMS and other social media.

4). Receiver: the intended target subjects. The gender, age, ethnic background, current attitudes and behaviours of relevance and media use of the target subjects are important in matching the right message to the right channel from the right source.

5). Destination: the desired outcome to the communication. This may include change in attitudes or beliefs or change in behavior.

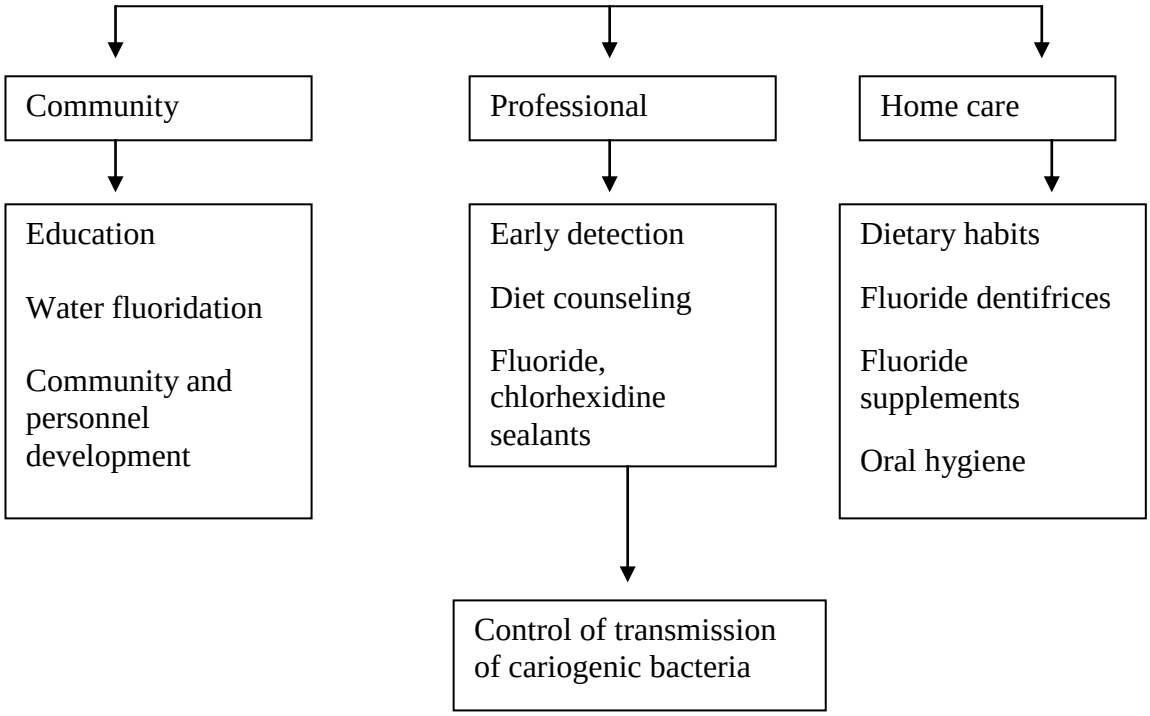
Further, this model provides a 12 step sequence of events, representing outputs, from communication which links initial exposure to a communication to long-term change in behavior. The steps are: exposure, attention, interest, understanding, skills acquisition, attitude change, memorization, recall, decision-making, behavior change, reinforcement and maintenance. All this steps illustrate that for a communication strategy to be effective, the message has to be carefully designed and delivered through the appropriate channel to reach the target audience. The subject has to be exposed to the message, pay attention to it and understand the message. Once understood by the individual, the message must create an inclination to change, reflected in attitude change and maintained until the receiver is in a position to act on that attitude change. Once the decision to change a behaviour has been made and acted on, this new behavior needs reinforcement to be maintained. The present study applied this model in designing

education materials (eg. visuals, leaflets,) and choosing appropriate channels (eg face-to-face communication, SMS message reinforcement, picture records) which are appropriate for the target population.

2.14 Strategies to tackle early childhood caries problem.

Early childhood caries is an infectious disease. Early intervention is needed to prevent transmission. Young children cannot intervene on their own, so adult assistance is required to prevent the development of the disease. The best intervention must involve parents or caregivers, health professionals and the community (Weintraub, 1998). According to Ismail (1998), there are three general approaches that have been used to prevent ECC. First, the community-based strategy that relies on educating mothers in the hope of influencing their dietary habits as well as those of their children (Ripa, 1988). This approach also includes fluoridating the water supply and personal and community preventive programs in high risk communities. The second approach is based on the provision of examination and preventive care in dental clinics. The third involves the development of appropriate dietary and self care habits at home. All three approaches include the education of the mothers or caregivers to follow healthy dietary and feeding habits in order to prevent the development of ECC.

Figure 2.6 Strategies for prevention of ECC



(Ismail, 1998).

Addressing the role of dietary factors in reducing caries disparity in children requires a comprehensive perspective and consideration of the multiple, constantly changing variables that affect eating behaviors and health status. To close the gap between those who experience higher rates of diseases compared with those who have access to education and health care, begins with education but will require government and community action as well. The measures needed the actions of multiple partners including health care providers (pediatricians, other physicians, dentists, nutritionist and allied health professionals), local community leaders, legislators, governments, educators, the media, the industry and other concerned individuals and organizations (Mobly *et al*., 2009).

The children's oral health and general health can be improved with 7 elements:

1. Dietary counsel.

- Health professional and others need to counsel parents, other caretakers and children to moderate sugar, salt and fat intake to achieve adequate growth and development and adhere to high-quality diets, following the Food Pyramid Guide by the Ministry of Health, Malaysia. Education should include frequency of consumption of sugary foods and beverages and why frequency can increase caries risk. Support in nutrition education and skill development for health literacy for future medical professionals and continuing education for practitioners can enhance these efforts (Carlson & Veschucio, 2006).

2. Advocacy.

- Health professional and allies should organize, lead, and work with local community, state and national organizations to improve access to healthy diet, including the promotion of legislation to provide incentives for establishing well-stocked supermarkets and grocery stores in poor neighborhoods.

3. Health professional training.

- Health professional training and continuing education should include skill development in diet promotion and counseling in support of oral health and general health. Representation on local, regional and state boards involved in improving environments that support healthy communities, schools and families should be sought and leadership should be achieved.

4. Advice to expectant mothers.

- Educational protocols to advise pregnant mothers about healthy diets and provide guidance on infant feeding, emphasizing the value of breast feeding

and the necessity of restricting nighttime bottle feeding to decrease caries risk.

5. Guidance on home eating patterns.

- Parents should be advised that they are role models of eating behavior at home by providing high-quality meals and having fruits and vegetables and other healthy foods available as snacks. Advice should include discouraging frequent consumption of high-fat, high-sugar foods and the realization that acceptance of new foods may require repeated presentations of the food. Community resources to assist families in developing skills in purchasing and preparing healthy foods and meals should be included in patient education.

6. Culture/ethnic sensitivity.

- Family demographics, culture/ethnic practices and food related environment issues should be routinely taken into consideration to drive education and counseling to the unique needs of a family.

7. Skilled health care providers.

- Multidisciplinary teams including dental professionals, pediatricians, nurses, registered dietetics and nutritionists, family practice physicians and other allied health care professional should be trained to screen, educate and counsel children and families to access medical and dental care and visit homes with active health promotion programs that include diet, nutrition and dental education resources. Awareness among primary care providers of the potential association between obesity and malnutrition and caries can lead to early interventions and improved health status for all children (Mobly *et al*., 2009).

In Malaysia, the government aspires to achieve a developed nation status by the year 2020 (Vision 2020). The Ministry of Health subsequently proposed the following vision: "Malaysia is to be a nation of healthy individuals, families and communities, through a health system that is equitable, affordable, efficient, technologically-appropriate, environmentally-adaptable and consumer-friendly, with emphasis on quality, innovation, health promotion and respect for human dignity and which promotes individual responsibility and community participation towards an enhanced quality of life".

In order to achieve that, the National Health Policy has laid down the direction for all health and health-related initiatives towards the Vision 2020 goals. It is thus imperative that a strategic oral health plan be also developed to achieve the desired oral health goals. The initiative taken by the Oral Health Division, Ministry of Health (MOH), as the lead agency for oral health in the country, to formulate a National Oral Health Plan (NOHP) for the year 2010 is most appropriate (Oral Health Division, 2006). The focus was on oral health conditions of public health importance viz; dental caries, periodontal conditions, oral malignancies and dental injuries. From 2011-2020 a new set of national oral health plan was developed to further improve or reset unattained objectives in 2010.

One of the major unattained objectives of the NOHP 2010 was the reduction of preschool caries prevalence and severity in Malaysia. Thus new strategies to reduce the prevalence of preschool dental caries should focus on the need to forge smart partnerships and promote intersectoral collaboration. Various government agencies, private dental practitioners, the Malaysian Dental Association (MDA) and other professional bodies, universities, industries, nutritionists, sports and recreation bodies, water authorities, consumer associations and other related organisations need to be involved for the realisation of the goals. Oral health education and health promotion is

recognised as the key element in empowering individuals and families towards achieving their health potential.

Apart from school children and the general public, educational strategies must also be targeted to expectant mothers, care-givers/cares in nurseries and childcare centers, institutions for the elderly and other groups with special needs, kindergarten teachers, health workers and adults at high risk to oral cancer. Nutrition and oral health components, injury prevention, disease risk factors, high-risk habits and self-examination for mouth cancer are some of the messages to be emphasized.

The oral health messages in educational strategies must be made easily accessible to the public through various media. By enabling individuals to take responsibility for their own health, it would empower them to secure healthier futures for themselves. Communities and the government must ensure that both social and physical environments are controlled to protect health and to enable people to exercise these responsibilities. The private sector must play a more active role in supporting government efforts in health promotion. The water fluoridation programme, which has contributed to improved oral health status of school children and young adults, should be further strengthened especially in states which have fared poorly or have stopped the program altogether. In schools where good values are being instilled in young minds, a clean and safe environment, conducive to health, should be created for promoting good oral hygiene practices and healthy lifestyles. Schools are also the ideal venues for advocating the use of mouth guards for sports.

To reduce health inequalities and barriers to access, health facilities also need to be made physically accessible to all adults especially the poor, the disabled and the elderly. In addition, the need for enforcement of sugar content labeling in foods and a standardised system of labeling fluoride concentration on all toothpastes with instructions on safe usage of toothpaste for children are some specific measures

advocated. The establishment of a National Oral Health Foundation, which will involve NGOs and industries, was also suggested. To further promote the early detection of oral cancer, opportunistic screening using other healthcare workers in primary prevention will give wider coverage to this programme and increase the number of people screened. In addition there is the call for the setting up of an oral cancer resource centre to collaborate further research in oral cancer.

Other general strategies identified include advocating a national food and nutrition policy with the aim of achieving an acceptable level of per capita sugar consumption and proposal for tax exemption or reduction for essential oral care products. The latter goals are very relevant to the present study. Table 7 shows the relevant nutritional and dietary strategies pertinent to the present research on ECC.

Table 2.7 Strategies to achieve goals for dental caries in NOHP for the year 2010.

STRATEGIES FOR ALL AGE GROUPS	
Objective: To reduce prevalence and severity of dental caries and reduce tooth loss	
GENERAL STRATEGIES	**AGENCIES**
1. To promote an ideal sugar intake of not more than 50g per person per day (current daily intake of Malaysians is 125g per person)	*MOH, Nutrition Association*
2. To promote a less cariogenic pattern of sugar intake in the Malaysian diet and eating habits (reduce sugary snacks)	*Food manufacturers, MOH, MODT, Consumer groups*
3. To advocate for sugar content labelling in an easily understood format (e.g. teaspoonfuls equivalent per serving)	
4. To advocate for tax exemption on alternative sweeteners, sugar-free confectionery and drinks and basic oral care products (e.g.toothbrushes, toothpaste, dental floss, mouthrinses etc.)	*MOH, private & NGOs in oral health, MOF*

2. STRATEGIES FOR SPECIFIC AGE GROUPS	
Objective: To reduce dental caries experience among **6-year-olds (Pre-school)**	
EDUCATIONAL STRATEGIES	**AGENCIES**
1. To ensure that all expectant mothers attend oral health talks. 2. To make available oral health pamphlets in public/private clinics and maternity homes. 3. To incorporate oral health messages in antenatal products e.g. milk supplements for mothers. 4. To include nutrition and oral health in the training of kindergarten teachers and childcare providers.	*MOH* *MOH, private* *Food industry* *MOE, KEMAS/JKMM*
ENVIRONMENTAL STRATEGIES AGENCIES	
1. To make toothbrushing troughs, low sinks and mirrors available at all kindergartens and nurseries to promote tooth brushing and personal hygiene. 2. To extend incremental dental care and preventive services to kindergartens 3. To make available sugar-free medicines.	*MOE/ KEMAS* *MOH* *Drug manufacturers*
LEGISLATION/ ENFORCEMENT STRATEGIES AGENCIES	
To advocate that non-milk extrinsic sugars not be added into baby food and milk formula.	*MODT/ food manufacturers*

(Oral Health Division, 2006).

2.15 Health Promotion Intervention study targeting ECC risk reduction.

Health promotion intervention can produce a variety of effects including disease prevention, increases health awareness, risk reduction and reduction of demand for health services. Theory and research suggest that the most effective health promotion intervention program are those that use multiple risk factors and aim to achieve multiple goals of awareness, information transmission, skill development, supportive environments and policies with emphasis on high risk group (Glanz *et al*., 1996; Pelletier, 2001).

The types of intervention found in the health promotion intervention are individual counseling, group teaching only, group teaching with individual counseling, and environmental changes. Intervention which is more comprehensive with emphasis on the high risk group will yield better outcomes in term of health measures and cost reduction. However, the low risk group should not be ignored so that they will remain in the low risk category and not progress to high risk group (Heaney and Goetzel, 1997; Pelletier, 2001). Table 2.8 shows some of the latest health promotion intervention programs that targeted on ECC risk and their effectiveness.

Table 2.8 Health promotion intervention programs targeted on ECC risk and their effectiveness.

Authors	Study design	Objective	Method	Results	Conclusion
(Plutzer K & Keirse M.J., 2011)	Randomized controlled trial	To examine whether single parenthood (mother only) affects the effectiveness of an oral health promotion program to their ECC in the child	First-time mothers were enrolled in a randomized controlled trial of anticipatory guidance to prevent ECC. The intervention was applied during pregnancy and when the child was 6 and 12 months old. Mothers in control group received no intervention. The presence of ECC was assessed at 20 months of age and compared between children from one-and two-parent families.	Total participants were 649 women and child. Children from one-parent families had a 2.3 times higher incidence of ECC than children from two-parent families. The i**ntervention** reduced the frequency of ECC from 8.1% to 1.1% in two-parent families (relative risk: 0.14) and from 16.3% to 4.5% (relative risk: 0.28) in one-parent families. One case of ECC was prevented for every nine single mothers receiving anticipatory guidance compared with one case per 15 partnered mothers. Despite a greater reduction in the absolute risk of ECC in children from one-parent families, the i**ntervention** reduced their ECC experience only 3.5-fold compared with sevenfold in children from two-parent families	The **intervention** produced a greater reduction in the frequency of ECC in children from one-parent families than in those from two-parent families. This did not reduce their disadvantage, though, as they still had a four times higher risk than children from two-parent families. Mothers and children in one-parent families need substantially more attention and support than those in two-parent families to eliminate their disadvantage in suffering ECC.
(Feldens *et al*., 2010)	Parallel randomized trial	To investigate the effectiveness of home visits advising mothers about healthy feeding practices during the first year of life on the occurrence of ECC and severe ECC at 4 years of age.	The intervention group received monthly advice up to 6 months and then at 8, 10 and 12 months by nutritionist based on the "Ten Steps for Healthy Feeding". The primary outcome was the occurrence of ECC at age 4. Secondary outcomes included the occurrence of severe ECC, number of affected teeth, missing and filling.	Of 500 mothers-child pairs (200 intervention, 300 control), 69.3% control and 53.9% intervention had ECC, home counseling reduced the incidence by 32% (RR0.68, 95% CI 0.50-0.92). The mean number of affected teeth was lower for the intervention group (3.25) compared with control group (4.15).	Home nutritional advice during the first year of life decreases caries incidence and severity at four years of age in a low income community.

Authors	Study design	Objective	Method	Results	Conclusion
(Plutzer K & Spencer A.J., 2008).	Randomized controlled trial	The purpose of this study was to test the efficacy of an oral health promotion programme for the parents of infants, starting during the pregnancy, using a randomized controlled trial	Mothers in the test group received oral health promotion information during pregnancy, and later when the child reached 6 and 12 months of age. At the second round,the test group mothers were randomized again. The information was reinforced in one of the test subgroups through a telephone consultation. There was no contact with mothers in the control group after enrolment. At the age of 20 ± 2.5 months all test and control group children were examined by a dentist. The case definition of an incidence of S-ECC was one or more upper incisor teeth being carious at the level of a cavitated or noncavitated lesion.	Of 649 women enrolled in the programme (test group 327, control group 322), 441 had their child examined at follow-up. The incidence of S-ECC in the test group was 1.7% and in the control group 9.6% ($P < 0.001$)	An oral health promotion programme based on repeated rounds of anticipatory guidance initiated during the mother's pregnancy was successful in reducing the incidence of S-ECC in these very young children.
(Feldens *et al*., 2007)	Randomized controlled trial	Assess the effectiveness of home visits for advising mothers about breast feeding and weaning on ECC at the age of 12 months.	The intervention group received advice 10 days after the child's birth, monthly up to 6, 8, 10 and 12 months. The assessment of dental caries was done at 6 and 12 months of age.	10.2% of children in intervention group and 18.3% of the controls had caries. The odds of caries was 48% lower for the intervention group, (OR 0.52, 95%CI 0.27-0.97). Mean SD was lower for the intervention group (0.37) when compared with control group (0.63). The intervention group had longer duration of breast feeding, later introduction of sugar and smaller probability of ever having eating biscuits, honey, soft drinks, fromage-frais, chocolate and sweets.	The home visits for dietary advice appear to help reducing dental caries in infants. Greater efforts are needed to tackle cariogenic dietary behavior even further, as a relevant proportion of children of the intervention group were shown to present with dental caries. Further studies should examine the effect of the intervention in the longer term.

Authors	Study design	Objective	Method	Results	Conclusion
(Davies *et al*., 2007)	Randomized controlled trial	This paper reports the results of a community trial to measure the clinical impact of a linked series of interventions on **Early Childhood Caries** (ECC) and general **caries** levels among five-year-old children. It exemplifies the problems of undertaking population based interventions in deprived communities	In the active PCG, children who attended designated clinics for their 8-month developmental checks and/or MMR inoculations at 12 to 15 months, were given gift bags, the first contained a trainer cup, the second fluoride toothpaste (1450 ppm F) and toothbrush. Parents were also given written, pictorial and verbal advice on oral care. Further supplies of toothpaste and brushes were posted to the children's homes at 20, 26 and 32 months. When five years of age children in the two PCGs were examined in school.	Participants in the active PCG the prevalence of ECC, **caries** and extraction experience and mean dmft (20%: 54%: 3%: 2.2) were lower than in 'participants' in the comparison area (32%: 64%: 12%: 3.7). All differences were statistically significant. When all children (participants and non-participants) in the two PCGs were compared, the differences were much reduced (30%: 63%: 6%: 3.1 vs. 32%: 64%: 12%: 3.6). A higher proportion of children in the active PCG area (47%) were found not to have participated in the interventions, when compared to 21% in the comparison area. Disease levels in the non-participants in the active PCG were particularly high. The impact of participation bias, changes in baseline balance, population mobility and alternative study design on outcomes are explored.	The impact of non-participation in a deprived, urban conurbation with high levels of population mobility are sufficient to dilute the impact of a **health intervention** such that few benefits are discernible at a population level.
(Vachirarojpisan *et al*., 2005)	A one-year **intervention** programme	To evaluate the process and outcomes of a participatory dental **health** education (DHE) programme for preventing **early childhood caries** (ECC).	520 mothers/caregivers of 6-19 month-old children who lived in a rural area of Thailand. Small group discussion with active involvement in the **intervention** group and the national teaching DHE programme in the control group	The percent of subjects using a toothbrush and tooth brushing with fluoride toothpaste was 93% and 87% respectively in the i**ntervention** group, significantly higher ($p<0.01$) than the control group (73% and 58% respectively). Night time bottle-feeding, falling asleep with a bottle and sweet snack diet behaviour appeared the same in both groups. The net cavitated carious increment was 3.5 (SD=3.4) teeth in the **intervention** and 3.2(SD=3.5) in the control group. **Health** centre staff were very	The participatory dental **health** education model was shown to be a practical and effective method for increasing oral hygiene practice, but was not sufficient to prevent the development of ECC. This single **intervention** in the short term is not seen as sufficient to prevent the development of ECC.

				supportive of the programme and suggested extending the participatory format to other child **health** topics.	
Authors	**Study design**	**Objective**	**Method**	**Results**	**Conclusion**
(Davies *et al.*, 2005)	Randomized controlled trial	This paper reports the results of a community trial to assess the effects of a multi-stage dental **health promotion** programme in reducing **Early Childhood Caries** (ECC).	Two **health** districts (Primary Care Groups) were matched for dental disease levels and socio-demographic factors. One was randomly allocated to be the test Primary Care Group (PCG), the other the control PCG. Children in the test PCG received a series of interventions to support positive dental **health** behaviour from the age of 8 to 32 months. Interviews were conducted with parents of children aged 21 months and clinical examinations were undertaken on a larger cohort of children aged 3-4 years in test and control PCGs.	Prevalence of ECC in children who had received the interventions was 16.6% compared with 23.5% of children in the control area, a reduction of 29% (p=0.003). The mean dmft (1.17) and prevalence of general **caries** experience (28.7%) in the test children were also significantly lower than for children in the control PCG (1.72: 39.2%) (p=0.001). Analysis from a community perspective, showed the prevalence of ECC in the test and control PCGs was 21.3% and 22.8% respectively and the mean dmft 1.47 and 1.72. The proportion with general **caries** experience remained statistically significant in favour of the test area 33.8% vs 39.9% (p=0.01). Parents in the test PCG were more likely to report cessation of bottle use (33% vs 18%), use of sugar-free drinks (49% vs 24%), commencement of brushing before first birthday (45% vs 27%) and twice daily brushing (52% vs 34%).	The parents who received this multi-stage **intervention** were more likely to report adoption of three positive oral **health** behaviours; using a trainer cup from one year of age, using safe drinks and brushing twice daily with a fluoride toothpaste. The programme failed to reduce the prevalence of ECC in the community but the prevalence of ECC and general **caries** experience among the children who participated was less than among children in the control PCG.

2.16 Summary

The literature review has argued about the need to seek a new perspective to improve health in an integrated manner because health and oral health is integrated. The traditional method of intervention was usually separated and run by different professional groups ie. dentists and nutritionists. Nutritionists aim to modify diet or nutrition to improve health in the hope that oral health will ensue. However, this is not usually the case because they rarely consider the dietary effects to oral or dental health. However the present study argues that it may be possible to use intervention strategies meant to improve dental health status (ie. Prevention of ECC) in order to indirectly influence general health status in young children (ie BMI status) through an integrated health promotion package.

To support this contention, the literature on health (ie. malnutrition problems) and oral health (ie. ECC caries problems) of preschoolers and toddlers was reviewed especially in the poorer socio-economic states of Kelantan and East Malaysia (Section 2.3 and Section 2.4). The following sections (Section 2.5) dealt with its definition, aetiology and factors influencing ECC such as diet and sugar intake issues, globally as well as in Malaysia. It is clear that new approaches to intervention in Kelantan is needed because the present approaches to improve toddlers and preschool oral health status do not seem to have a large impact on dental caries prevalence and severity.

Based on official recommendations of sugar intake levels (Section 4.0), current knowledge on health promotion principles (Section 5), health promotion planning models (Section 5.1) and behaviour change intervention models (Section 5.2, 5.3, 5.4), a new health promotion intervention package was designed (described in Materials and Method Section) aimed to reduce incidence of Early Childhood Caries (ECC).

This is a prospective study on 2-3 year old caries-free toddlers at baseline to assess the effectiveness of the health promotion package spread over a period of 18

months to see whether ECC (dmft) can be reduced together with improvements in nutritional status measures (BMI-for-age, WAZ and HAZ). Additionally, a proxy population of 5-6 year old preschoolers was used as a comparison if the current toddlers program remains unchanged.