The Comorbidity of Early Childhood Caries and Iron Deficiency
In Preschool Children

By

Ann C. Y. Szeto

B.A., The University of British Columbia, 1997
Dip.DH, Vancouver Community College, 2000

A Thesis Submitted in Partial Fulfillment of
The Requirements for the Degree of

Master of Science

in

The Faculty of Graduate Studies
(Department of Oral Health Sciences)

We accept this thesis as conforming
To the required standards

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Dedicated to

my dear parents

and

my loving husband, Carlos

Chapter 1

1. INTRODUCTION

Early childhood is an important stage in a child's life. Normal growth and development at this stage can be hindered by the common, but preventable, conditions of early childhood caries (ECC) and iron deficiency (ID).

ECC is a serious condition that affects thousands of young B.C. children on an annual basis. Further, dental treatment under general anesthetic (GA) is the most common reason for a child to be admitted to BC hospitals (Association of Dental Surgeons of British Columbia [ADSBC], 2001). A conservative estimate of the annual cost of treating ECC under GA in BC exceeds $10.5 million (ADSBC, 2001). In addition to the financial costs associated with treatment, this preventable condition limits access to operating rooms for children with other medical conditions (ADSBC, 2001).

Iron deficiency is the most common nutritional deficiency of young children. Infants from 6 months to 2 years of age are especially vulnerable to this condition because by age 4-6 months, the body becomes deplete of its gestational iron stores and an adequate intake of iron is essential to prevent the development of iron deficiency (Looker, Dallman, Carroll, Gunter, & Johnson, 1997). Meeting iron requirements are further challenged by the onset of weaning and the rapid physical growth of infants and toddlers. In fact, during early childhood, the recommended intake of iron relative to body weight exceeds that at any other stage of life, including that of adult men. In addition, children are challenged to receive adequate dietary iron because they tend to consume soft, plant-based foods (carbohydrates) which have less available iron than meat which requires more chewing. Further, children also consume smaller quantities of foods overall. Therefore, careful dietary planning is important to ensure young children meet their high dietary iron requirements.

Both ECC and ID can negatively affect the quality of life of young children. Dental decay can be painful and diminish a child's ability to eat nutritiously and sleep properly (ADSBC, 2001). Children with ID tend to fatigue easily and have a decreased appetite. Further, irreversible developmental and cognitive delays are associated with prolonged ID (Michaelsen, Weaver, Branca, & Robertson, 2000). Therefore, both ECC and ID may have an immense impact on a child's physical growth and social development.

ECC and ID are common conditions with complex multifactorial etiologies. Both conditions are especially prevalent in young children from lower socioeconomic backgrounds. Moreover, unhealthy dietary and feeding practices are risk factors common to both ECC and ID. Excessive consumption of beverages, especially cow's milk, may increase a child's risk to both conditions. Fortunately, both ECC and ID are preventable. Establishing that there is a dietary link between the two conditions may bring increased commitment to prevention of both conditions from all healthcare providers who work with young children and their families. Such an intersectoral approach to preventing both these conditions may eventually result in a decreased prevalence of both ECC and ID in high risk children.

1.1. Purpose of Study

The overall goal of this study was to explore the dietary risk factors that may contribute to both ECC and ID.

The objectives of the study were to:

1. determine the prevalence of dental decay and iron deficiency in a sample of preschool children from Vancouver, British Columbia,
2. explore the socio-demographic variables, dietary habits and dental health practices that may be associated with early childhood caries and iron deficiency in these children, and
3. explore a possible relationship between early childhood caries and iron deficiency by investigating common explanatory variables, most specifically dietary patterns.

Chapter 2

2. REVIEW OF THE LITERATURE

2.1. Early Childhood Caries.

2.1.1. Definition

Dental caries in young children is a serious problem. Early childhood caries (ECC) is the term currently used to refer to extensive decay in young children. In the past, the term "nursing bottle mouth" was used to describe a pattern of decay affecting the primary maxillary anterior teeth and the maxillary and mandibular first molars (Fass, 1962). Other terms including nursing bottle caries, nursing bottle syndrome, milk bottle syndrome, baby bottle caries, and baby bottle tooth decay have also been used (Ripa, 1998). All these terms reflect the understanding of the day that this characteristic pattern of decay was purely a result of inappropriate baby bottle use. In 1994, a conference at the Center for Disease Control and Prevention developed the currently used term, "early childhood caries" (Center for Disease Control and Prevention [CDCP], 1994). This new terminology represents an evolving understanding of the multifactorial etiology of ECC (Reisine & Douglass, 1998) and the current awareness that the relationship between bottle habits and rampant tooth decay is not absolute (Tinanoff, 1998). In other words, not all children with ECC have a history of inappropriate bottle use, and conversely, many children with negative bottle feeding habits do not develop ECC.

In 2003, the American Academy of Pediatric Dentistry published their definition of ECC. The condition was defined as the presence of one or more decayed (cavitated or noncavitated), missing (due to decay) or filled tooth surface (dmfs) on any primary tooth in a child less than 6 years of age. Severe ECC (S-ECC) was the presence of caries on any smooth surface in a child under age 3 years. For children ages 3 to 5 years of age, S-ECC is characterized by a dmfs ≥ 1 on the smooth surface of the primary maxillary anterior teeth, or a dmfs of ≥ 4 (age 3 years), ≥ 5 (age 4 years), and ≥ 6 (age 5 years) (American Association of Pediatric Dentists [AAPD], 2003).

2.1.2. Prevalence

The prevalence of dental caries in the general population has declined in recent years primarily as a result of increased exposure to fluoride, usually from toothpastes (van Loveren & Duggal, 2001). Determining the "true" prevalence of ECC has been difficult because preschool children are so challenging to access (Ripa, 1988). The reported prevalence also varies depending on the criteria used to define ECC. Because of the relationship between socioeconomic status (SES) and ECC, prevalence varies depending on the SES of children surveyed. ECC is "unequally" distributed in preschool children; 25% of the children experience 80% of the caries (NIH, 1996). Despite these challenges, a variety of surveys suggest that about 8% of 2-year-olds and over 40% of 5-year-olds have at least one decayed or filled tooth (Vargas, Crall, & Schneider, 1998; Ramos-Gomez, Weintraub, Gansky, Hoover, & Featherstone, 2002).

The prevalence of ECC in Canadian children varies throughout the country. Children aged 9 months to 5 years of age in Toronto had a prevalence of 7.4% (Budowski, 1989).

Preschool Inuit children in the Northwest Territories had a much higher prevalence of 65% (Albert, Cantin, Cross, & Castaldi, 1988). In B.C., Derkson & Ponti (1982) found a prevalence of ECC of 3.2% amongst 9 month to 6 year olds in Vancouver. Recent screenings throughout B.C. by community dental health staff found that ECC affected 11% of kindergarten children surveyed with a range from 7.9% to 27.4% depending on the region (Bassett, McDonald, & Woods, 1999). Caution is suggested in comparing these figures because of the differing definitions of ECC used by each group of investigators mentioned above..

2.1.3. Biological Risk Factors

Dental caries is an infectious and transmissible disease (Krausse, 1965) with a multifactorial etiology. It requires three primary factors: cariogenic microflora, substrates, and susceptible tooth and host (Krausse, 1965). Substrate is fermented by cariogenic microflora which leads to a lowered oral pH. Depending on the tooth's susceptibility and host's antibacterial and buffering abilities in the saliva, this decreased pH may lead to enamel demineralization (Keyes & Jordan, 1963). The three primary factors required for dental caries to occur will now be discussed in detail.

2.1.3.1. Microflora

Mutans streptococci (MS) is the species of oral bacteria primarily associated with the initiation of the caries process. MS have unique cares-inducing properties that include the ability to adhere to tooth surfaces, to produce copious amounts of acids by fermentation of dietary sugars, and to thrive in low pH environments (Sheiman, 2001).

The initial timing of MS colonization in the mouths of infants remains controversial. Early investigators determined that MS needs a non-shedding oral surface to colonize. They concluded that colonization follows the eruption of teeth (Berkowitz, Jordan, & White, 1975). Further, a discrete window of infectivity ranging from 19-31 months of age for MS was suggested (Caufield, Cutter, & Dasanayake, 1993). However, more recent evidence suggests that these cavity-causing bacteria can be found in the mouths of infants prior to tooth eruption (Wan et al., 2001; Tinanoff, Kanellis, & Vargas, 2002; Berkowitz, 2003).

Early age of initial colonization and the presence of high levels of MS are considered major risk factors for ECC (Berkowitz, 2003). A significant increase in MS levels often precedes the onset of ECC and salivary levels of the bacteria have been used to predict caries risk (Brown, Driezen, & Handler, 1976; Klock & Krasse, 1979). A strong correlation has been observed between MS species and counts between a mother and her child. The mother is the usual source of the MS and transmits the bacteria to her child by close contact and the sharing of food and utensils (Tinanoff et al., 2002; Berkowitz, 2003).

The concentration of MS in the oral microflora of children with ECC routinely exceeds 50% of the cultivable plaque flora and over 10% of the saliva flora (van Houte, Gibbs, & Butera, 1982). In contrast, MS forms less than 1% of the plaque flora in caries-free children (Berkowitz, 1996). Further, children with ECC have been reported to have a level of MS in plaque that is 100 times higher than that of their caries-free peers (Chen, 1995).

Historically, lactobacilli were considered the primary bacteria in the dental caries process. However, current knowledge links the presence of lactobaccilli in the oral cavity to the progression, rather than initiation, of caries. Lactobacilli are commonly found in high levels within cavitated lesions (von Houte, 1980). High counts of MS and lactobacilli are significant indicators of high caries risk.

2.1.3.2. Host

2.1.3.2.1. Saliva

As the main host defense against dental caries, saliva plays an important role in neutralizing acids produced by dental plaque and in the clearance of foods from the oral cavity (McGhee & Kiyono, 1993; Seow, 1998). The contents of saliva also provide the main immunological defense against dental caries. Infants develop saliva secretory immunoglobulin A antibodies (sIgA) at the same time that oral bacteria colonize their mouths (Seow, 1998). sIgA provides specific immune defense against cariogenic bacteria by interfering with bacterial attachment to the tooth surface (Seow, 1998). Further, inhibition of bacteria metabolic activity by sIgA may also be important (McGhee & Kiyono, 1993; Seow, 1998). However, it is difficult to correlate sIgA and caries in infants and young children because their secretory responses are likely still immature (Gahnberg, Smith, Taubman, & Ebersole, 1985; Gleeson et al., 1991). Furthermore, little clinical evidence exists indicating that sIgA protects against dental caries (Michalek & Childers, 1990).

The flow rate of saliva is also an important variable in determining its significance as a host defense. Flow rate influences the rate of oral clearance, buffering capacity, and antimicrobial activity. Since saliva flow rate is at its lowest during the night and/or during sleep, continuous ingestion of sugary liquids at this time is a significant risk factor for ECC (Seow, 1998).

2.1.3.2.2. Tooth maturation or defects

Enamel defects, common in the primary dentition, occur with a prevalence ranging from 13-39% in normal full-term infants. In preterm or low birth-weight babies, the prevalence exceeds 62% (Tinanoff et al., 2002). Localized enamel defects have been attributed to local trauma and infections. Generalized hypoplasia has been associated with hereditary conditions, birth prematurity, low birthweight, infections, malnutrition, metabolic disorders, and chemical toxicity (Seow, 1998).

Enamel maturation occurs during and following the eruption of the primary teeth. This is a critical period for caries susceptibility if the immature enamel is exposed to cariogenic microflora and frequent ingestion of fermentable carbohydrates (Seow, 1998). Structural defects in the enamel (hypoplasia) or a change in opacity further increase the risk of caries in primary teeth as the irregular pits and grooves on the tooth surface increase plaque retention. As well, clearance of food particles may also be delayed, thereby continuously exposing the defective and vulnerable tooth surface to the acidic oral environment created by the bacteria (Horowitz, 1998; Seow, 1998). Although enamel hypoplasia has been hypothesized to be a risk factor for ECC, the role of subclinical enamel hypoplasia remains uncertain (Seow, 1998).

2.1.3.3. Substrate

2.1.3.3.1. Cariogenicity

To allow production of sufficient amounts of acid by bacteria to demineralize enamel, sugars or refined carbohydrates must be present and utilized as substrate by cariogenic bacteria (Sheiham, 2001). Dietary sugars are simple carbohydrates that include glucose, fructose, sucrose, and lactose (found in milk products) (Wardlaw, 1997). Refined carbohydrates are starches processed through fine grinding and heat treatment. They are retained on the teeth for prolonged periods and easily broken down by oral bacteria into acids that lead to enamel demineralization. Although starchy foods alone are less cariogenic than sucrose, those starchy foods that also contain sucrose may be as cariogenic as sucrose alone (Rugg-Gunn, 1996).

The literature on caries risk can be confusing because some studies focus on "sugars", while others on refined carbohydrates. Nevertheless, both substrates are considered to be risk factors for ECC. MS are able to utilize sugar and fermentable carbohydrates to produce glucan polymers that promote bacterial adherence to the tooth surface and increase the thickness of the plaque. However, sucrose is considered the most cariogenic sugar because oral bacteria are able to use it to produce plaque dextrans which facilitate bacterial adherence (Mikkelsen, 1996) and replace earlier-colonizing bacteria with MS (Tanzer, 1989).

Opinions differ as to whether it is the total amount or the frequency of sugar that is most closely associated with caries experience. The Threshold Theory suggests a recommended "safe" maximum for daily sugar consumption. If the "threshold" is exceeded, caries risk is increased (Sheiham, 1991; Eurodiet Core Report, 2001; van Loveren & Duggal, 2001). However, other researchers have demonstrated that it is the frequency and duration of the tooth's exposure to sugar rather than the total amount of sugar that is related to dental caries (Bowen, Amsbaugh, Monell-Torrens, & Brunelle, 1983; van Loveren & Duggal, 2001).

Frequency of snacking between meals is a risk factor associated with ECC (Tsubouchi, Tsubouchi, Maynard, Domoto, & Weinstein, 1995). Frequent food consumption, especially foods containing refined sugars, enables continual acid production by cariogenic bacteria leading to demineralization of the tooth. Equally important, the ongoing low pH of the oral environment does not provide the opportunity for enamel remineralization to occur. Over time, if demineralization exceeds remineralization, carious lesions develop and progress to frank decay (Tinanoff et al., 2002).

Concerns regarding inappropriate baby bottle and sippy cup use are related to the frequency of ingesting liquids containing simple sugars. Children with ECC are more likely to be fed with a bottle containing fluids other than water beyond age 1, especially during sleeptime (Tsubouchi et al., 1995). The risk of caries also increases in children who are bottle fed until an older age due to a longer duration of bottle use (Leverett et al., 1993; Litt et al., 1995). However, the associations between prolonged and inappropriate bottle-feeding practices and caries rate is not absolute as some investigators have found little to support nighttime bottle use as a major caries risk factor (Reisine & Douglass, 1998). Nevertheless, nighttime bottle use should be discouraged as it contributes to increased contact between substrate and bacteria (Tinanoff & Palmer, 2003). The low pH oral environment that results from this continuous feeding is especially devastating to the primary teeth when the baby bottle or sippy cup is used at night and at nap-time. Saliva flow rates are reduced at night and during sleep (Seow, 1998).

Another area of debate is the potential cariogenicity of prolonged or nighttime breast-feeding (Kotlow, 1977; Valaitis, Hesch, Passarelli, Sheehan, & Sinton, 2000; Tinanoff & Palmer, 2003). Although there are some anecdotal reports that this infant feeding practice is associated with ECC, the contribution of other cariogenic dietary practices cannot be dismissed. Child-rearing practices such as the use of food to soothe the child and unrestricted access to snacks may contribute to the caries experience of breast- and bottle-fed children (Johnsen, 1982; Tinanoff & Palmer, 2003).

Sweetened foods, especially beverages, require little grinding or chewing, and therefore are popular amongst children (Falco, 2001). Fruit juices and fruit-flavored drinks can greatly contribute to ECC due to their high sugar content and acceptance by children. They are often continually given to children in bottles and sippy cups as snacks due to their low cost and misunderstood nutritional value (Tinanoff et al., 2002). Increased consumption of regular soda and powdered beverages has also been reported to be associated with increased caries risk in preschool aged children (Marshall et al, 2003).

The cariogenicity of cows' milk remains controversial. Although milk sugar (lactose) has been implicated in the etiology of ECC, it is not fermented as completely as refined sugars. The phosphoproteins in milk inhibit enamel demineralization and antimicrobial factors such as lactoferrin[1] interfere with oral bacteria (Losnedahl, Wang, Aslam, Zou, &

[1] Lactoferrin deprives micro-organisms of iron and thereby inhibits their growth or kills them altogether.

Hurley, 1996). As well, α-1 casein, a milk protein, concentrates in the acquired pellicle and inhibits MS adherence to the hydroxyapatite (Reynolds & Wong, 1983). Milk's role in ECC is a concern because other food products or sugar are sometimes combined with milk. Consequently, milk can serve as a vehicle for cariogenic substances (Imfeld, 1983; van Loveren & Duggal, 2001; Tinanoff et al., 2002).

In summary, the simultaneous presence of cariogenic bacteria, substrate, and a susceptible tooth and host are essential to the caries process. The acidic oral environment that results from substrate fermentation by the oral bacteria may lead to enamel demineralization. This process depends on host factors such as the saliva's flow rate, antibacterial and buffering capacity, and the presence of a susceptible tooth surface. Frequent intake of sugars or refined carbohydrates between meals allows the bacteria to lower the pH of the oral environment making it favorable to enamel demineralization. Further, retentive foods provide a continuous source of food for the bacteria and therefore are also a significant risk factor for ECC. As well, continuous use of the baby bottle or sippy cup containing fluids other than water during the day or at bedtime may also contribute to ECC.

2.1.4. Non-Biological Risk Factors

2.1.4.1. Socioeconomic Status

ECC disproportionately affects children from low-income families (Demers et al., 1990; Litt et al., 1995; Henry, 1997). Bottle habits, use of preventive dental services, toothbrushing frequency and effectiveness, and sugar consumption are behaviors that may be influenced by socioeconomic status and are likely to have a direct effect on caries risk (Litt et al., 1995; Douglass, 2000).

The mother or caregiver's education has also been demonstrated to be a predictor of ECC (Grindefjord, Dahllof, Nilsson, & Modeer, 1995; Ramos-Gomez et al., 2002). As well, in industrialized countries, caries prevalence is significantly higher in children from cultural minorities (Grindefjord et al., 1995). Children of new immigrant families in Canada are often at risk for ECC. Many immigrant families experience socioeconomic challenges because the parents' education and employable skills may not be fully recognized in their new country. Language may also pose a barrier to employment and, together with poverty, will affect the family's access to dental care.

2.1.4.2. Parenting and Family Issues

A lenient parenting style has been reported to be associated with increased caries risk (Kawabata et al., 1997). A variety of behaviors are reflective of a "lenient parenting style". For example, children with caries may snack more frequently, a possible indication of caregivers' indulgence towards the children. Further, children who watch television during meals are also at greater risk for developing dental caries possibly as a result of prolonged acidity in the oral cavity due to the extended time spent eating (Kawabata et al., 1997). As well, this habit may indicate the presence of other poor feeding behaviors for the child. This practice of indulgence may be culturally determined (Tsubouchi et al., 1995). Further, a caregiver who is less willing to tolerate stress and upset the child increases the child's risk to ECC (Weinstein, Domoto, Wohlers, & Koday, 1992; Tsubouchi et al., 1995).

Children from single-parent families may be at increased risk for ECC. Families in this circumstance are also more likely to be low-income. Consequently, single-parent families may be more susceptible to stress due to reduced family support and financial challenges, and preventive behaviors may be forfeited for more immediate concerns (Litt et al., 1995; Ramos-Gomez et al., 2002). Poor oral health of the parents is also associated with increased prevalence of caries in their children (Henry, 1997; Mattila et al., 2000). Therefore, risk factors to ECC related to family circumstances may include the family's lack of preventive information, barriers in accessing dental care, transmission of high counts of MS from the parents to their children, or inappropriate dietary practices in the family.

2.1.4.3. Preventive Dentistry

2.1.4.3.1.Dental homecare

Opinions differ about the caries-preventive role of toothbrushing. Some evidence suggests a strong correlation between visible plaque on the upper anterior teeth at 19 months of age, and caries at age 3 (Demers et al, 1990; Alaluusua & Malmivirtia, 1994; Messer, 2000). Further, there are also reports that increased frequency and parental involvement in toothbrushing decreases the prevalence of smooth surface caries (Winter, Rule, Mailer, James, & Gordon, 1971; Wendt, Hallonsten, Koch, & Birkhed, 1994), while other investigators have not observed this relationship (Febres, Echeverri, & Keene, 1997). As well, caregivers of children with caries are reported to be less aware of the need to clean the teeth at an early age and are less likely to be able and willing to cope with an uncooperative child (Tsubouchi et al., 1995).

Contrary to the notion that early initiation of toothbrushing is important in reducing caries experience, most studies have not found a relationship between the age at which toothbrushing begins and prevalence of ECC (Serwint, Mungo, Negrete, Duggan, & Korsh, 1993). Although regular toothbrushing may counteract the cariogenic effects of a child's diet, evidence suggests that children at increased risk for ECC due to high sugar consumption or inappropriate bottle use are also more likely to have poor oral hygiene (Paunio, Rautava, Helenius, Alanen, & Sillanpaa, 1993). Further, it is more likely the fluoride that is available in most toothpastes rather than toothbrushing that decreases caries risk (Health Education Authority, 1996; Sutcliff, 1996).

2.1.4.3.2. Access to Fluoride

Exposure to fluoride remains the best measure to prevent dental caries (Levy, 2003) because it reduces the dissolution of enamel, encourages enamel remineralization, and alters dental plaque by decreasing its acid production (Sheiham, 2001). Fluoride can be delivered topically and systemically through rinses, dentrifice, and water. Good oral hygiene and regular use of fluoride reduce the risk of dental decay even with frequent sugar consumption (van Loveren & Duggal, 2001). Although there is little evidence that toothbrushing alone reduces caries, studies have shown that toothbrushing when used with fluoridated toothpaste does prevent decay (Health Education Authority, 1996; Sutcliff, 1996; Burt & Eklund, 1999). Increased contact with the toothpaste by extending toothbrushing time and minimizing rinsing with water following brushing maximizes the benefits of fluoride in preventing dental caries (Sjögren & Birkhed, 1993; Tinanoff et al., 2002).

Unlike rinses and dentrifice, the delivery of fluoride in water is ideal as no parent or child compliance is required. Unfortunately, the percentage of the Canadian population that has access to fluoridated water remains low. Continued controversy regarding dental fluorosis and the challenges in calculating the optimal daily level of fluoride intake have prevented universal acceptance of water fluoridation. This attitude is unfortunate because water fluoridation remains the most equitable, effective, and efficient means of delivering fluoride to a community (Slade, Spencer, Davies, & Stewart, 1996). A study of Medicaid-eligible children in Louisiana found that children not residing in a community with fluoridated water were three times more likely to receive dental treatment under GA. The cost of their treatment was double that of children with access to fluoridated water (CDC, 1999). Further, water fluoridation has reduced dental decay in primary teeth by 30 to 60% (Newbrun, 1989). Finally, at an estimated average cost of $1 CDN per person annually, water fluoridation is extremely cost effective (CDC, 2001).

2.1.5. Implications for Child Health

ECC has health implications that may alter a child's quality of life. In addition to the pain and suffering caused by decayed teeth, ECC may affect a child's growth and development, speech, and self-esteem (Davies, 1998; Weinstein, 1998). ECC is a medical problem because children with this condition have been reported to grow at a slower pace than their caries-free peers (Acs, Shulman, Ng, & Chussid, 1999). Investigators have reported that children with ECC are in the lowest 10^{th} percentile for weight and are less than 80% of ideal weight (Acs, Lodolini, Kaminsky, & Cisneros, 1992). The reduced weight and height may be the result of decreased food intake due to pain and infection associated with dental caries. Alternatively, both the growth lag and dental caries may be the result of poor dietary practices (Tinanoff & O'Sullivan, 1997). Fortunately, following dental treatment, children with ECC seem to catch-up to their caries-free peers in weight (Acs, Shulman, Ng, Chussid, 1999).

ECC may result in a premature loss of primary teeth. This loss may lead to problems in the development of the permanent teeth and dental arches. Without the primary teeth to preserve space and guide the permanent teeth into the arch, misalignment and malocclusion of the permanent teeth may occur. Consequently, the permanent teeth may be vulnerable to dental problems such as caries and periodontal disease (ADSBC, 2001).

The psychological impact of ECC on a child is also an important consideration. The premature primary tooth loss or malocclusion of the permanent teeth is aesthetically displeasing (ADSBC, 2001), and therefore may affect a child's self-confidence.

ECC also affects a child's quality of life. The chronic pain caused by ECC may affect a child's ability to eat and sleep. Further, poor nutrition and sleeplessness may affect behavior and ability to learn. Investigators at Montreal Children's Hospital reported that prior to dental treatment under general anesthetic, 43% of children had difficulty eating and 35% of children had problems sleeping. Dental treatment improved both of these problems significantly with 59% of the children eating more and 84% sleeping better following treatment (Low, Tan, & Schwartz, 1999).

ECC, a disease with a complex etiology, may have a profound effect on a child's life. The pain and infection that may result from dental decay have implications for behavior and a child's ability to eat, sleep, and learn. In addition, the appearance of the teeth and normal growth may be affected.

2.2. Dietary Iron

Iron, an important trace mineral, is found in every cell of the body. It is essential to red blood cell function. Iron needs to be replenished from the diet, but is likely the most difficult mineral to obtain in adequate amounts from the North American diet (Davis & Stegeman, 1998). It is also difficult to get sufficient amounts of iron due to its low bioavailability in most foods. Other components of foods such as phytates, tannin, and calcium also negatively affect absorption of iron.

The primary function of iron is the creation of heme groups that are in hemoglobin and myoglobin (Wu et al., 2002). Hemoglobin molecules in the red blood cell transport oxygen from the lung to the cells and take carbon dioxide away from the cells for excretion by the lungs. Myoglobin is the iron-containing compound found in muscle cells that binds oxygen in muscle tissue (Wardlaw, 1997). Further, iron also plays a critical role in the myelination of the nervous system and is involved in the enzyme pathways of cellular metabolism (Antrim, 2004). Iron is also necessary for immune function and assists in the liver's role in drug detoxification (Fairbanks, 1994).

2.2.1. Requirements (for Children)

Iron requirements for young children vary depending on age and rate of growth (Table 1). Full-term infants have iron stores built-up during gestation (Williams, 2001). When supplemented by breast milk or iron-fortified infant formula, these stores fulfill an infant's iron requirements until approximately 4-6 months of age. Although breast milk does not contain a lot of iron (0.03-0.05 mgs/100 mls), iron from breast milk is well absorbed (Buchanan, 1999; Antrim, 2004). Because the period between 6 and 12 months of age is a time of rapid development, infants require at least 7 mg of daily iron. Consequently, for infants solely breastfed at that age, iron-fortified foods need to be introduced into the diet to meet the increasing iron requirements and to prevent iron deficiency. Non-breast fed infants can meet their dietary iron requirements by consuming iron-fortified infant formula. From ages 1-6 years, iron requirements range from 7-8 mgs per day (The National Academy of Sciences, 2000).

Although most of the body's iron is re-used[2], replenishment with dietary iron is necessary with the increases in blood volume, muscle and their tissue growth that accompany physical growth (Saarinen, 1978) and to replace the small amounts of iron lost during cell turnover in the gastrointestinal tract, skin, hair, and urine (Carley, 2003). When the body has surplus iron, it is stored in the liver, spleen, and bone marrow, and is called ferritin (Wu, Lesperance, & Bernstein, 2002).

[2] Iron in the body is recycled when the iron from old blood cells are scavenged by macrophages before the blood cells are taken out of circulation and destroyed. The iron is then returned to the storage pool to be used again (Florida State University College of Medicine, 2004).

Table 1. Iron Requirements for Children[a]

	Requirement for Absorbed Iron (gm/d)		Dietary DRIsa (mg/d)	
Age (y)	Median	97.5th percentile	Ear	RDA
Males				
1.5	0.62	1.24	3.4	6.9
2.5	0.54	1.23	2.9	6.8
3.5	0.61	1.36	3.4	7.6
4.5	0.63	1.45	3.5	7.9
5.5	0.70	1.60	3.9	8.1
Females				
1.5	0.64	1.25	3.4	6.9
2.5	0.63	1.30	2.7	7.2
3.5	0.59	1.32	3.3	7.3
4.5	0.65	1.45	3.4	8.1
5.5	0.64	1.52	3.4	8.4

[a] from the National Academy of Sciences, 2000

2.2.2. Bioavailability and Absorption

Iron in foods is available in heme and non-heme forms. The human body absorbs heme iron found in meats better than non-heme iron found in plant foods. Iron's bioavailability varies from less than 2% in certain plant foods, to 15-20% in meats, and almost 50% in human breast milk (Saarinen, Siimes, & Dallman, 1977; Yip & Dallman, 1996; Hurrell, 1997; Zimmerman, 2001).

Iron bioavailability in foods is also influenced by the presence of enhancers (e.g. ascorbic acid) and inhibitors (e.g. phytate, tannin, and calcium) of iron absorption from the diet (Davidsson, et al., 1994; Shah, Griffin, Carlos, Lifschitz, & Abrams, 2003). The absorption of iron is enhanced when fruit juice or vitamin C is consumed with iron-containing foods (Hurrell, 1997; Zimmerman, 2001). Evidence suggests that a 50mg supplement of vitamin C can potentially increase the absorption of non-heme iron by threefold (Hallberg & Rossander, 1984; Zimmerman, 2001). Iron from foods high in phytates such as spinach and lentils are poorly absorbed. The bioavailability of iron also decreases when iron-containing foods are consumed with coffee, tea (tannin), or milk (Hurrell, 1997; Zimmerman, 2001). Calcium also inhibits the absorption of iron and therefore large amounts of calcium (>250mg) in multimineral preparations will also affect the bioavailability of iron (Zimmerman, 2001; Yip & Dallman, 1996).

Infants receive their dietary iron exclusively from breast milk or iron-fortified infant formula until approximately 4-6 months of age when other foods are introduced into their diet. Because of their rapid physical growth and limited eating capacity, toddlers and preschoolers are susceptible to iron deficiency. Careful meal planning is important to ensure dietary iron requirements are met. Selecting meat, fish, or poultry as the principal protein in a meal rather than dairy products or eggs increases the iron absorption by four-fold (Zimmerman, 2001). In addition to including iron-rich green leafy vegetables with meals, the choice of beverage is also important. Accompanying meals with orange juice doubles the absorption of iron from the meal. Conversely, milk and iced tea will decrease the iron absorption (Hurrell, 1997).

2.2 3. Iron Deficiency

2.2.3.1. Prevalence

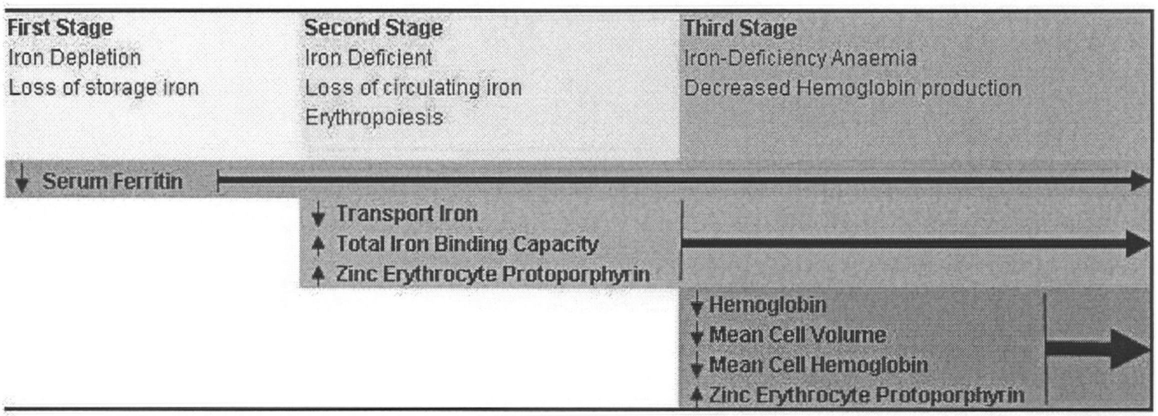
Iron deficiency (ID), the most common nutritional deficiency worldwide, is especially prevalent among infants and children (Zimmerman, 2001). In the United States, iron deficiency anemia (IDA) is estimated to affect 9% of children age 1-2 and 3% of children age 3-5 (Antrim, 2004). In Canada, 4-5% of non-aboriginal[3] preschoolers and 14-24% of First Nations and Inuit infants and children experience IDA (Zlotkin, 2003; Antrim, 2004). The National Nutrition Survey conducted 25 years ago reported approximately 19% of infants and toddlers had IDA in Canada (Canadian Task Force on the Periodic Health Examination, 1979). It appears from recent studies that the prevalence of iron deficiency has decreased among the general population, although the incidence among high risk populations such as the First Nations is still high (Zlotkin, 2003; Antrim, 2004). The overall prevalence of ID amongst children under 5 years of age in BC is unknown, because most previous studies have only focused on the children under 2 years of age who are at greatest risk for ID. Considering the high prevalence of ID amongst certain populations of preschoolers, more research focused on this age-group of children is needed.

[3] Non-aboriginal in Canada refers to all ethnicities with the exception of the First Nations, Inuit, and Métis.

2.2.3.2. Stages

There are 3 characteristic and progressive stages of iron deficiency. Each stage defines iron status according to the amount of iron in each of three compartments: storage[4], transport[5], and functional[6]. Iron depletion, without anemia, is often asymptomatic and although dietary history can identify at-risk children, confirmation requires laboratory tests that assess blood, tissue, or bone marrow for the iron levels in each of these three compartments.

Figure 1. **Stages of development of iron-deficiency.**



Adapted from "Iron Status in a Group of 9 Month Old Infants," by D. N. Lwanga, Unpublished master's thesis, p. 18, University of British Columbia, Vancouver, British Columbia, Canada.

[4] Iron is stored in the bone marrow and liver and its level can be determined by measuring serum ferritin (Zimmerman, 2001).
[5] Transport iron plays a critical role in the oxygen transportation and can be found in red blood cells as hemoglobin (Zimmerman, 2001).
[6] In the functional compartment, iron is found in myoglobin cells (stores oxygen in muscle cells that are released to provide energy during physical activity), and is also involved in energy production and enzyme function (an essential cofactor for several enzyme systems) (Zimmerman, 2001).

2.2.3.2.1. Iron depletion.

Iron depletion occurs when dietary intake of iron is inadequate for hemoglobin synthesis and iron stores must be used. This stage is asymptomatic and iron transport and functional roles are unaffected. Erythropoiesis is not overtly affected. This condition escapes detection by hemoglobin or hematocrit[7] screening (Carley, 2003). Iron depletion can be clinically determined through measuring serum ferritin, a storage protein. Ferritin is a sensitive marker of iron storage and decreases as iron stores diminish. A serum ferritin level less than 12 μg/L is indicative of iron depletion. The ferritin level, however, is increased by acute inflammation (Lesperance, Wu, & Bernstein, 2002) and varies greatly throughout childhood (Geaghan, 1999). A low serum ferritin of less than 12 μg/L, however, is a sensitive and specific marker of deplete iron stores. In children where insufficient iron stores in the bone marrow continue to diminish, iron deficiency erythropoiesis may occur.

2.2.3.2.2. Iron deficiency erythropoiesis (IDE).

In iron deficiency erythropoiesis (IDE), iron stores are significantly reduced and hemoglobin synthesis is affected (Carley, 2003). IDE status can be determined by assessing the zinc protoporphyrin (ZPP)[8] in red blood cells. A blood test with a ZPP greater than 70μmol/mol is likely indicative of IDE. The ZPP value is preferable in screening for IDE as it is not affected by anemia related to blood loss, although this is unlikely in children in

[7] Hematocritic screening measures the percentage of whole blood that is comprised of red blood cells. Both the number and the size of the red blood cells are measured.

[8] Protoporphyrin is a heme precursor that normally binds with iron to form hemoglobin. In IDE, deplete iron stores result in the accumulation of protoporphyrin. This excess proptoporphyrin combines with zinc forming ZPP. Consequently ZPP increases with inadequate iron supply (Gibson, 1990; Lwanga, 1996).

Canada. However, ZPP is decreased by conditions such as lead poisoning and chronic inflammation (Lee and Nieman, 2003), although lead poisoning is extremely rare among infants and children in Vancouver. Other indicators of IDE include an increase in the total iron binding capacity (TIBC) due to greater free binding sites on the plasma iron transport protein (Gibson, 1990; Oski, 1993; Lwanga, 1996). If left untreated, IDE may progress to become iron deficiency anemia.

2.2.3.2.3. Iron deficiency anemia (IDA).

Children with iron deficiency anemia, the most advanced stage of iron deficiency, have insufficient iron stores to maintain hemoglobin production. At this stage, clinical manifestations of ID are likely to be observed. Indices of IDA include a serum ferritin level less than 12 μg/L and a blood ZPP greater than 70 μmol/mol. There is also a decrease in the mean cell volume (MCV), a measure of the red blood cell size (i.e. smaller cells have less hemoglobin) (Gibson, 1990). Clinically, a blood test on a child with IDA will reveal a decrease in mean cell hemoglobin (MCH), a measure of the average weight of hemoglobin in each red blood cell, and characteristic microcytic, microchromic ells (Antrim, 2004).

Low hemoglobin (Hgb) and hematocrit values are also present in these children. Hgb levels that are more than 2 standard deviations below the normal mean for age are observed in IDA (Wu et al., 2002). The Hgb level can be used to classify the severity of IDA as mild, moderate, or severe (DeMaeyer, 1989; Michaelson et al., 2000). Prolonged IDA can lead to detrimental and possibly irreversible cognitive and physical consequences for an infant or young child (Table 2). Further clinical signs and symptoms will be discussed in 2.2.4.4.2.

Table 2. Classification of Iron Deficiency Anemia

Classification	*Haemoglobin level (g/dl)*
Severe	< 7
Moderate	< 10 (in children aged between 6 months and 5 years) < 9 (in infants less than 6 months)
Mild	10 – 11

2.2.3.3. Risk Factors

2.2.3.3.1. Child's age.

Young children are vulnerable to develop iron deficiency due to 1) their high dietary needs during rapid growth, 2) their low intake of dietary iron, and 3) their high consumption of cows' milk and other foods that inhibit the absorption of iron (Michaelson et al., 2000). From ages 4 to 12 months, an infant's blood volume doubles. However, their iron stores are often depleted by 6 months of age. Consequently, sufficient intake of dietary iron is critical during this period of rapid growth and red blood cell synthesis (Saarinen, 1978).

The small amounts of food young children consume and their selective food choices may further compromise their ability to satisfying their high dietary iron requirements. Consequently, to maintain a healthy iron status, iron-rich foods must be emphasized in a child's diet (Zimmerman, 2001). However, babies fed with iron-fortified formula throughout the first year will enter their second year of life with high iron stores, and thereby masking the effect of their diet.

2.2.3.3.2. Socioeconomic status.

Children from families with lower socio-economic status are at increased risk for iron deficiency (Lehmann, Gray-Donald, Mongeon, & Di Tommaso, 1992). In the U.S., the NHANES I study (1968-1973) reported that IDA prevalence amongst 12 to 36 month-old children from low-income families was 21% compared to 7% of children from higher-income families (Dallman, Yip, & Johnson, 1984). This difference in prevalence can be reasonably attributed to differences in feeding practices and dietary intakes of iron (Greene-Finestone, Feldman, & Luke, 1991). These differences may include the amount of milk consumption as well as the intake of iron-rich foods such as meat, fish, and poultry. Further, feeding practices that affect the choice of beverage accompanying meals will affect iron absorption. For children that are not receiving adequate iron through foods, a daily intake of a 5-10 mg iron supplement is important to ensure iron requirements are met (Zimmerman, 2001).

Children of some ethnic backgrounds may be at greater risk for iron deficiency as a result of cultural differences related to food consumption, prolonged bottle feeding, language barriers, and socioeconomic factors (Buchanan, 1999). Although the Canadian Task Force for Periodic Health Examination (1994) has considered infants of Chinese descent to be at increased risk for IDA, other studies have not found IDA to be more common amongst Chinese children (Sargent, Stukel, Dalton, Freeman, & Brown, 1996; Innis, Nelson, Wadsworth, MacLaren, & Lwanga, 1997). Canadian studies have also suggested that children from First Nations and Inuit descent are also at increased risk for IDA with a prevalence of 14% and 24% respectively (Zlotkin, 2003; Antrim, 2004). This risk may be attributed to dietary practices that include increased consumption of beverages (especially milk or soft drinks) and of foods that are poor sources of iron.

2.2.3.3.3. Health conditions.

Although less common than dietary factors amongst infants, other causes of ID include stomach conditions that greatly decrease gastric-acid secretion and reduce the body's ability to absorb iron such as prolonged achlorhydria[9] (Zimmerman, 2001; Conrad, 2003). Other causes of ID include conditions associated with gastrointestinal blood loss, such as milk protein allergy or parasitic infections (Sullivan, 1993). Small but chronic blood loss from the gastrointestinal tract may, over time, result in ID (Zimmerman, 2001). Early feeding with cows' milk (before 12 months) place infants at increased risk for IDA due to the milk's poor bioavailability and high calcium. Infant formula is expensive and not always readily available in remote areas.

Premature infants are also more susceptible to iron deficiency as they may not have an adequate gestational store of iron at birth. Further, chronic illness reduces the body's ability to mobilize iron from stores and consequently, the iron supply to the bone marrow for hemoglobin synthesis is also reduced. During chronic illness, food intake is often reduced as is the intake of heme-containing meats. The mobility and transfer of iron stores is also limited by deficiencies in vitamin A, vitamin B6, and copper (Zimmerman, 2001).

[9] Achlorhydria is the abnormal deficiency or absence of hydrochloric acid in the gastric juices of the stomach. Since hydrochloric acid is necessary for protein digestion, achlorhydria may result in impaired digestion and absorption.

Children with small amounts of lead in their body may also have impaired hemoglobin synthesis that can progress to ID. Since lead and iron share the same absorption pathway and iron absorption is enhanced during ID, lead is more readily taken up by the body and can further aggravate the anemia (Michaelson et al., 2000). However, elevated blood lead is not a problem amongst Vancouver children.

2.2.3.3.4. Child's feeding practices.

Diets poor in iron are the most common cause of iron deficiency in infants and young children (Buchanan, 1999). Breast-fed infants over 3-6 months of age who are not given iron supplements or foods with sufficient iron are at increased risk for ID (Innis et al., 1997). Excessive consumption of cows' milk may also result in ID because cows' milk contains little iron, and the iron is of low bioavailability. In addition, because it is difficult for infants under 12 months of age to digest the milk protein in cows' milk, some investigators suggest that large intakes of milk at this age can lead to a loss of iron through gastrointestinal bleeding (Fomon, Zeigler, Nelson, & Edwards, 1981; Zimmerman, 2001). Gastrointestinal blood loss due to cows' milk feeding doesn't seem to be a problem in children over 1 year of age; it is recommended that infants under 1 year of age not be given cows' milk. Further, infants and children consume relatively large quantities of milk and milk products and plant-based foods such as cereals, breads, and pastries which require little chewing. However, these non-heme foods have low iron bioavailability compared to the heme in meat (Zimmerman, 2001). Children on vegan diets are especially susceptible to ID because most non-heme sources of iron have low bioavailability. For these children, careful dietary planning that includes vitamin C and iron-rich plant foods such as whole grains, dried fruits and nuts, and legumes are important to ensure adequate dietary iron (Wardlaw, 1997).

2.2.3.4. Implications for Child Health

Iron deficiency poses a serious health concern in infants and young children. It can lead to altered cognitive and physical development that lasts beyond the duration of the nutrient deficit.

2.2.3.4.1. Cognitive concerns.

The growth and development of the central nervous system (including brain growth, dendritic aborization and myelination) occurs most rapidly from the second trimester until 18-24 months of age (Dobbing, 1990; Williams, 2001). Inadequate iron during this critical period of development may result in reduced essential metabolic pathways in the brain. Consequently, this reduction increases the child's risk for impaired cognitive development (Grindulis, Scott, Belton, & Wharton, 1986; Moffatt, Longstaffe, Besant, & Dureski, 1994; Lozoff, Brittenham, Wolf, & Jimenez, 1996; Williams, 2001), poor educational performance (Lozoff, Jimenez, & Wolf, 1991; Hurtado, Claussen, & Scott, 1999), and lower test scores for motor development milestones (Lozoff et al., 1987).

Evidence suggests that ID also alters a child's emotional state. Deficient children may be more withdrawn, inattentive, and tired. These children also have decreased activity and involvement when presented with stimuli (Walter, Andraca, Chadud, & Perales, 1989; Michaelsen et al., 2000). Although the association between iron deficiency and low developmental test scores may be due to confounding factors such as poor socioeconomic situation or other nutrition-related conditions, iron deficiency likely results in the delays of mental development as described (Williams, 2001).

Investigators have reported that the cognitive and physical delays associated with ID in infants persevere despite iron therapy and the elimination of anemia. Children with a history of ID as infants continue to achieve lower test scores than their peers even 10 years following their treatment as infants (Lozoff, Jimenez, Hagen, Mollen, & Wolf, 2000). However, correcting the anemia in preschool children has led to marked improvements in the learning difficulties associated with IDA. The child's age at the time of the deficit and the duration and degree of the ID are critical in determining the child's risk of permanent developmental delays (Parks & Wharton, 1989; Michaelsen et al., 2000).

2.2.3.4.2. Physical concerns.

Iron deficiency may also hinder physical growth. This effect on growth may be linked to changes in eating behavior due to a loss of appetite (Levitsky & Strupp, 1995; Zimmerman, 2001; Carley, 2003), or to behavioral alterations associated with IDA (Lozoff et al., 1998).

ID may be associated with abnormal gastrointestinal (GI) function leading to inflammation of the oral mucosa and conditions such as hypochlorhydria, malabsorptive syndromes, and GI bleeding (Baynes & Bothwell, 1990; Zimmerman, 2001). Further, the intestinal mucosa can become leaky and result in a loss of iron and other nutrients (Antrim, 2004).

ID may also increase the child's susceptibility to infection because of lowered cell-mediated immune resistance. Consequently, children with ID may be susceptible to recurrent infections in childhood such as frequent colds, flu, and ear infections

(Zimmerman, 2001; Dallman, 1987). Other clinical signs associated with ID include pallor or dry skin, brittle hair, and knoilonychia (poorly-formed, upturned nails).

Children with ID also exhibit a lack of energy and tend to fatigue easily (Zimmerman, 2001). They may also become more clingy and irritable and have decreased interactions with their immediate environment. It is also common amongst children with iron deficiency to have breath-holding spells (Antrim, 2004). It remains unclear whether some of these problems are the cause of or the result of ID, but fortunately most can be reversed with proper treatment of the deficiency (Williams, 2001).

2.3. Commonality between ECC and ID

ECC and ID are preventable conditions common in young children. Both conditions are most prevalent in families with socioeconomic challenges. Ethnic minorities, new immigrants, single parent families, and families where parents have limited education may be at particular risk. The parents of children with ECC or ID are likely unaware of the causes of these conditions or may face barriers accessing preventive resources. Moreover, poor diet and inappropriate feeding practices are significant contributors to both ECC and iron deficiency. Furthermore, both children with ECC and ID tend to have similar patterns of excessive beverage consumption (Skinner, Carruth, Bounds, & Ziegler, 2002; Levy, Warren, Bronffitt, Hillis, & Kanellis, 2003). Large amounts of fluids displace the children's appetite for iron-rich and less cariogenic foods. Despite these possible shared risk factors, no definitive studies have yet been done to investigate whether ECC and ID share similar dietary patterns. Establishing that there is a dietary link between the two conditions may bring increased commitment to prevention of both conditions from all healthcare providers who work with young children and their families. Such an intersectoral approach to preventing both these conditions may eventually result in a decreased prevalence of both ECC and ID in high risk children.

Chapter 3

3. METHODS

3.1. Overview of Study

This two-stage, cross-sectional exploratory study targeted children between the ages of 18 months and 5 years residing in Vancouver, British Columbia. Ethics approval for this study was received from The University of British Columbia's Clinical Research Ethics Board and the Children's and Women's Health Centre of British Columbia's Research Review Committee (Appendix A).

3.1.1. Planning the Study

An interdisciplinary group of researchers and community health staff developed and planned this study. The team included dentistry, nutrition, and speech and language professionals from academic, community, and research backgrounds. Numerous meetings were held to determine and refine the objectives and design of the study. As well, issues related to recruitment including the target population, venues for recruitment, and incentives for participation were discussed. The location, protocol, and implementation of the Stage 2 Dental and Nutrition Clinics were discussed and revised over several meetings. Meetings continued to be held throughout the project for ongoing feedback and to ensure all team members had current knowledge of the study's progress (Appendix B).

3.1.2. Stage 1: Recruitment

Between January and May 2003, children and their parents were recruited from a variety of community locations in Vancouver. Children participating in a public dental health program ("Smile-to-Smile Knee-to Knee") operated by dental staff from the North Community Health Office of Vancouver Coastal Health were invited to participate. As well, parents of children from local daycare centers and parents attending food depots were recruited. Speech-language pathologists affiliated with Vancouver Coastal Health assisted in the recruitment process by introducing the study to their young clients and parents.

Parents of potential subjects were approached at the community location by study investigators (ZV & AS) and were given a brief overview of the study. Those parents who expressed interest in participating with their children signed a consent form (Appendix C). After completing the consent form, parents completed a screening questionnaire (SQ) about their child's dietary habits and food preferences, toothbrushing habits, and family socio-demographics. This questionnaire concluded with an invitation for the parent and child to participate in the second stage of the study, the Dental and Nutrition Clinic. Interested parents provided their contact information so an appointment could be scheduled for the second stage of the study.

3.1.3. Stage 2: Dental and Nutrition Clinics

Parents who indicated interest in participating in the second stage of the study were telephoned by a study investigator (AS) to set up an appointment. If a parent agreed to participate, the parent and child were appointed to one of four clinics scheduled at the North Community Health Office. Appointments were scheduled every 10 minutes from 9am to 5pm (11am to 7pm for one clinic day to accommodate working parents) on four Mondays between May 5 and June 2, 2003.

Upon a parent's arrival at the clinic, an overview of clinic activities was given and parents were asked to sign a consent form for this stage of the study (Appendix C). Each parent then completed a general information sheet that included contact information for the child's doctor and dentist, and a brief medical history. Parent and child were then given a "passport" of the "stations" they needed to attend. At these stations, the child's anthropometric measurements, usual dietary intake, oral care habits, and oral health status were assessed and documented, and venous blood was taken. The four stations were the following:

1. "Roger Ruler": Anthropometric measurements (blood pressure, height, and weight)
2. "Amazing Apple": Food frequency questionnaire (types and amounts of foods)
3. "Mister Molar": Oral care questionnaire and dental exam by dentist
4. "Brave Bee": Venous blood draw

3.2. Clinical Protocol

3.2.1. Questionnaires

3.2.1.1. Screening Questionnaire

The screening questionnaire (SQ) (Stage 1) was developed and refined at a series of team meetings. Designed to gather information on the family's socio-demographics, oral care behaviors, and feeding practices, this questionnaire was self-administered, but clarification was provided to the parents by study personnel when necessary. The SQ underwent focus group testing for validity prior to the study; time did not permit reliability testing. Spanish, Punjabi, Chinese, and Vietnamese translations were available (Appendix D).

3.2.1.2. Food Frequency Questionnaire

The food frequency questionnaire (FFQ) administered at Stage 2 was a modification of a questionnaire previously developed[10]. Our modifications ensured better recording of dietary habits of young children and easier administration within a short length of time. The FFQ was designed to gather data on the food consumption patterns of each child (Appendix E). It was administered in a 20-60 minute interview by one of three trained nutritionists. Models of food were available to assist the parents in estimating the quantity of food consumed by their child. An interpreter was present if the parent did not understand or

[10] The FFQ used in this study was previously used by the Nutrition Research Program at the BC Research Institute.

speak English. The FFQ had previously undergone testing for validity and reliability (Williams, 2001).

3.2.1.3. Oral Care Questionnaire

The oral care questionnaire (Stage 2) was developed by a group of four dental professionals (RH, PG, TW, & AS). This self-administered questionnaire contained 9 questions assessing the frequency of dental visits, bottle-use, parental attitude towards primary teeth, and current dental homecare practices (Appendix F). The questionnaire was focus group tested for validity.

3.2.2. Clinical Assessments

3.2.2.1. Anthropometrics

Height and weight were measured and recorded by a trained project staff person on a balance beam scale. The child remained fully clothed and removed only his/her shoes. Blood pressure was measured on the upper part of the child's arm using an automatic blood pressure monitor with a child–size cuff (Appendix G).

3.2.2.2. Dental Examination

One dentist (PG) completed dental exams on all children. This exam was conducted either in the dental chair or using the knee-to knee position (depending on the age and cooperation of the child). A dental light, mirror, and explorer were used for all exams. No radiographs were taken. The extent and severity of dental decay was assessed using a modification of the "iceberg" model of caries experience (Pitts, 1997). Plaque was categorized as "light" or "heavy" according to the amount present on teeth surfaces 51 buccal, 54 buccal, and 84 lingual (Appendix H).

3.2.2.3. Blood Work Assessments

After all the questionnaires and the dental exam were completed, venous blood was taken from the children by a phlebotomist. All vials used in gathering the blood work were pre-labeled with the child's pre-assigned subject code. Blood analysis occurred later that same day at the Children's & Women's Health Centre of British Columbia.

3.2.3. Data Analysis

All subjects were assigned a subject identification number. The questionnaire and clinical data for all the children was entered on a Microsoft Excel spreadsheet. Frequency tables were generated and some variables (e.g. children's age) were plotted to assess their distribution. Some categories were collapsed when appropriate (e.g. the three categories for family income of <\$20,000, \$20,000-\$50,000, and >\$50,000 were collapsed into <\$20,000 and ≥\$20,000). The Statistical Package for the Social Sciences (SPSS) was used for bivariate analysis using Chi-squares and Fisher's Exact Tests for categorical data, and one-way ANOVA and t-tests for continuous data. Backward logistic regression models were then created to explore significant predictors of caries severity for all children. Statistical significance was established at $p=0.05$.

Measurements of the height- and weight-for-age, as well as the weight-for-stature were compared to the Centre for Disease Control and Prevention (CDC) Growth Charts (CDC,

2000) to determine whether the children were “low”, “normal” or “high” when compared to the 75^{th} percentile for age and gender.

The data from the FFQ was entered into the Elizabeth Stuart Hands and Associates (ESHA) Food Processor Program and data relevant to the study were further analyzed. This included data on total calories, sugar and fluid consumption. The grams of sugar intake provided by the ESHA Program’s analysis of dietary intake for each child were converted to calories by multiplying the value by 4. Proportions of sugar consumption to calories were then calculated by dividing the total sugar in calories by total calories consumed by the child.

The blood was analyzed for essential and toxic trace elements and serum ferritin; In addition, a complete blood count was done. The children were categorized as “normal” (serum ferritin $\geq$12μg/L) plus hemoglobin >110g/L, “iron deplete (ID)” (serum ferritin <12μg/L) plus hemoglobin >110g/L, “iron deficient erythropoiesis (IDE)” (iron deplete and ZPP >70μmol/mol), and “iron deficient anemic (IDA)” (iron deficient erythropoiesis and Hgb <110g/L) according their blood work results. Analysis included collapsing the categories and evaluating the children according to “normal” and “deficient” (iron deplete, IDE, and IDA) iron levels. Parents of children who were iron deficient were notified of their child’s iron status through a letter and urged to contact the child’s physician. Results of the blood work were also mailed to the child’s physician.

The data from the dental questionnaire was analyzed as previously described. Each child’s total number of decayed, missing (due to decay), and filled tooth surfaces, “dmfs”, was calculated. A child’s dental health status was assessed by their dmfs and plaque scores.

Initial analysis included all 99 children from Stage 2. However, in recognition that older children were more likely to have caries and younger children were more likely to be iron deficient, further analysis of the variables was done with the sample divided into "under 36 months" and "over 36 months". This division reflected the bimodal age distribution of the children in the study. For the children under 36 months, caries status was represented by dmfs>0 (presence of decay) or dmfs=0 (absence of decay). For children over 36 months, caries status was analyzed according to the absence or presence of caries, as well as severity of caries.

Chapter 4

4. RESULTS

One hundred and ninety-one children were recruited for Stage 1. Ninety-nine of their parents consented to participate in Stage 2 of the study. Only the information gathered from the 99 "Stage 2" children was analyzed.

In all cases where raw numbers and percents are presented, the percent is represented in the tables as "valid percents."[11] Those few children with missing data are not listed in the tables. Data on an extensive number of variables were collected for each child in the study. However, only results relevant to the objectives of this study will be presented and analyzed.

4.1. Stage 1 Data: Screening Questionnaire (SQ)

Data from the Stage 1, Screening Questionnaire (SQ), will be presented first.

4.1.1. Demographics

Demographic information was collected in the SQ, and is presented in Table 3 for the 99 children who returned for Stage 2. The distribution of the children's ages, represented by Figure 2, shows that age generally followed a bimodal distribution. That is, the children "clustered" in two age groups: one group of children from 18 to 36 months of age and the remainder from 36 to 71 months.

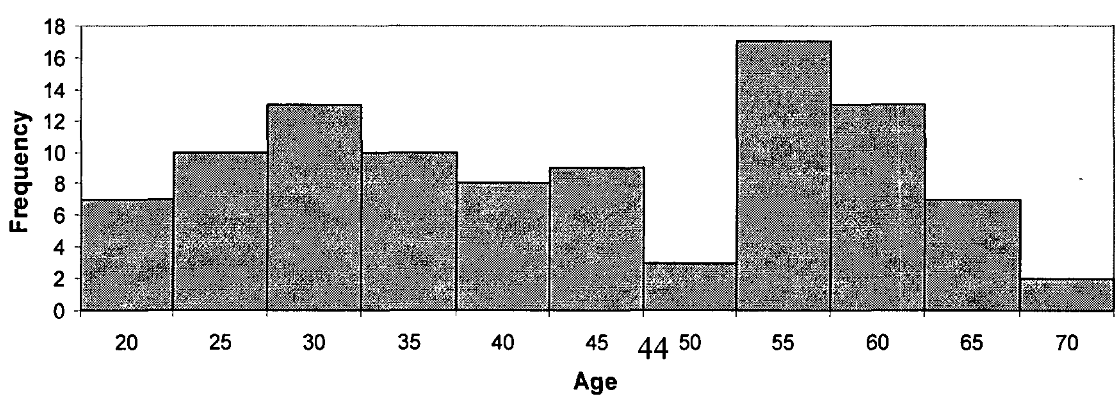
[11] "Valid percents" is a calculation based only on data with a subject response and therefore considered "valid". Data that do not have a response are not included in the analysis.

Table 3. Demographics of Study Sample

	N	Valid %
Age (months)		
Range	20 - 71	
Mean (SD)	43.4 $\pm$ 14.7	
< 36 months	35	35.4
$\geq$ 36 months	64	64.6
Gender		
Male	62	62.6
Female	37	37.4
Ethnicity		
Caucasian	22	23.9
Oriental	30	32.6
Multi-ethnic/Other	40	43.5
Post-secondary education		
Mother		
Yes	63	67.0
No	31	33.0
Father		
Yes	51	63.8
No	29	36.3
Total family income		
< $20,000	47	50.5
$\geq$ $20,000	46	49.5

* From the Screening Questionnaire

Figure 2. Age distribution.



4.1.2. Eating Patterns

Data associated with the children's eating patterns are presented in Table 4. Eating patterns include variables such as meat, fish, and poultry consumption, and number of times a child eats something each day. Most parents (62.0%; n=59) reported that they had concerns about their child's eating. The most frequent concerns were that the child was a "picky eater" (17.8%; n=33) and "won't try new foods" (14.6%; n=27).

According to the SQ, the children consumed an average of 3.1 ± 1.3 cups of milk daily, with 65.0% (n=61) of children drinking 3 or more cups daily. The average daily consumption for juice was slightly less at 2.8 ± 1.4 cups with 46.5% (n=47) drinking 3 or more cups daily. Overall, all 94 children who answered the SQ consumed 3 or more cups of fluid (other than water) daily.

Table 4. Eating Patterns from Screening Questionnaire

	n	Valid %
Food security[12]		
Not a concern	54	54.5
Concern	44	44.4
Concerned about child's eating		
No	36	37.9
Yes	59	62.1
Meat, fish, poultry consumption (per week)		
< 5 times	46	49.5
≥ 5 times	47	50.5
Number of times child eats something (per day)		
Mean (SD)	4.9 ± 1.6	
≤ 5	61	65.6
> 5	32	34.4

4.2. Stage 2 Data: Dental and Nutrition Clinics

4.2.1. Anthropometrics

Measurements of the children's height and weight were used to calculate their weight-for-age, height-for-age, and weight-for-stature. The z-score for the children's weight-for-age, height-for-age, and weight-for-stature were compared to the Centre for Disease Control and Prevention (CDC) Growth Charts (CDC, 2000) to determine whether the children were "low", "normal" or "high" when compared to the 75th percentile of their peers of similar age or stature (Table 5). Most of the children were normal (mean=42.7%,

[12] "Food security" refers to the parents' report that financial issues affected the quality or variety of foods the family eats.

n=39) or high (mean=38.2%, n=35) when compared to the 75th percentile of children of their same age and stature for gender. Only 19.1% (n=17) of the children scored low compared to their peers.

Table 5: Anthropometric Measurements of Study Population (75th Percentile of z-scores)

		n	Valid %
Weight-for-Age			
	Low	18	19.6
	Normal	34	37.0
	High	40	43.5
Height-for-Age			
	Low	18	19.8
	Normal	43	47.3
	High	30	33.0
Weight-for-Stature			
	Low	16	18.0
	Normal	39	43.8
	High	34	38.2

*based on CDC Growth Charts: United States (2000)

4.2.2. Eating Patterns from Food Frequency Questionnaire

The FFQ provided extremely detailed information on the types and amounts of foods consumed by each child. For purposes of this project, analysis of the FFQ was limited to daily sugar consumption and types and amounts of beverages consumed on a daily basis (Table 6 and 7).

Table 6. Sugar Consumption of Study Sample (Daily) from FFQ

	All Children
Calories (kcal)	
Range	1085.2 - 4856.9
Mean (SD)	2221.9 $\pm$ 733.9
Sugar (g)	
Range	48.5 - 371.8
Mean (SD)	149.5 $\pm$ 63.0
% of calories as sugar[a]	
Range	13.0 - 44.0
Mean (SD)	27.0 $\pm$ 6.0

[a] Includes all dietary sugars (sucrose, glucose, fructose, and lactose) and calculated by the following formula: $\frac{\text{Sugar (g)} \times 4}{\text{Total Calories (kcal)}} \times 100$

In addition, beverage consumption as reported in the FFQ was analyzed (Table 7). In all, 63.6% of children (n=63) consumed 3 or more cups of fluid daily according to the FFQ.

Table 7: Beverage Consumption Reporting on the SQ and FFQ

	SQ n = 94	**FFQ** n = 99
Milk	3.1 ± 1.3	2.4 ± 1.7
Juice	2.8 ± 1.4	1.5 ± 1.4
Total	6.0 ± 1.9	4.1 ± 2.5

* Mean ± SD (cups per day)

The patterns of beverage consumption were also examined. Baby bottle and sippy cup use[13] for fluids other than water was frequent or had been a frequent habit among the children with 59.1% (n=54) describing a history of often carrying a bottle throughout the day, and 40.9% (n=38) a history of napping or sleeping with a bottle.

4.2.3. Dental Health

Data on dental health behaviors is presented in Table 8.

Table 8. Dental Data from the Oral Health Questionnaire

	n	Valid %
Baby teeth are important		
Yes	83	91.2
No or Not Sure	8	8.8
Dental visits		
Parent's		
At least once every 2 years	47	50.5
Once every 3 yrs /When something hurts/Never	46	49.5
Child's		
At least once a year	51	54.8
When something hurts/Not yet	42	45.2
Daily toothbrushing		
By parent		
Yes	61	66.3
No	31	33.7
By child		
Yes	73	77.7
No	21	22.3
Use of fluoride toothpaste		
Yes	68	73.9
No	24	26.1
Child's teeth clean after brushing		
Yes	37	39.8
No	56	60.2

[13] Parents were asked to report on their child's current or historical use of the baby bottle and/or sippy cup in the questionnaire.

4.2.4. Caries Status

Results of dental exams revealed that, as expected, caries status did not follow a normal distribution. About 1/3 (n=35) or 35.4% of children were caries-free (dmfs=0). Another 1/3 (n=32) or 32.3% had a moderate caries score, (dmfs>0 and ≤5). A further 1/3 (n=32) or 32.3% had high caries or dmfs>5 (Table 9). For the first stage of the analysis, caries-free and moderate caries children (dmfs≤5) were combined into a "low caries" group (n=67; 67.7%), and the remaining 32 children with dmfs>5 were designated a "high caries group."

Chi-square or Fisher's Exact Tests were used to compare the low caries to the high caries children for a variety of variables. Children with high caries were significantly more likely to be older, i.e. over 36 months of age (Table 9). Because so few children under 36 months of age had severe caries (dmfs>5), children were also grouped according to "presence" (dmfs>0) or "absence" (dmfs=0) of caries to allow further analysis of caries status for the younger age group (Table 8). Children with dmfs>0 were called "dmfs+" and those with dmfs=0 were "dmfs–". Dental plaque was also measured as either light or heavy[14]; 75% of the children had heavy plaque deposits. Because of the lack of variation in the assessments of plaque, these results were not analyzed further.

[14] The definition of light or heavy plaque was at the discretion of the dentist (PG) who did the dental exam on all the children.

Table 9. Caries Status of Study Sample from the Dental Examination[a]

	All Children (n=96)		Under 36 months (n=34)		Over 36 months (n=62)	
dmfs (Range)	**0 - 45**		**0 - 37**		**0 - 45**	
Mean (SD)	**7.2 (11.3)**		**2.1 (6.4)**		**10.0 (12.4)**	
Severity of caries	**n**	**Valid %**	**n**	**Valid %**	**n**	**Valid %**
Low (dmfs $\leq$ 5)	65	67.7	32	94.1	33	53.2
High (dmfs > 5)	31	32.3	2	5.9	29	46.8
Presence of caries	**n**	**Valid %**	**n**	**Valid %**	**n**	**Valid %**
dmfs -	34	35.4	21	61.8	13	21.0
dmfs +	62	64.6	13	38.2	49	79.0

[a] Of the 99 children that participated in Stage 2 of the study, dental exams were completed on 96 of the children.

4.3. Explanatory Variables and Caries Status

The questionnaires and clinical evaluations provided detailed information on the dietary habits, oral care, and dental status of the children in the study. However, only data of interest to the goals of this study was further analyzed.

4.3.1. All children

As previously described, distribution of caries did not follow a normal distribution. Therefore non-parametric analyses by Chi-square tests or, when fewer than 5 subjects in a category, Fisher's Exact Tests were done. The relationship between caries status (high or low) and the demographic, dietary, and dental health variables was explored (Table 10).

However, because few variables demonstrated a significant relationship, only selected variables that were significant or approached significance are listed in the tables.

Table 10. Selected Variables and Caries Status for All Children (n=96)[a]

	Caries status		
	dmfs≤5 (n=65)	**dmfs>5 (n=31)**	**p-value**
Demographic variables			
Child's age (months)			
Mean (SD)	38.5 (14.7)	54.4 (10.2)	<0.001 [b]
Gender			
Male	37 (56.9%)	24 (77.4%)	0.009
Female	28 (43.1%)	7 (22.6%)	
Family income			
<$20,000	28 (45.2%)	18 (64.3%)	0.05
≥$20,000	34 (54.8%)	10 (35.7%)	
Food security			
Concern	25 (39.1%)	18 (60.0%)	0.03
Not a concern	39 (60.9%)	12 (40.0%)	
Dental			
Daily toothbrushing by parent			
Yes	44 (72.1%)	15 (51.7%)	0.06
No	17 (27.9%)	14 (48.3%)	
Child's dental visits			
At least once a year	27 (43.5%)	23 (76.7%)	0.003
When something hurts/not yet	35 (56.5%)	7 (23.3%)	

[a] Of the 99 children that participated in Stage 2 of the study, dental exams were only completed on 96 of the children.
[b] P-value determined by t-test (all other p-values determined by chi-square or Fisher's Test).

Significant relationships were observed between caries status and age and gender. Children with high caries were older (mean age=54.4 months; p=<0.001). As well, girls were significantly less likely to have high caries compared to boys (p=0.009). Further, a significant relationship was observed between family income and caries status, p=0.05. Of those 28 children with "high caries", 64.3% (n=18) were from a family with an annual income less than $20,000. Only n=10 (35.7%) of the high caries children were from families whose annual income was $20,000 or more. Parents who reported the quality or variety of foods served at home was affected by finances (i.e. "food security") were significantly more likely to have children with "high caries" compared to children of parents who did not have these concerns about food (p=0.03). A significantly greater percent of children with high caries (76.7%; n=23/30; p=0.003) were likely to have visited the dentist at least once a year than those with low caries (43.5%; n=27/62).

Backward stepwise logistic regression was done to analyze the effect of a number of variables on the outcome variable, caries severity, while controlling for other potential covariates. Preliminary models included demographic, anthropometric, dietary, bloodwork, and dental health variables. Only two variables, age and food security remained in the final model (Table 11).

Table 11. Logistic Regression of Select Variables of Significance

	B	S.E.	Wald	df	Sig.	Exp (B)
Age	0.099	0.026	14.268	1	0.000	1.104
Food security	1.861	0.660	7.945	1	0.005	6.432
Dental IQ[a]	0.373	0.202	3.425	1	0.064	1.452
Constant	-7.806	1.712	20.797	1	0.000	0.000

[a] Dental IQ includes the following variables: parent's and child's dental visits, use of fluoride supplements or toothpaste, if the child's teeth are clean following brushing, and whether the child sleeps with or carries a bottle or sippy cup.

Given that caries and age were significantly associated, caries status was further analyzed with children divided into younger (under 36 months) and older (over 36 months) children.

4.3.2. Children Under 36 Months

Analysis of caries status in children under 36 months was undertaken with presence (dmfs+) or absence (dmfs-) of caries as the caries outcome variable. Because only 2 children under 36 months had high caries, severity of caries was not an appropriate outcome variable for this age group. None of the variables related to severity of caries for the entire group of children were related to presence of caries in children under 36 months. However, another dietary variable, the daily percentage of calories contributed by sugar was significantly related to presence of caries in these young children (p=0.003; Table 12). Caries-free children were less likely than caries-positive children to have more than 30% of daily calories from sugar.

Table 12. Sugar Consumption for All Children Under 36 Months (n=34)

	Caries Status		p-value[a]	Odds ratio	95% CI
% of Calories as Sugar	dmfs-	dmfs+			
< 30%	17	5	0.03	1.0	1.1-45.4
$\geq$ 30%	4	8		6.8	
Total	21	13			

[a] P-value determined by Fisher's Exact Test

4.3.3. Children Over 36 Months

Caries status for children over 36 months (n=62) was analyzed using both caries outcome variables: presence or absence of caries and severity of caries. Fisher's Exact Tests and odds ratios[15] were calculated to allow further related analysis of predictive variables for caries (Table 13).

[15] Odds ratio is a statistical comparison of whether the probability of an event is the same for two groups. An odds ratio of 1 can be interpreted as an equal probability of an event occurring for both groups while an odds ratio greater than 1 implies that the event is more likely to occur in that group. An odds ratio of less than 1 implies the event is less likely to occur in that group.

Table 13. Select Variables of Caries for Children Over 36 Months (n=62)

	dmfs +	dmfs -	p-value[a]	Odds ratio	95% CI	dmfs ≤ 5	dmfs > 5	p-value[b]	Odds ratio	95% CI
Income										
<\$20,000	30	3	0.01	5.6	1.1 – 30.9	15	18	0.15	0.4	0.1-1.3
≥\$20,000	16	9		1		17	8		1	
Food Security										
Yes	26	4	0.08	2.7	0.8 – 9.2	12	18	0.06	3.2	1.1-8.9
No	22	9		1		21	10		1	
Daily milk (cups/day)[c]										
<3	32	12	0.05	1	1.0 – 40.7	27	17	0.08	1	1.0-9.8
≥3	17	1		6.4		6	12		3.2	
Total fluids (cups/day)[c]										
<3	14	6	0.09	1	0.6 – 12.8	13	7	0.2	1	0.8-7.3
≥3	32	5		2.7		16	21		2.4	
Sugar Consumption[d]										
<50%	7	5	0.05	1	1.0-14.2	6	4	0.2[a]	1	0.3-6.8
≥50%	42	8		3.8		27	25		1.4	

[a] P-value determined by Fisher's exact test.

[b] P-value determined by Chi-square test.

[c] Values for daily milk and total fluid consumption from food frequency questionnaire.

[d] Includes all dietary sugars (glucose, sucrose, and lactose) and calculated by the following formula: $\frac{\text{Sugar from all fluids and sugary snacks (g)}}{\text{Total sugar (g)}} \times 100$

Annual family income was related to caries-free status. Children from families who reported a total household income of less than \$20,000 were more likely to have caries ($p=0.01$). Severity of caries and income were not significantly related ($p=0.15$). The association between families that reported no concerns about food security and low caries also approached significance ($p=0.06$).

While family income was the only significant demographic variable, dietary variables of significance included daily milk and sugar consumption. Total milk consumption according to the FFQ was also associated with caries. Children who drank less than 3 cups of milk daily were more likely to be caries-free (37.5%; n=12) compared to children who consumed more than 3 cups of milk (5.9%; n=1) ($p=0.05$). Sugar consumption was associated with caries experience for children over 36 months. Children with diets that had sugar constituting 50% or more of their daily calories were more likely to have caries ($p=0.05$). Increased intake of milk and consumption of beverages and snacks containing a high percentage of sugar were associated with caries in the older children in the study (Table 13).

4.4. Iron Store Status

For iron stores, 75.0% (n=72) of children had normal stores and 25.0% (n=24) of children were iron deficient. Among the children with iron deficiency, 58.3% (n=14) were iron deplete, 25.0% (n=6) had iron deficiency erythropoiesis (IDE), and 17% (n=4) had iron deficiency anemia (IDA) (Figure 3). Children under 36 months had a significantly higher prevalence of iron deficiency compared to children over 36 months ($p\leq0.05$) (Table 14).

Figure 3. **Prevalence of iron deficiency stages in study sample**

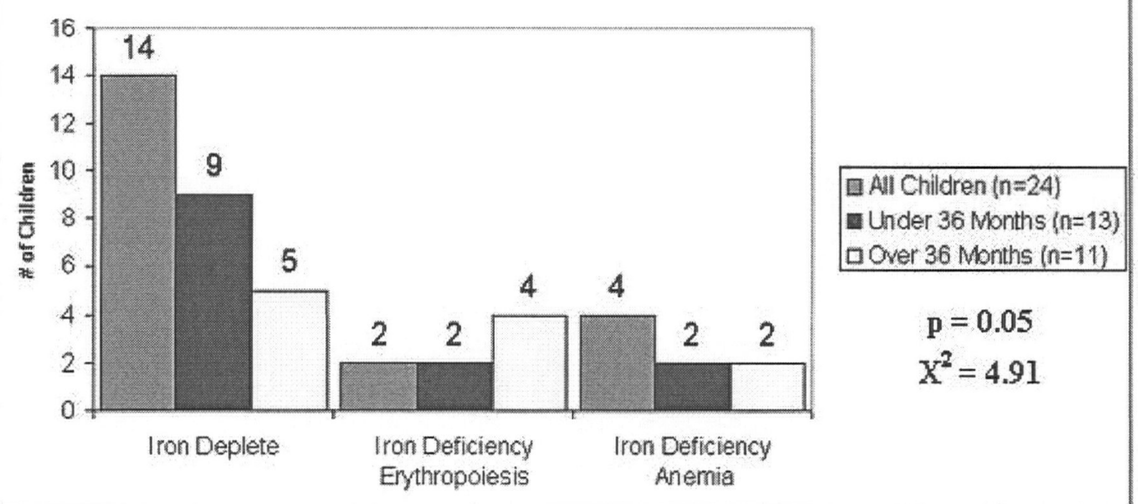


Table 14. Iron Store Status of Study Sample from Blood Analysis

	All Children		Under 36 months		Over 36 months			
	n	**Valid %**	**n**	**Valid %**	**n**	**Valid %**	**p-value**	**Chi-square**
Normal	72	75	21	61.8	51	82.3	0.05	4.91
Deficient	24	25	13	38.2	11	17.7		

4.5. Explanatory Variables for ID

The initial analysis explored all the children in the study by iron store status (normal versus iron deficient). Because children less than 36 months were more likely to be ID ($p=0.05$) than older children, younger and older children were then analyzed independently.

4.5.1. All Children

This analysis included all 99 children in Stage 2 of the study and compared children with normal iron stores (n=72) to those with iron deficiency (n=24). Children's dental visits was significantly related to iron status (p=0.01). Children with ID are less likely to visit the dentist at least once per year. Iron status was not significantly related to any socioeconomic or anthropometric variables, although gender approached significance, p=0.06 (Table 15). ID appeared to be more common in girls. Because no variables appeared to be significantly related to ID other than dental visits, odds ratios were not calculated. More complex multivariate analysis, e.g. logistic regression, was not done. Those explanatory variables that demonstrated an association with caries status for all children did not show such an association with iron status.

Table 15. Select Variables of Iron Status for All Children (n=99)

	Iron Status		
	Normal n=72	Deficient n=24	p-value [a]
Demographic variables			
Child's gender			
Male	49 (68.1%)	12 (50.0%)	0.06
Female	23 (31.9%)	12 (50.0%)	
Family income			
<$20,000	35 (52.2%)	12 (52.2%)	0.09
≥$20,000	32 (47.8%)	11 (47.8%)	
Food security [b]			
Concern	32 (44.4%)	12 (52.2%)	0.2
Not a concern	40 (55.5%)	11 (47.8%)	
Dental			
Child's dental visits			
At least 1x/year	42 (61.8%)	7 (31.8%)	0.01
When something hurts/not yet	26 (38.2%)	15 (68.2%)	

[a] P-value determined by Chi-square or Fisher's Test.

[b] The number of children included in each variable may not total 99 due to non-responses.

Although Chi-square analysis failed to show any relationship between cups of milk per day and iron status, a one-way ANOVA demonstrated significant differences in milk consumption between children at increasing stages of iron depletion (Table 16). As children's iron status worsened, milk consumption significantly increased. This trend was also observed with total fluid consumption, but was not statistically significant. However, given this relationship was observed with milk consumption reported in the SQ, no further post-hoc analysis was done. This finding was not replicated when the FFQ beverage consumption was analyzed.

Table 16. Iron Stores & Milk and Total Fluid Intake

	#	Milk [cups/day] (SD)	Total Fluid [cups/day] (SD)
Normal	71	2.9 (1.4)	5.7 (2.3)
Deplete	14	3.0 (1.4)	5.9 (1.8)
Deficient	6	4.0 (1.1)	6.5 (1.6)
Anemic	3	4.7 (1.5)	7.3 (1.5)
		F-Stat=2.7, p=0.05	F-Stat=0.9, p=0.5

[a] Values for daily milk and total fluid consumption from the screening questionnaire.

4.5.2. Children Under 36 Months

No statistically significant relationships were found between iron status and any of the demographic, anthropometric, and socioeconomic variables that were analyzed in children under 36 months of age. However, total daily milk consumption from the SQ was related to iron store status for children under 36 months (p=0.03; Table 16 and 17). Iron deficient children were more likely to consume 3 or more cups of milk per day.

Table 17. Daily Milk Consumption and Iron Status for Children Under 36 Months (n=34)

	Milk (cups)/day	Iron Status: Deficient	Iron Status: Normal	p-value	Odds ratio	95% CI
Screening Questionnaire	< 3	2	11	0.03[a]	1	0.9-51.7
	≥ 3	11	10		6.1	
	Total	13	21			
Food Frequency Questionnaire	< 3	6	13	0.3[b]	1	0.5-7.5
	≥ 3	7	8		1.9	
	Total	13	21			

[a] P-value determined by Fisher's Exact Test
[b] P-value determined by Chi-square Test

Again, this result was not confirmed when the FFQ data were analyzed in the same manner.

4.5.3. Children Over 36 Months

None of the anthropometric, socioeconomic, or dietary variables that we analyzed appeared to be associated with iron status in the older children.

Chapter 5

5. DISCUSSION

5.1. Limitations of the Study

Prior to discussing the findings of this cross-sectional, exploratory study some limitations related to study design and implementation of the study will be reviewed:

- Sampling method and recruitment strategy
- Age range of participants
- Social desirability bias
- Screening questionnaire
- Food frequency questionnaire

5.1.1. Sampling Method and Recruitment Strategy

If the goal of the study was to determine the prevalence of disease in the general population, a random sample of Vancouver children would have been recruited. However, given that the goal of the research was to explore a possible relationship between early childhood caries and iron deficiency by investigating common dietary patterns, and that both of these conditions are prevalent in low-income and ethnic minority children, our recruitment targeted sites frequented by low-income families (Dallman et al., 1984; Demers et al., 1990; Gary-Donald, Di-Tommaso, & Leamann, 1990; Litt et al., 1995; Henry, 1997). Therefore our sample was non-random and purposive. The sample also consisted of volunteer parents (selection bias).

However, this deliberate recruitment strategy limited our ability to generalize the study's results to the entire population of Vancouver children. As well, the 99 children and their parents who agreed to participate in the second stage of the study may not reflect the general population (participation bias). Of the 191 parents who were approached and agreed to participate in the first stage of the study, only one-half continued to the second stage. More parents might have participated in a one-stage design. However, it was not reasonable to implement all the questionnaires and clinical assessments at the recruitment locations (i.e. food depots, daycares). Parents who took the time to participate may have been more motivated and aware of child health concerns. Further, the sample of 99 subjects who ranged from early childhood to kindergarten age proved to be too small to draw conclusions about two conditions that affect different ends of the preschool age spectrum. A more limited age range of children, e.g. 3 years and under would have better fulfilled the goals of our study.

5.1.2. Age Range of Participants

The extensive age range of the participants in the study was a limitation. The range from 18 to 71 months of age represents a lengthy period of growth and development. Because of this time of rapid change, dietary intake and practices likely differed greatly between the younger and older children in the study. The Canadian Food Guide recommends that, although preschoolers (ages 2-5) require similar variety of foods, the amounts consumed depend on age, body size, activity level, growth rate, and appetite. Further, the younger children were at greater risk of iron deficiency while the risk of caries was greater in the older children. This variation in risk and the broad age range made it challenging to study the common risk factors of these two conditions.

5.1.3. Social Desirability Bias

Questionnaires that require retrospective reflection are vulnerable to recall bias. Consequently, it was difficult to be sure of the accuracy of the parents' responses to all of our questionnaires. For example, responses to the oral homecare questionnaire suggested a "high dental IQ", i.e. that parents knew expected answers. Parents may have provided "expected" answers which may not necessarily have been accurate reflections of their homecare practices. Parents gave responses that they knew were desirable, but not necessarily what they did. As well, the nature of some of the questions made the questionnaires susceptible to "socially desirable" responses. The interview format of the FFQ may also have been prone to this social desirability bias because the presence of the nutritionists who administered the questions may have affected the parents' response. Parents wanted to give the "right" answer.

Although the screening questionnaire was translated into multiple languages, attaining informed consent, and completing the food frequency and homecare questionnaires were challenging when the parents had a limited understanding of English. Moreover, it was difficult to assess whether any biases were introduced with "on-the-spot" verbal translation of the questionnaires

5.1.4. Screening Questionnaire

The screening questionnaire (SQ) was mainly a tool to recruit subjects and generate interest in the project, rather than a reliable instrument for gathering data. The SQ was tested in focus groups for validity, but its reliability was not established. Although results from the SQ demonstrated some significant relationships (e.g. iron deficiency and cups of milk), lack of reliability testing and concerns about the environment where the SQ was completed probably resulted in some measurement error. However, the demographic data collected was probably reasonably correct.

5.1.5. Food Frequency Questionnaire

In contrast, the FFQ had been used in previous research and shown to be able to rank infants in relation to sources of dietary iron intake and status (Williams, 2001). The FFQ provided information on the types, amounts, and frequency of food consumed over a one day, one week, or two week period. Although collaborative studies have many benefits, the type of dietary data needed for our study of dental health did not suit the objectives of other study investigators. Because of this, daily frequency of intake was not entered. A more specific record outlining the daily frequency of eating and time of consumption during the day such as obtained by a 24 hour food recall, or a prospective food record would have been more useful to us. For children with ECC, the frequency that bacteria are in contact with cariogenic substrates, the way cariogenic foods are consumed, and the retentiveness of foods are more significant than total quantity of food consumed over an extended period of time (Serwint et al, 1993).

The FFQ assessed children's food consumption patterns as recalled by their parents. Unfortunately, this method of collecting dietary data tends to overestimate the food consumption (Hankins et al., 1970). As well, it was uncertain whether the dietary data recorded reflected the type and quantity of food served by the parents or the actual food consumed by the child. It was anticipated that parents would "over-report" in the FFQ, however beverage consumption was lower than what was reported on the SQ. Perhaps milk in a bottle was not seen by parents as necessary information to include in the FFQ. Again, this finding likely reflects the dubious accuracy of the SQ.

Parents' report on beverage consumption in the SQ did not correspond to their responses in the FFQ completed at a later date. It is difficult to determine whether this discrepancy was due to environmental influences during the completion of the screening questionnaire (i.e. food depots, daycares), recall biases, the FFQ's tendency to overestimate food consumption, or bias because the FFQ was implemented by an interview. Further, children participating in the study were undergoing rapid growth and the types and quantities of food they consume are continually changing. Consequently, the differences in consumption patterns between the two instruments may also be attributed to the weeks that lapsed between the completion of the screening and food frequency questionnaires.

In the interview, there may have been some confusion amongst parents about which category in the FFQ corresponded to the juice that their children consumed. Further, in entering the dietary data, fruit juice was assumed to be "100% natural and unsweetened." Since nearly half of the families reported that they had "food security" concerns, it is likely that many of these families opted to purchase less expensive juices that are sweetened which would directly affect the children's total sugar consumption. Thus, sugar consumption may be under-reported in the FFQ.

5.2. Characteristics of the Study Sample

Some findings of interest about the children and families in our study warrant further discussion. About twice as many boys as girls participated in the project (Table 3). This difference was not intentional and the explanation for this difference is unknown. Over 75% of the children were from ethnic minorities[16] and over 50% of the families had an annual income of less than $20,000 (Table 3). According to Statistics Canada's after-tax low income cut-off (LICO) for a family of three in 2000 is $23,415. Compared to Statistic Canada's 2001 Census which reported that 20.8% of families in Vancouver live below the LICO, the fact that more than half of the families in the study were below the LICO was troubling, but not unexpected. The disproportionate number of ethnic minority and low-income families that participated in this study was related to the recruitment locations targeted by the study investigators. Programs in Vancouver that assist low-income families were recruitment sites for the study (i.e. food depots, dental health programs implemented by public health professionals).

Although household income and parent's education are usually correlated (Petersen, 1992; Verrips et al., 1992; Khan & Cleaton-Jones, 1998), such a relationship was not observed in the families participating in this study. Many of the parents in our study were immigrants whose post-secondary education may not be recognized in Canada which

[16] According to Statistics Canada (2001), 37% of the Vancouver population is visible minorities. Visible minorities are defined by the *Employment Equity Act* as "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour."

would affect their employment in well-paying jobs. It is troubling that so many well-educated parents are unable to earn an income above the poverty line.

All children were weighed and measured. Although half of the children in the study were living in households with financial challenges and most parents (62.1%) were concerned about their child's eating, the majority of the children (80.9%) were considered normal or above average for their weight- or height-for age and weight-for-stature compared to the 75th percentile for children of their same age and gender. Only 19.1% rather than the expected 25% of children were below normal for their age and gender. When considering the large daily caloric intake of the children, it is very likely that they are consuming more calories, but not necessarily more nutritious foods. According to the CDC growth charts, children on average weigh more than they did in 1977, although their height remains the same (US Department of Health and Human Services, 2000). This increase in weight may have implications for the increase in childhood obesity (US Department of Health and Human Services, 2000).

The screening questionnaire (SQ) gathered information on eating patterns. Meat, fish, and poultry (MFP) consumption was investigated because of the study's focus on iron store status. Infants of nine months of age who consume less MFP are more susceptible to iron deficiency (Innis et al, 1997). Parents were also asked about the number of times their child eats or drinks per day to assess the frequency of daily food consumption. Other investigators have found an increased caries risk in children that snack frequently (Tsubouchi et al, 1995). Most children ate an average of five times per day, which is equivalent to the recommended three meals and two snacks of the Canadian Food Guide

(2004) (Table 5). The reports of the number of times the children ate daily is likely an underestimation as parents were often unsure what and how often the children ate when they had another caregiver (i.e. spouse, relative, and daycare or preschool staff). Previous investigators have also suggested snacking reports to be inconsistent between the children and their parents (Elkman, 1990). Further, this frequency of eating was surprisingly low when considering the high daily average calories for children in this study as reported in the FFQ (mean = 2222 kcal) (Table 6).

The food frequency questionnaire provided extensive information on the children's caloric intake and nutrient consumption. The mean caloric intake (2222 kcal) of the children in the study was much higher than the dietary reference intakes (DRI)[17] (Institute of Medicine of the National Academies, 2002). Again, this difference may be attributed to the tendency of the FFQ to overestimate food consumption (Hankins et al., 1970). Or if 80% of the children are above the 75th percentile for weight, then over consumption of energy may be a problem.

The dental health status and dental health behaviors of the children were assessed by a questionnaire and clinical dental exam. The children in the study had patterns of dental visits similar to their parents with half visiting the dentist at least once per year (54.8% and 50.5% respectively; Table 8). About two-thirds or 66.3% of parents reported brushing their child's teeth daily. However, only 39.8% of parents reported that they felt their child's teeth were clean following brushing (Table 8). Quality of oral hygiene in young children is

[17] According to the DRI, boys between the ages of 3-5 with low physical activity levels should have a total energy expenditure between 1,324 to 1,466 kcal/day, while girls of the same age and physical activity level should have a total energy expenditure between 1,243 to 1,379 kcal/day. .

usually assessed by parental self-reports of brushing. To our knowledge, no previous study has actually asked parents to give an subjective assessment of tooth cleanliness. Only 4 out of 10 parents felt their brushing was effective.

Moreover, since fluoride is well-recognized for its role in the prevention of dental caries, it was surprising that 26.1% of the children in the study did not use fluoridated toothpaste (Table 8). With non-fluoridated toothpaste being more challenging to find and more expensive to purchase, it was astonishing to find that over a quarter of our families, many of whom were low-income, used toothpaste without fluoride. This finding may be due to the concern some parents had regarding the safe use of fluoride for young children.

5.3. Early Childhood Caries (ECC)

5.3.1. Definition and Prevalence

The criteria for caries severity in children that we used in this study are actually quite similar to the definition of early childhood caries (ECC) and severe early childhood caries (S-ECC) of the American Academy of Pediatric Dentistry (AAPD, 2003). The AAPD defines ECC as the presence of any decayed, missing (due to decay) or filled primary tooth surface (dmfs). This definition is equivalent to our definition of "dmfs +" and "dmfs –" criteria. S-ECC (severe ECC) is defined by the AAPD as any smooth surface caries on a child under 3 years of age, or a dmfs of ≥ 4 (age 3 years), ≥ 5 (age 4 years), and ≥ 6 (age 5 years). Our study used a more conservative definition of dmfs ≤ 5 as "low caries" and dmfs >5 as "high caries" for all the children. Extending the AAPD definition to our study sample, 62 (64.6%) children have ECC and 47 (47.5%) have S-ECC.

A previous study of low-incomeVietnamese children ages 3 to 74 months in Vancouver reported a prevalence of ECC of 20.5% in children over 18 months (Harrison et al., 1997). Assessments of children entering kindergarten in Vancouver concluded 27.4% had nursing bottle tooth decay (Bassett, McDonald, & Woods, 1999). Unfortunately, comparisons with our results are difficult because of the differences in definitions of ECC. Certainly, the children in our study had high levels of dental caries.

5.3.2. Explanatory Variables and Caries

The bi-variate analysis demonstrated age to be significantly related to caries experience for children ($p<0.001$; Table 10). As children and their teeth age, there are increasing opportunities for caries to develop as a result of increased exposure to cariogenic factors. Gender also appeared to be significantly related to caries, with girls less likely to be in the high caries group (Table 10). This significant difference in caries status between genders is supported by some studies on children under 6 years of age that found caries to be more prevalent in males (Verrips, Frencken, Kalsbeek, ter Horst, Filedt Kok-Weimar, 1992; Maciel , Marcenes, Watt, Sheiman, 2001). However, other investigators found no gender differences (Al-Hosani and Rugg-Gunn, 1998; Habibian, Beighton, Stevenson, Lawson, & Roberts, 2002). Moreover, our multivariate analysis demonstrated no relationship between gender and caries; only age and food security remained as predictors of caries severity (Table 11).

In addition to age, the relationship between total household income and caries status was also statistically significant ($p=0.05$; Table 10). Similar to other studies on ECC (Demers et al., 1990; Litt et al., 1995; Henry, 1997), children from families with greater financial challenge were also more likely to have severe caries. This association may be related to accessibility to information on prevention and dental care. Affordability of homecare aids such as toothbrushes as well as financial and other stresses experienced by the parents may also be related to their children's poor oral health status (Litt et al., 1995; Quinonez et al., 2001; Ramos-Gomez et al., 2002). The multivariate analysis did not demonstrate a relationship between income and severity of caries. However, the income variable used in the logistic regression was divided into three categories[18], rather than the "collapsed" two categories used in the follow-up bi-variate analysis (Table 10) which may explain the lack of relationship.

We also examined a variable referred to as "food security", i.e. whether financial concern affected the quality or variety of foods the family eats. Children from families where food security was a concern were also more likely to have ECC (p=0.03; Tables 10 and 11). A recent study by Casey et al (2004) demonstrated a relationship between food security and maternal depression. Both ECC and maternal depression are conditions more likely to be found in low-income families. Furthermore, some studies have found food security and normal child health and development are inversely related (Alaimo, Olson, Frongillo, Briefel, 2001; Alaimo, Olson, Frongillo, 2001). Food security remained in the logistic regression as a predictor of caries severity. Caution in interpreting the significance of the food security variable is necessary because of the concern about the accuracy of the SQ used to collect data on the variable.

[18] In the initial multivariate analysis, the income variable was divided into three categories: less than \$20,000, \$20,000-\$50,000, and more than \$50,000.

The children's z-scores for height and weight for their age, as well as their weight-for-stature were not significantly related to caries status. This observation differs from the findings of Li, Navia, & Bian (1996), who reported that low height for age was related to caries status in young children. Given the ethnic diversity amongst the children in the study, it is difficult to know whether our z-score comparisons of height-, weight-for-age, and weight-for-stature based on the CDC growth chart were accurate for our multi-ethnic children.

Sugar consumption was significantly related to caries status in this group of children. The term "sugar" varies in ECC research from its use as a general and undefined term (Tinanoff & Palmer, 2000), to a more generic term encompassing sucrose, fructose, glucose, and lactose (The National Academy of Sciences, 2002). Although the general use of the term "sugar" poses a challenge for interpreting results, investigators agreed that "sugar" is associated with dental caries (Mattila et al., 2000; Tinanoff & Palmer, 2003). The FFQ and ESHA Food Processor Program allowed for a unique and detailed analysis of the children's sources of dietary sugar. This in depth investigation revealed that ECC risk related to sugar consumption was different amongst the younger and older children in the study. Similar to a study by Karjalamen, Soderling, Sewon, Lapinleimu, & Simell (2001), the percentage of daily total sugar intake (including natural sugars from fruits)[19] from fluids (including milk) and snacks compared to was related to caries status for the older children (Table 13). However, in younger children, the percentage of daily calories contributed by

[19] The cut-off of 50% was used in this assessment because only one child had sugar from fluids and sugary snacks account for less than 25% of total daily sugar consumption (12 children had less than 50%).

sugar[20] was associated with caries experience (Table 12). Although we are uncertain what accounts for the difference in the association between sugar consumption and caries experience, we speculate it may reflect subtle differences in dietary practices between the younger and older children.

Further, investigators have suggested that regular soft drinks and beverages from powder are more strongly associated with caries risk than juice (Marshall et al., 2003). Unfortunately, this could not be confirmed in our study because of the small number of children who reported consuming soft drinks. Furthermore, the nature of the data entry used in our study did not enable an analysis of the frequency of foods consumed through the day at this time.

The role of milk sugar, "lactose", remains controversial in studies of ECC. While some studies found evidence that suggests milk sugar may prevent caries (van Loveren & Duggal, 2001; Imfeld, 1983) or is neutral (Marshall et al., 2003), the results of our study showed that milk consumption is related to ECC. Older children who drank less milk (< 3 cups) were more likely to be caries-free (Table 13). However, how the milk is consumed was not investigated in our study. The cariogenicity of milk can differ greatly if it is consumed during a meal compared to during sleep (Douglass, Tinanoff, Tang, Altmen, 2001). Milk's cariogenicity is also affected by the addition of sweetened substances (Imfeld, 1983; van Loveren & Duggal, 2001; Tinanoff et al., 2002). Further, when milk sugar was not included in our calculation of sugar consumption as suggested by The National Academy of Sciences (2002) on dietary reference intakes for macronutrients, total

[20] The cut-off of 30% was used in this assessment to provide for some leeway for the RDI of 25% for sugar consumption in proportion to total daily caloric intake (The National Academy of Sciences, 2002).

sugar intake was much lower and not significantly associated with caries status. Moreover, it is possible that children who drank less milk consumed other nutritious and less cariogenic foods that require chewing while those children who consumed greater amounts of milk may be displacing other foods. Investigators have reported a decrease in milk consumption and increase in juice and soft drink consumption in children (Borrud, Enns, Mickle, 1997). In addition to its association with dental caries, these changes in children's beverage consumption also decrease calcium intake and increases the potential for obesity (Marshall et al., 2003). The dietary and feeding patterns amongst these children who consumed large amounts of milk should be examined further for factors related to ECC that may differ from other children.

Dental visits and oral health practices were assessed in the dental questionnaire and clinical exam. Children who had dental visits at least once a year (76.7%) were more likely to have a high dmfs score than their peers who did not go to the dentist regularly ($p=0.003$; Table 10). Of the 31 children with a dmfs>5, almost one-third (29%; n=9) had full coverage crowns or teeth extracted due to decay, events which substantially increased their dmfs score. Also included amongst the 99 children in the study are 12 children (12%) who had undergone general anesthetic for the treatment of caries. Stainless steel crowns are often the treatment choice for high-risk children who have a general anesthetic for dental treatment. Therefore, amongst the children who visited the dentist at least once a year were those who received extensive restorative and surgical treatment for caries. Such comprehensive treatment would substantially increase the "m" and "f" component of dmfs.

The use of fluoride as part of regular homecare was also assessed. While 75.0% of children used fluoride toothpaste regularly, no significant relationship was found between fluoride use and caries status. This finding does not agree with that of other studies (Aaltonen, 1991; Health Education Authority, 1996; Sutcliff, 1996; Lopez Del Valle, Velazquez-Quintana, Weinstein, Domoto, Leroux, 1998). In addition to its positive effects in caries prevention, fluoridated toothpaste is also more accessible and economical than non-fluoridated toothpastes, factors that are likely important for parents who expressed financial concerns. Multi-variate analysis showed dental practices and caries status were not significantly associated in this group of children (Table 11).

5.4. Iron Deficiency (ID)

5.4.1. Prevalence of Iron Deficiency

The prevalence of iron deficiency in the preschool children in the study was 25.0%. Analysis of iron status and age showed that the prevalence of ID in children between 20-35 months was 38.2% and in the older children between ages 36 to 71 months was 17.7% (Table 14). Further, 9.5% of the younger children and only 3.9% of the older children had IDA. It is difficult to determine whether the prevalence of ID and IDA of the children found in our study is similar to the general population because most studies focus on infants and toddlers (Table 18). As expected, the older children in our study were less likely to have ID compared to the younger children as they require less dietary iron relative to the amount of food they consume. As well, older children tend to consume more iron-rich foods including iron fortified cereals.

Table 18. Select Studies on Iron Deficiency Anemia and Low Iron Store

Author (yr of publication)	Location	Date of Study	Study Population	Age (mos)	n	Criteria for Iron Status Classification		Prevalence (%)	
						Iron deficiency anemia	Low iron stores	Iron deficiency anemia	Low iron stores
Lehmann et al. (1992)	Montreal	1989-1990	Low-income, predominately Caucasian	10 - 14	218	Ferritin ≤10μg/L with Hgb ≤115g/L or MCV ≤70fL	Ferritin ≤10μg/L	27	37
Zlotkin et al. (1996)	Toronto, Halifax, Montreal, Edmonton	NR	Representative of general population with the exception of higher parental education	8.6 - 15.2	428	Hgb ≤110g/L with ferritin ≤10μg/L or ZPP ≥100μg/L	Ferritin ≤10μg/L	4.3	34
Innis et al. (1997)	Vancouver	1993	Predominately middle and higher income	9	434	Hgb ≤101g/L, or Hgb ≤111g/L with 2 or 3 indicators of low iron (ie: ferritin ≤10μg/L, TIBC >60μmol/L, and ZPP >70μmol/mol	Ferritin ≤10μg/L	7	24

NR: not reported; Hgb: hemoglobin; ZPP: zinc protoporphyrin; TIBC: total iron binding capacity; MCV: mean cell volume

5.4.2. Explanatory Variables and Iron Deficiency

Age was significantly related to iron status. Younger children, as previously described, were more likely to have ID (p=0.05; Table 14). Differences in eating patterns between the younger and older children likely explain this difference in iron status.

Gender also approached significance in relation to iron status (p=0.06; Table 15). Females appeared to be more likely to be iron deficient than their male peers, but the girls were also, on average, younger than the boys in this study which may explain the difference.

Although inadequate consumption of meat, fish, and poultry is associated with increased risk of ID in infants of nine months of age(Innis et al., 1997), no relationship between these variables and ID was observed in the children in this study from the data analyzed. However, excess consumption of milk ($\geq$3 cups per day) did increase the risk of ID in younger children ($p=0.03$; Table 17). This association was based on results of the SQ and was not observed in the FFQ, so caution is needed in interpreting this result (Table 17). A link between cows' milk consumption and ID in infants under 12 months is thought to be due to the low iron content of bovine milk, its poor bioavailability, and the potential for intestinal bleeding associated with excess milk consumption (Fomon, Zeigler, Nelson, & Edwards, 1981; Zimmerman, 2001). As well, excessive consumption of milk may displace the children's calories from other nutritious and iron-rich foods.

Analysis of dental health variables showed that children's dental visits were significantly related to iron status. Children with ID were less likely to visit the dentist at least once per year ($p=0.01$). This finding was not unexpected as younger children are more likely to have ID. Their parents may not take them to the dentist until they are older. Because the bivariate analyses demonstrated no relationships of significance, more complex multivariate analyses were not explored.

5.5. Early Childhood Caries, Iron Deficiency and Common Explanatory Variables

Caries experience and iron store status were associated with age for the children in the study. However, the associations were in opposite directions; older children had more dental decay and ID was more prevalent in younger children. This dichotomy of the age groups is likely a result of differences in eating patterns; older children consume greater quantity and varieties of foods compared to their younger peers and are more resistant to ID. However, these dietary habits and the longer exposure of their teeth to cariogenic factors increase their risk of dental caries.

Although a relationship between milk and caries was demonstrated in older children, we did not confirm a relationship between milk and iron status in younger children because a significant relationship was only observed in the data gathered from the SQ.

5.6. Conclusion

This cross-sectional, exploratory study looked at the demographics, dietary patterns, and dental health factors that may be related to ECC and iron deficiency in a purposive volunteer sample of 99 children aged 18 to 71 months in Vancouver, British Columbia. The observed prevalence of ECC of 64.4% and ID of 25.0% in the sample of children was alarming and the following associations were found:

- Older children were more likely to have ECC and younger children more likely to have ID.
- Economically disadvantaged children in the study were at greater risk for ECC as reflected in family income and food security concerns.
- Younger children who consumed a significant proportion of their calories as sugar and the older children who consumed large amounts of sugar in beverages and snacks (not including natural sources of sugars such as fruits) in proportion to total sugar consumption were at increased risk for ECC.
- Although a relationship between milk consumption and ECC was observed, the relationship between milk and ID could not be confirmed as a significant relationship was observed was not observed in both the questionnaires that inquired on milk consumption.

The overall goal of this cross-sectional, exploratory study was to determine if two of the more common conditions of early childhood, early childhood caries and iron deficiency, were linked by common dietary or other etiological factors. While no consistent links were observed, the study confirmed some existing knowledge, demonstrated some new associations, and suggested routes of further inquiry.

5.7. Recommendations for Future Research

Although this exploratory study did not draw definitive conclusions about the relationship between beverage consumption, caries, and iron status, older children with decay and younger children with iron deficiency tend to have eating patterns related to beverage consumption that differ from other children. Because of the diversity in dietary habits and frequent changes in dietary practices, studies of young children should focus on a limited age range. Further studies with a larger group of children with a smaller age range should be pursued (e.g. only children under 3 years of age). The interaction between food security, family income, and ECC or iron deficiency also merit additional study. While previous investigators have found associations between family income and ECC or iron deficiency, the role of food security in these conditions requires further investigation due to its reported association with poverty, maternal depression, and negative health and development of children (Alaimo, Olson, Frongillo, & Briefel, 2001; Alaimo, Olson, Frongillo, 2001; Casey et al., 2004).

We encourage research in the following areas:

- Future studies should include a larger sample size to increase power of the results involving a limited age range of younger children (e.g. ages 2-3 years).
- Future research should include case control studies that compare children under 3 years of age with ECC to their peers without ECC.

- Since frequency of food consumption is associated with dental caries, further studies should include a 24-hour recall of the quantity and how foods are consumed throughout the day. Moreover, this research should include specific information regarding the sugar content of beverages.
- Development of appropriate assessment tool should be sought to obtain accurate reports of beverage consumption.
- With the significant relationship between socioeconomic status and ECC or ID, future studies should investigate the link between family income, food security, and early childhood conditions related to feeding patterns.

Chapter 6

6. REFERENCES

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Chapter 7

7. APPENDICES

Appendix A Certificates of Approval

Appendix B Study Team and Chronology of Study-related Meetings

Appendix C Consent Forms

Appendix D Screening Questionnaire

Appendix E Food Frequency Questionnaire

Appendix F Oral Health Questionnaire

Appendix G Anthropometrics Form

Appendix H Dental Exam

Appendix B: Study Team and Chronology of Study-related Meetings

Study Team

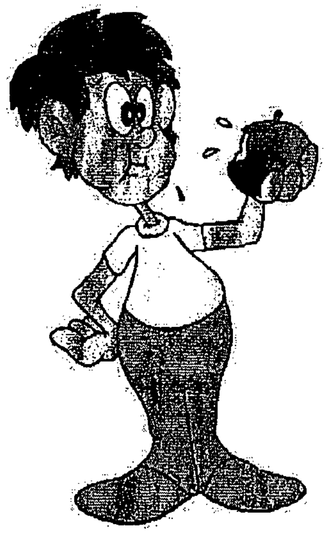
Name	Role	Organization
Dr. Rosamund Harrison	Chair, Pediatric Dentistry	University of British Columbia
	Associate Professor, Faculty of Dentistry	University of British Columbia
Dr. Gary Derkson	Head, Department of Dentistry	BC Children's Hospital
	Associate Professor	University of British Columbia
Dr. Sheila Innis	Director Nutrition Research Program	BC Research Institute
	Professor, Department of Pediatrics	University of British Columbia
Ann Szeto	MSc Candidate, Faculty of Dentistry	University of British Columbia
Ziba Vaghri	PhD Candidate, Faculty of Nutrition	University of British Columbia
Dr. Pam Glassby	Supervising Dentist	Vancouver Community Dental Program
	Instructor	University of British Columbia
Barbara Crocker	Community Nutritionist	Vancouver Coastal Health Authority
Tana Wyman	Dental Hygienist	Vancouver Coastal Health Authority
Sue Wastie	Speech Pathologist	Vancouver Coastal Health Authority

Chronology of Study-related Meetings:

Date	Activity	Location
July 2002	Meeting	BC Research Institute
October 1, 2002	Meeting	BC Research Institute
January 8, 2003	Meeting with Speech Language Pathologists	Mt St Joseph Hospital
January 14, 2003	Recruitment Food Bank	Trout Lake Food Bank
January 27, 2003	Meeting	BC Research Institute
January 28, 2003	Recruitment	Raven Song Community Center
February 18, 2003	Meeting	North Health Office
February 18, 2003	Recruitment	Raycam Community Center
February 26, 2003	Meeting	North Health Office
March 4, 2003	Focus Group	North Health Office
March 5, 2003	Meeting	North Health Office
March 6, 2003	Meeting	North Health Office
March 11, 2003	Recruitment Food Bank	Unitarian Church & First Lutheran Church
March 12, 2003	Recruitment Food Bank	Raycam Community Center
March 14, 2003	Recruitment	Eastside Family Place
March 26, 2003	Meeting with staff & volunteers	North Health Office
April 30, 2003	Meeting	North Health Office
May 5, 2003	Dental & Nutrition Clinic	North Health Office
May 7, 2003	Meeting	BC Research Institute
May 12, 2003	Dental & Nutrition Clinic	North Health Office
May 20, 2003	Meeting	BC Research Institute
May 26, 2003	Dental & Nutrition Clinic	North Health Office
June 2, 2003	Dental & Nutrition Clinic	North Health Office

Appendix D: Screening Questionnaire

WHAT DO CHILDREN LIKE TO EAT?



ꕤ Dear parents ꕤ

We need your help! We know that children can have strong likes and dislikes when it comes to choosing food and drink. We are a research team from Vancouver who are working with Parents, Speech-Language Pathologists, Nutritionists, Dentists and Health Nurses in the community to find out what young children eat and to try to find out how the foods they choose affect their development.

We would like you to be part of our research to gather information on which food children like to eat. The first thing we have to do is to collect information on a large number of pre-school children. So we are asking you to complete this survey and return it to us. Someone from our research team can help you if necessary, or you can fill it out yourself and send it back to us. There are no right or wrong answers, only answers that best describe what you feel or think.

The second step of this research will involve a small number of children for measuring and weighing, a dental exam, and a blood count. There are no costs to you for these tests. Please indicate if you are willing to help in the second step of this research on the end of the form.

All your responses will be strictly confidential.
THANK YOU FOR YOUR HELP!
Dr. Sheila Innis and Ziba Vaghri

Subject Code # __________

CHILDREN'S EATING PREFERENCES
One Year to Five Years of Age

Please choose the answers that best describe your child.

1. **FOOD:**

a) Does your child eat meat, fish[1] or poultry[2]?

☐ No ☐ Less than 5 times a week ☐ 5 times a week ☐ More than 5 times a week

b) Does your child avoid any of these foods? (check all that apply)

☐ Eggs ☐ Milk ☐ Fish/Shellfish[1] ☐ Lamb ☐ Poultry[2] ☐ Beef products ☐ Pork products

c) Children's intakes often vary from one day to the next. On average, how many times a day, *including all meals, snacks and treats*, does your child eat something?

☐ One ☐ Two ☐ Three ☐ Four ☐ Five ☐ Six ☐ Seven ☐ Eight ☐ Nine ☐ Ten ☐ More than ten

heck which of the following your child always or almost always eats:

☐ Dieakfast ☐ Lunch ☐ Dinner

2. **DRINKS:**

a) How many cups/bottles of milk does your child drink per day? (One cup = 250 ml = 8 oz or one standard single-serving tetra pack)

☐ None ☐ One ☐ Two ☐ Three ☐ Four ☐ Five ☐ More than five

b) How many cups/bottles of juice does your child drink a day?

☐ None ☐ One ☐ Two ☐ Three ☐ Four ☐ Five ☐ More than five

c) My child drinks mostly... (can check more than one)

☐ Milk ○ whole 3.3% ○ 2% ○ 1% ○ skim ○ chocolate ○ goat ○ soy ○ rice
☐ Coffee ☐ Tea ☐ Fruit juice/drink ☐ Pop/soda ☐ Other ______________

3. How many times a day are your child's teeth brushed with toothpaste?

☐ By the child	○ zero	○ one	○ two	○ three
☐ By the parent	○ zero	○ one	○ two	○ three

4. Yesterday, did your child eat...? (please check all that apply)

☐ Meat ☐ Fish/Shellfish[1] ☐ Poultry[2] ☐ None of these

1- Includes: fish, crab, lobster, oysters, clams, scallop, mussels, etc.
2- Includes: chicken, duck, turkey, etc.

Subject Code # ______

CHILDREN'S EATING PREFERENCES
One Year to Five Years of Age

5. My child likes/dislikes:

	Likes	Dislikes	Not offered
Foods that require chewing (meat, chicken, etc.)	❑	❑	❑
Soft foods (yogurt, soft fruits, cooked vegetables)	❑	❑	❑
Crunchy foods (raw vegetables, hard fruits, etc.)	❑	❑	❑

6. Are you concerned about your child's eating?

❑ Yes ❑ No

Why? Please check all that apply

❑ Picky eater ❑ Doesn't eat often enough ❑ Won't try new foods
❑ Eats too much ❑ Always eats the same foods ❑ Eats unhealthy foods
❑ Eats too often ❑ Not enough variety in diet ❑ Doesn't eat enough
❑ Other ____________________

7. Was your child breast-fed?

❑ Yes ❑ No
For how long? ________

8. Did your child drink infant formula?

❑ No ❑ Iron-fortified formula ❑ Regular formula (non iron fortified)
For how long? ________

9. Does your child take a vitamin/mineral supplement?

❑ Yes ❑ No
Please list name of supplement(s) and how often taken:

____

10. How often has someone in your family not eaten the quality or variety of foods that you wanted because of lack of money?

❑ Always ❑ Almost always ❑ Sometimes ❑ Hardly ever ❑ Never

11. Please record your postal code ____________________

Subject Code # ______

CHILDREN'S EATING PREFERENCES
One Year to Five Years of Age

Child's Background

Gender ☐ Male ☐ Female

Date of Birth ____/____/____
Month Day Year

Birth Weight ______________

Place of Birth ______________

Child's weight (if known) ______ (specify lbs or kg) ☐ don't know

Child's height (if known) ______ ☐ don't know

Child's waist measurement (if known) ______ ☐ don't know

Ethnic Background

Mother's Ethnicity ______________ **Father's** Ethnicity ______________

Parent's Background

1. **What is the total income in your family? (i.e. yours and your partner's income)**
   - ☐ Less than $20,000
   - ☐ $20,000 - $50,000
   - ☐ More than $50,000

2. **Highest level of education completed**

(Mother)
- ☐ Less than high school
- ☐ High school
- ☐ College
  How many years? ___
- ☐ University
  How many years? ___
- ☐ Degree attained (specify)
  ____

(Father)
- ☐ Less than high school
- ☐ High school
- ☐ College
  How many years? ___
- ☐ University
  How many years? ___
- ☐ Degree attained (specify)
  ____

Subject Code # ______

CHILDREN'S EATING PREFERENCES
One Year to Five Years of Age

Participation in the Second Stage

The second stage of this study will involve a free dental exam and blood screening of your child. Your child's measurements will also be taken. The time commitment for this will be about 30 minutes. Blood screening will involve taking a small amount of blood. May we contact you to ask for your child's participation? By agreeing to future contact, this does not mean that you are obligated to participate.

If you would like to participate in this second stage please write your name, address and phone number below and someone from our team will contact you.

☐ Yes/Maybe - I would like to take part in the second stage of the research.

Name ____

Phone Number ______________________________________

Address ____

Street number and name

____

City Province Postal Code

What **time of day** would be best to contact you by phone?

☐ Morning	☐ Afternoon	☐ Evening
Specify time ________	Specify time ________	Specify time ________

☐ No – I don't want to participate in the second stage of the research.

Appendix E: Food Frequency Questionnaire

FOOD FREQUENCY QUESTIONNAIRE

NUTRITION

RESEARCH
PROGRAM

Subject Number____________________

Location of Visit____________________

Interviewer________________________

Subject's ID code: 03ZV

Nutrition Research Program
University of British Columbia

	Item Name	Brand/Homemade	Amount	Frequency
	DAIRY PRODUCTS			
1)	Milk (drinking) - cow (homo, 2%, 1%, skim), goat, rice, soy, chocolate, hot chocolate		☐ cup/ml	☐ Day
			☐ cup/ml	☐ Day
2)	Goat's milk		☐ cup/ml	☐ Day
3)	Milk in cereal		☐ cup/ml	☐ Day
4)	Cheese - cheddar, mozzarella, Swiss, brie		☐ oz/g ☐ cup ☐ slice	☐ Day ☐ Week
5)	Cream cheese	☐ Brand ☐ Homemade	☐ oz/g ☐ tsp ☐ Tsp	☐ Day ☐ Week ☐ Every 2 weeks
6)	Cottage cheese (1%, 2%, creamed or whole)		☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
7)	Processed cheese (Lite or regular-including the ones on sandwiches and hamburgers)	☐ Brand	☐ Slices	☐ Day ☐ Week ☐ Every 2 weeks
8)	Cheese Spreads (Lite and regular) Cheez Whiz - Country Crock	☐ Brand	☐ oz/g ☐ tsp ☐ Tsp	☐ Day ☐ Week ☐ Every 2 weeks
9)	Soy cheese	☐ Brand	☐ oz/g ☐ cup ☐ Piece	☐ Day ☐ Week ☐ Every 2 weeks
10)	Goat cheese		☐ oz/g ☐ Piece	☐ Day ☐ Week ☐ Every 2 weeks
11)	Paneer		☐ oz/g	☐ Day ☐ Week ☐ Every 2 weeks
12)	Yogurt	☐ Brand	☐ oz/g ☐ cup/ml	☐ Day ☐ Week ☐ Every 2 weeks
13)	Minigo (Yoplait fresh cheese product)		☐ oz/g ☐ cup/ml	☐ Day ☐ Week

Subject's ID code: 03ZV

Nutrition Research Program
University of British Columbia

	Item Name		Brand/Homemade	Amount		Frequency
						☐ Every 2 weeks
14)	Ice cream/ Frozen yogurt	______	☐ Brand ______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
15)	Milkshakes/ Yogurt shakes	______	☐ Brand ______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
16)	Puddings	______	☐ Brand ______ ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
17)	Other Dairy Products- eggnog, Caresses, fresh cheese	______	______	______	☐ oz/g ☐ cup/ml ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
	EGGS					
1)	Eggs - fried, scrambled - poached, deviled, boiled - omelet, quiches	______	______	______	☐ number	______ ☐ Day ☐ Week ☐ Every 2 weeks
2)	Egg yolk only	______	______	______	☐ number	______ ☐ Day ☐ Week ☐ Every 2 weeks
3)	Egg whites only	______	______	______	☐ number	______ ☐ Day ☐ Week ☐ Every 2 weeks
	TABLE/COOKING FAT					
1)	Margarine for spreading on breads and crackers	______	☐ Brand ______	______	☐ oz/g ☐ tsp ☐ Tsp	______ ☐ Day ☐ Week
2)	Margarine for spreading on vegetables or cooking vegetables and eggs and…	______	☐ Brand ______	______	☐ oz/g ☐ tsp ☐ Tsp	______ ☐ Day ☐ Week ☐ Every 2 weeks
3)	Butter for spreading on breads and crackers	______	☐ Brand ______	______	☐ oz/g ☐ tsp ☐ Tsp	______ ☐ Day ☐ Week ☐ Every 2 weeks
4)	Butter for spreading on vegetables or cooking vegetables and eggs and …	______	☐ Brand ______	______	☐ oz/g ☐ tsp ☐ Tsp	______ ☐ Day ☐ Week ☐ Every 2 weeks
5)	Cooking oils (example In cooking pancakes	______	☐ Brand ______ ☐ Homemade	______	☐ tsp ☐ Tsp	______ ☐ Day ☐ Week

Subject's ID code: 03ZV

Nutrition Research Program

University of British Columbia

	Item Name		Brand/Homemade	Amount		Frequency	
			______	______		______	☐ Every 2 weeks
6)	Salad Dressings	______	☐ Brand ______	______	☐ tsp ☐ Tsp ☐ cup/ml	______	☐ Day ☐ Week ☐ Every 2 weeks
7)	Mayonnaise Miracle Whip	______	☐ Brand ______	______	☐ oz/g ☐ tsp ☐ Tsp	______	☐ Day ☐ Week ☐ Every 2 weeks
8)	Peanut butter - tahini, nut butters	______	______ ☐ Brand ☐ Homemade	______	☐ oz/g ☐ tsp ☐ Tsp	______	☐ Day ☐ Week ☐ Every 2 weeks
9)	Whipped Toppings - Cool Whip, Nutri Whip - whipping cream	______	______ ☐ Brand ☐ Homemade	______	☐ oz/g ☐ tsp ☐ Tsp	______	☐ Day ☐ Week ☐ Every 2 weeks
10)	Other Table/Cooking Fats – cereal cream, sour cream	______	______	______	☐ tsp ☐ Tsp ☐ cup/ml	______	☐ Day ☐ Week ☐ Every 2 weeks
	BREADS/CEREALS AND BAKED GOODS						
1)	Bread (including pita/bagels) corn, rye, sourdough, chapatti, roti	______	______ ☐ Brand ☐ Homemade	______	☐ piece	______	☐ Day ☐ Week
2)	Buns/Rolls (including hamburger/hot dog buns)	______	______ ☐ Brand ☐ Homemade	______	☐ piece	______	☐ Day ☐ Week
3)	Breadsticks/Croutons	______	______ ☐ Brand ☐ Homemade	______	☐ piece	______	☐ Day ☐ Week
4)	Cereals, cold breakfast	______	______ ☐ Brand ☐ Homemade	______	☐ cup	______	☐ Day ☐ Week
5)	Cereals, hot breakfast	______	______ ☐ Brand ☐ Homemade	______	☐ cup	______	☐ Day ☐ Week
6)	Wheat germ (used in/on foods)	______	______ ☐ Brand ☐ Homemade	______	☐ tsp ☐ Tsp	______	☐ Day ☐ Week ☐ Every 2 weeks
7)	Pancakes/Waffles	______	______ ☐ Brand ☐ Homemade	______	☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
8)	Muffins, bran, fruit	______	______	______	☐ piece ☐ small ☐ large	______	☐ Day ☐ Week ☐ Every 2 weeks
9)	English Muffin						

	Item Name		Brand/Homemade	Amount	Frequency
			☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
10)	Scones/Tea Biscuits		☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
11)	Poptarts/ Toaster Pastries		☐ Brand	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
12)	Donuts/Fritters			☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
13)	Danish/Pastries		☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
14)	Croissants		☐ Brand ☐ Homemade	☐ oz/g ☐ cup/ml ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
15)	Cakes/Squares - brownies, cake rolls, cheesecake		☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
16)	Pies/Tarts, fruit pies		☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
17)	Cookies		☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
18)	Tortilla, flour or corn, Taco shells,		☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
19)	Other Breads/Cereals and Baked Goods; cinnamon buns, wagon wheels		☐ Brand ☐ Homemade	☐ oz/g ☐ cup/ml ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
20)	Instant noodle, rice noodle or any other type))		☐ Brand	☐ oz/g ☐ cup/ml ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
21)	Rice, any type cooked		☐ Brand ☐ Homemade	☐ oz/g ☐ cup/ml ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
22)	Rice and pasta			☐ oz/g	☐ Day

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	Item Name	Brand/Homemade	Amount	Frequency
		☐ Brand ☐ Homemade	☐ cup/ml ☐ piece	☐ Week ☐ Every 2 weeks
23)	Boiled pasta-plain Spaghetti, egg noodles etc		☐ oz/g ☐ cup	☐ Day ☐ Week ☐ Every 2 weeks
24)	Canned pasta e.g Ravioli	☐ Brand ☐ Homemade	☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Month
25)	Macaroni and cheese, other pasta dishes with cheese	☐ Brand ☐ Homemade	☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
26)	Other grain products couscous		☐ cup	☐ Day ☐ Week ☐ Every 2 weeks

MEAT, FISH AND POULTRY

	Item Name	Brand/Homemade	Amount	Frequency
1)	Beef (steak, roast, ground, etc)		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
2)	Hamburgers	☐ Brand ☐ Homemade	☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
3)	Pork (steak, roast, chops, etc)		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
4)	Ham		☐ oz/g ☐ slices	☐ Day ☐ Week ☐ Every 2 weeks
5)	Bacon		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
6)	Lamb (including roast, chops, etc)		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
7)	Chicken, turkey or other poultry		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
8)	Chicken nuggets/ strips	☐ Brand ☐ Homemade	☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
			☐ oz/g	☐ Day

Item Name	Brand/Homemade	Amount	Frequency
9) Wild game (moose, deer, etc fresh, frozen, dried)	☐ Brand ☐ Homemade	☐ piece	☐ Week ☐ Every 2 weeks
10) Canned fish and Shellfish, example, Tuna, salmon, sushi…	☐ Brand	☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
11) Fresh and frozen fish and shell fish		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
12) Other seafood - scallop, clams - Lobsters, mussels, oysters		☐ oz/g ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
13) Deli meats; bologna, salami, pepperoni, shell fish		☐ oz/g ☐ slices	☐ Day ☐ Week ☐ Every 2 weeks
14) Wieners, hot dogs, sausages		☐ oz/g ☐ number	☐ Day ☐ Week ☐ Every 2 weeks
MEATALTERNATI VES			
1) Firm or medium firm tofu or soybean curd	☐ Brand	☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
2) Soft or desert tofu	☐ Brand ☐ Homemade	☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
3) Soy wiener/ vegetarian wiener	☐ Brand ☐ Homemade	☐ oz/g ☐ cup ☐ number	☐ Day ☐ Week ☐ Every 2 weeks
4) Other meat replacements	☐ Brand	☐ oz/g ☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
COMBINATION DISHES CASSEROLS WITH MEAT, FISH AND POULTRY			
1) Mixed dishes prepared, with beef (e.g. shepherd's pie, pot pie, chili, stew)	☐ Brand ☐ Homemade	☐ oz/g ☐ cup ☐ Tbsp	☐ Day ☐ Week ☐ Every 2 weeks
2) Mixed dishes made with fish (e.g., tuna casserole)	☐ Brand ☐ Homemade	☐ oz/g ☐ cup	☐ Day ☐ Week ☐ Every 2 weeks
3) Mixed dishes made with		☐ oz/g	☐ Day

	Item Name		Brand/Homemade		Amount		Frequency
	pork		☐ Brand ☐ Homemade		☐ cup		☐ Week ☐ Every 2 weeks
4)	Mixed dishes made with lamb		☐ Brand ☐ Homemade		☐ oz/g ☐ cup		☐ Day ☐ Week ☐ Every 2 weeks
5)	Pizza with meat		☐ Brand ☐ Homemade		☐ slice		☐ Day ☐ Week ☐ Every 2 weeks
6)	Enchiladas and Taco with meat		☐ Brand ☐ Homemade		☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
7)	Filled buns, baked or steamed, meat filled				☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
8)	Luncheon Meats/ Spreads in sandwiches/subs		☐ Brand ☐ Homemade		☐ oz/g ☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
	COMBINATION DISHES WITH CHEESE						
1)	Enchiladas, cheese filled		☐ Brand ☐ Homemade		☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
2)	Perogies (potato and cheese filled, or onion filled)		☐ Brand ☐ Homemade		☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
3)	Pizza and pizza pockets with cheese and no meat		☐ Brand ☐ Homemade		☐ piece ☐ slice		☐ Day ☐ Week ☐ Every 2 weeks
4)	Quiche without meat (with cheese)		☐ Brand ☐ Homemade		☐ oz/g ☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
	COMBINATION DISHES WITH VEGETABLES						
1)	cooked lentils, beans, or peas (e.g. lentil stew or soup)		☐ Brand ☐ Homemade		☐ oz/g ☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
2)	Vegetarian pasta dishes		☐ Brand ☐ Homemade		☐ oz/g ☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
3)	Other mixed dishes		☐ Brand		☐ oz/g ☐ cup		☐ Day ☐ Week

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Item Name		Brand/Homemade	Amount	Frequency
		☐ Homemade	☐ piece	☐ Every 2 weeks
SOUPS				
1) Broth Type e.g. Vegetable	______	______ ☐ Brand ☐ Homemade	______ ☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
2) Broth type; chicken, Beef and fish	______	______ ☐ Brand ☐ Homemade	______ ☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
3) Cream-type soups	______	______ ☐ Brand ☐ Homemade	______ ☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
4) Noodle soups	______	______ ☐ Brand ☐ Homemade	______ ☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
5) Other types of soup	______	______ ☐ Brand ☐ Homemade	______ ☐ oz/g ☐ cup/ml ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
VEGETABLE; CANNED, FRESH OR FROZEN				
1) Broccoli	______	______	______ ☐ oz/g ☐ cup ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
2) Carrots	______	______	______ ☐ oz/g ☐ cup ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
3) Corn; cream or niblets	______	______	______ ☐ oz/g ☐ cup ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
4) Green peas	______	______	______ ☐ oz/g ☐ cup	______ ☐ Day ☐ Week ☐ Every 2 weeks
5) Spinach, cooked	______	______	______ ☐ oz/g ☐ cup	______ ☐ Day ☐ Week ☐ Every 2 weeks
6) Green beans, string beans, yellow beans	______	______	______ ☐ oz/g ☐ cup ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
7) Potatoes; mashed, baked, salad or boiled	______	______	______ ☐ oz/g ☐ cup ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks

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	Item Name		Brand/Homemade	Amount		Frequency	
8)	French fries, home fries, Pan fries	______	______	______	☐ oz/g ☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
9)	Squash, all types	______	______	______	☐ oz/g ☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
10)	Cabbage	______	______	______	☐ oz/g ☐ cup	______	☐ Day ☐ Week ☐ Every 2 weeks
11)	Brussel; sprouts	______	______	______	☐ oz/g ☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
12)	Celery	______	______	______	☐ oz/g ☐ cup ☐ sticks	______	☐ Day ☐ Week ☐ Every 2 weeks
13)	Chick peas	______	______	______	☐ oz/g ☐ cup	______	☐ Day ☐ Week ☐ Every 2 weeks
14)	Lentils/split peas	______	______	______	☐ oz/g ☐ cup	______	☐ Day ☐ Week ☐ Every 2 weeks
15)	Kidney beans	______	______	______	☐ oz/g ☐ cup	______	☐ Day ☐ Week ☐ Every 2 weeks
16)	tomato	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
17)	Lettuce	______	______	______	☐ cup ☐ leaves	______	☐ Day ☐ Week ☐ Every 2 weeks
18)	Cucumber	______	______	______	☐ cup ☐ slices	______	☐ Day ☐ Week ☐ Every 2 weeks
19)	Peppers	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
20)	Other vegetables	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks

Subject's ID code: 03ZV

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	Item Name		Brand/Homemade	Amount		Frequency	
	FRUIT (CANNED, FRESH OR FROZEN)						
1)	Apples and apple sauces	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
2)	Bananas	______	______	______	☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
3)	Oranges	______	______	______	☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
4)	Pears, peaches, nectarines and plums	______	______	______	☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
5)	Grapes	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
6)	Raisins, prunes and other dried fruits	______	______ ☐ Brand	______	☐ oz/g ☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
7)	Melon (eg. Cantaloupe, honeydew, watermelon)	______	______	______	☐ oz/g ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
8)	Lychee	______	______	______	☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
9)	Strawberries	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
10)	Other berries (blueberries, raspberries)	______	______	______	☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
11)	Fruit cocktail or fresh fruit salad	______	______ ☐ Brand ☐ Homemade	______	☐ cup	______	☐ Day ☐ Week ☐ Every 2 weeks
12)	Other fruits	______	______	______	☐ oz/g ☐ cup ☐ piece	______	☐ Day ☐ Week ☐ Every 2 weeks
	BEVERAGES						

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	Item Name		Brand/Homemade	Amount		Frequency
1)	Pure orange Juice and grapefruit juice	______	______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
2)	Apple juice	______	______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
3)	Five alive	______	______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
4)	Other fruit juices (eg. Grape, pear, pineapple, papaya, cranberry)	______	______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
5)	Prune juice	______	______ ☐ Brand ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
6)	Tomato and mixed Vegetable juices (eg. V8 juice)	______	______ ☐ Brand ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
7)	Carrot juice	______	______ ☐ Brand ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
8)	Sweetened fruit drinks including crystals and boxed varieties (eg. Tang, Kool-Aid, Ribena)	______	______ ☐ Brand ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
9)	Pop (regular)	______	______ ☐ Brand ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
10)	Pop (diet)	______	______ ☐ Brand ☐ Homemade	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
11)	Carbonated fruit drinks (eg. Koala Springs)	______	______ ☐ Brand ☐ Homemade	______	☐ oz/g ☐ cup/ml ☐ piece	______ ☐ Day ☐ Week ☐ Every 2 weeks
12)	Tea	______	______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks
13)	Coffee	______	______	______	☐ cup/ml	______ ☐ Day ☐ Week ☐ Every 2 weeks

	Item Name	Brand/Homemade	Amount	Frequency
14)	Other beverages	☐ Brand ☐ Homemade	☐ cup/ml	☐ Day ☐ Week ☐ Every 2 weeks
	DESSERTS			
1)	Custard	☐ Brand ☐ Homemade	☐ cup/ml	☐ Day ☐ Week ☐ Every 2 weeks
2)	Pudding	☐ Brand ☐ Homemade	☐ cup/ml	☐ Day ☐ Week ☐ Every 2 weeks
3)	Jello	☐ Brand ☐ Homemade	☐ cup/ml ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
4)	Popsicle or Mr. Freezie	☐ Brand ☐ Homemade	☐ oz/g ☐ cup/ml ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
	SNACKS			
1)	Plain or cheese crackers (Ritz, cheese type and soda crackers)	☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
2)	Wheat crackers (Stone wheat, thins, Triscuits, wholegrain, soda crackers)	☐ Brand ☐ Homemade	☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
3)	Potato chips, cheeses or tortilla chips	☐ Brand ☐ Homemade	☐ piece ☐ pkg	☐ Day ☐ Week ☐ Every 2 weeks
4)	Popcorn	☐ Brand ☐ Homemade	☐ oz/g ☐ cup	☐ Day ☐ Week ☐ Every 2 weeks
5)	Party snacks - Nuts & Bolts, pretzels - Crunch N Munch	☐ Brand ☐ Homemade	☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
6)	Walnuts		☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks
7)	Almonds		☐ cup ☐ piece	☐ Day ☐ Week ☐ Every 2 weeks

	Item Name		Brand/Homemade	Amount		Frequency	
8)	Other nuts				☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
9)	Seeds (eg, sunflower seeds)				☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
10)	Other seeds				☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
11)	Other snacks		☐ Brand ☐ Homemade		☐ oz/g ☐ cup ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
	JAMS, JELLIES, CANDIES						
1)	Candy		☐ Brand		☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
2)	Jam and jellies on bread		☐ Brand ☐ Homemade		☐ Tsp ☐ tsp		☐ Day ☐ Week ☐ Every 2 weeks
3)	Chocolate bar		☐ Brand ☐ Homemade		☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
4)	Granola bar		☐ Brand		☐ oz/g ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
5)	Fruit roll up, fruit leather		☐ Brand		☐ oz/g ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
6)	Sdckers lolly pops etc		☐ Brand		☐ oz/g ☐ piece		☐ Day ☐ Week ☐ Every 2 weeks
	CONDIMENTS						
1)	Tomato ketchup		☐ Brand ☐ Homemade		☐ Tsp ☐ tsp		☐ Day ☐ Week ☐ Every 2 weeks
2)	Chatni		☐ Brand ☐ Homemade		☐ Tsp ☐ tsp		☐ Day ☐ Week ☐ Every 2 weeks
3)	Other sauces		☐ Brand		☐ Tsp ☐ tsp		☐ Day ☐ Week

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	Item Name	Brand/Homemade	Amount	Frequency
		☐ Homemade		☐ Every 2 weeks
4)	Other condiments	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp	☐ Day ☐ Week ☐ Every 2 weeks
	PURCHASED INFANT, JUNIOR AND TODDLER FOODS			
1)	Cereal (eg. Rice, barley, oats or mixed)	☐ Brand	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
2)	Cereals mixed with yogurt or/and fruits	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
3)	Meat or poultry (eg. beef, pork, lamb, veal, ham, chicken or turkey)	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
4)	Liver	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
5)	Meat or poultry with rice or noodle dinner	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
6)	Vegetable and meat	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
7)	Vegetables	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
8)	Fruits	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
9)	Prunes	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
10)	Fruit desserts (eg. Tutti Frutti)	☐ Brand ☐ Homemade	☐ Tsp ☐ tsp ☐ jar	☐ Day ☐ Week ☐ Every 2 weeks
11)	Fruit yogurt desserts	☐ Brand	☐ Tsp ☐ tsp	☐ Day ☐ Week

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Item Name		Brand/Homemade	Amount	Frequency
		☐ Homemade	☐ jar	☐ Every 2 weeks
12) Custard or pudding	______	______ ☐ Brand ☐ Homemade	______ ☐ Tsp ☐ tsp ☐ jar	______ ☐ Day ☐ Week ☐ Every 2 weeks
13) Other purchased baby foods	______	______ ☐ Brand ☐ Homemade	______ ☐ Tsp ☐ tsp ☐ jar	______ ☐ Day ☐ Week ☐ Every 2 weeks

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1) Did you breast-feed your child?

☐ Yes ☐ No

If yes, please specify;

1-2 months ☐ 4-6 months ☐ 6-10 months ☐ 12-18 months ☐

2) Are you currently breast-feeding?

☐ Yes Number of times per day ______ ☐ No

3) Are you currently giving your child a commercial infant formula?

☐ Yes (please go to question 4)

☐ No (please go to question 5)

4) What brand types of formula do you Usually give your child?	Color of label	How many times per day or per week	How much does your child usually drink per day?
(1) ____________	______	______ times per ☐ day ☐ week	______
(2) ____________	______	______ times per ☐ day ☐ week	______
(3) ____________	______	______ times per ☐ day ☐ week	______

5) Do you usually give your child a vitamin/mineral supplement?

☐ Yes (please go to Q5)
☐ No

6) What brands/Types of Supplements?

(2) ____________ ☐ day ☐ week ☐ month

(1) ____________ ☐ day ☐ week ☐ month

(2) ____________ ☐ day ☐ week ☐ month

7) Does your child takes a bottle?

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At night	during day time naps	during the day
☐ Yes	☐ Yes	☐ Yes
☐ NO	☐ NO	☐ NO

8) What is usually in your child's bottle?

		At night	during day time
Milk;	Homogenized	______	______
	2%	______	______
	1%	______	______
	Skim	______	______
Juice		______	______
Water		______	______
Other		______	______

Appendix F: Oral Health Questionnaire

Subject's ID code: 03ZV

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Questions about Children's Teeth

1. Tell me about your own visits to the dentist. How often do you go to the dentist?

O At least once every 2 years
O Once every 3 or more years
O Only when something hurts
O Never

2. Now can you tell me about your child. How often do you take your child to the dentist?

O At least once a year
O When something hurts
O Not yet

3. Was your child ever put to sleep to have his/her teeth fixed?

O Yes O No

4. Do you think baby teeth are important?

O Yes O No O Not sure

5. Does your child use fluoride drops/tablet daily?

O Yes O No

6. What toothpaste does your child use?

O Colgate, Crest, Aquafresh
O Other (Oragel, First Teeth, Tom of Maine non-fluoridated)
O None

7. Do you think your child's teeth are clean after brushing?

O Yes O Okay, but not great O No O Not sure

8. How often did/does your child nap or sleep with a bottle containing something other than water (e.g. juice, milk)?

O At least twice a day at sleep-time and nap-time
O Only at night-time
O Only at nap-time
O Never
O Child never had a bottle, went from being breast-fed directly to a cup

9. How often did/does your child carry a bottle or sippy cup containing something other than water (e.g. juice, milk)?

O At least once a day
O Once a week or less
O Never

Appendix G: Anthropometrics Form

MEASUREMENTS RECORDING SHEET

1. Your child is a: Boy ☐ Girl ☐

2. What is your child's birth date?

Year/ Month/ day / /

3. What was your child's birth weight?
______ kg or ________ lbs

4. Was anyone of the followings true about your pregnancy?

He/she was born full term ☐

He/she was born prematurely ☐ ________ weeks of age

You gave birth to more than one child ☐ How many? ________ Babies

You were diagnosed with gestational diabetes ☐

You took vitamin and nutrient supplements ☐

You smoked yes ☐ no ☐ rarely ☐

5. Anthropometric measurements:

Wt: ________ lbs

Ht: _____ F _______ inch

BMI: kg / m^2

6. Blood pressure measurement: / MmHg

Appendix H: Dental Exam

Subject Code: 03ZV__

ORAL HEALTH ASSESSMENT FORM

CARIES BY SURFACE

0 = SOUND
1 = WHITE SPOT LESION
2 = ENAMEL DECAY
3 = DENTINAL DECAY
4 = PULPAL DECAY
5 = FILLED
6 = MISSING (Unerupted, Trauma, Exfoliated)
7 = MISSING (Extacted)

Quadrant 5

	M	O	D	B	L
51*		X			
52		X			
53		X			
54					
55*					

Quadrant 6

	M	O	D	B	L
61		X			
62		X			
63		X			
64					
65					

Quadrant 8

	M	O	D	B	L
81		X			
82		X			
83		X			
84					
85*					

Quadrant 7

	M	O	D	B	L
71		X			
72		X			
73		X			
74					
75					

Plaque Index

			L	H
54	55	B		
51	52	B		
84	85	L		

Bleeding ___Y ___N

Follow Up ___Y ___N

Comments:

___

___

___

Date: ____________

Dear parent of ____________

Thank you for bringing your child in for a dental check-up as part of our research project on "What Do Children Like to Eat?".

The dentist noted the following in ____________________ mouth:

☐ Your child has no problems now.

☐ Your child needs your help in brushing the teeth in the
Upper: __front __back __inside

Lower: __front __back __inside
(Check all areas involved)

☐ Your child has some beginning (very early) cavities on
Teeth: __upper __lower

Surfaces __front __back __ "in between teeth" __chewing
(Check all arches and surfaces involved)

☐ Your child has noticeable cavities on
Teeth: __upper __lower

Surfaces __front __back __ "in between teeth" __chewing
(Check all arches and surfaces involved)

☐ Please take your child to your family dentist for treatment.

Please call the North Community Health Office Dental Clinic at (604) 215-3935 if you have any further questions in locating a dental office for your child's treatment.