Iron status among infants 8-26 months of age in Vancouver and socio-cultural /dietary predictors of risk for iron deficiency anemia

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Abstract

The feeding practices of Chinese and Caucasian infants may place them at risk for IDA, and its deleterious consequences. It is currently recommended that dietary assessment is used to screen 'high risk' infants for risk of IDA, however, dietary instruments to assess iron nutrition among Caucasian and Chinese infants are not available. The purpose of this study was to develop and assess the utility of dietary instruments for identifying Caucasian and Chinese infants ages 8-26 mths with poor iron status.

Letters describing the study were sent to 1585 parents of potentially eligible infants identified through birth lists and 613 of these parents were contacted by telephone. Of these, 148 infants 8-26 mths of age, n=84 Caucasian, n=48 Chinese completed the study. Capillary blood samples were collected and analyzed for hemoglobin (Hgb), serum ferritin and soluble transferrin receptors (sTfR). A 191-item food frequency questionnaire (FFQ) was developed to provide a comprehensive assessment of the dietary intakes and sources of energy, iron and other dietary factors influencing iron absorption. Feeding history and current diet were assessed using a Socio-Cultural and Infant Feeding Questionnaire, a 3-day food record (3d-FR) and the interviewer-administered FFQ. The 3d-FR and FFQ were analyzed for dietary intakes and sources of energy, iron (total, heme and non-heme), vitamin C, calcium and dietary fibre using Food Processor®.

The FFQ measures of total and heme iron intakes showed criterion validity compared with sTfR:ferritin ratio ($r=-0.33$ and -0.27, respectively, $P<0.001$), and relative validity compared with 3d-FR measures of total and heme iron intakes ($r=0.65$ and 0.72, respectively, $P<0.001$). The prevalence of IDA (Hgb <110 g/L + serum ferritin ≤12 μg/L) was higher at ages 8-12 than 13-26 mths in Caucasian (15% vs. 4%) and Chinese (6% vs. 0%) infants ($P=0.001$). Low iron stores (serum ferritin ≤12 μg/L without IDA) was found in 30% of Caucasian and 19% of Chinese infants. The types and quantities of complementary foods fed, most notably the introduction of meats later than 9 mths of age, and subsequent low intakes of meats, in a predominantly breast milk diet were associated with the high prevalence of poor iron status among Caucasian infants. Four key dietary patterns were associated with poor iron status: 1) a history of no iron-fortified formula or supplemental iron; 2) cows' milk fed prior to 9 mths of age; 3) ≥800 g/day cows' milk/milk products; and 4) <30 g/day meats.

Primary prevention initiatives should be targeted to 8-12 mth old Caucasian infants and include ways to ensure adequate intakes of heme iron or alternatives to this, and avoidance of early introduction or excessive quantities of cows' milk. Brief dietary-screening tools for detection of infants at risk for IDA are presented but need to be field-tested in future research.

TABLE OF CONTENTS

PAGE

List of Tables

LIST OF FIGURES

Glossary of Terms

Abbreviations

24-hr recall	24-hour dietary recall
3d-FR	3-day food record
3d-WFR	3-day weighed food record
ATP	adenosine triphosphate
BCCH	British Columbia's Children's Hospital
CC	Community Centre
Fe^{2+}	ferrous
Fe^{3+}	ferric
Fe^{4+}	ferryl
FFQ	food frequency questionnaire for parents of infants 8-26 months of age
GI	gastrointestinal
Hgb	hemoglobin
HU	Health Unit
IDA	iron deficiency anemia
IDE	iron deficiency erythropoiesis
MCH	mean cell hemoglobin
MPF	Meats, poultry and fish
mths	months
n	number
NH	Neighbourhood House
RBC	red blood cell
RDA	U.S. Recommended Dietary Allowance
RNI	Canadian Recommended Nutrient Intake
SES	Socio-economic status
sTfR	soluble transferrin receptor

TfR	transferrin receptor
TIBC	total iron binding capacity
TS	transferrin saturation
U.S.	United States
WIC Program	Special Supplemental Food Program for Women, Infants and Children Program

Definition and Terms

Units

μg	micrograms
g	grams
kcal	kilocalorie
L	litre
mg	milligrams
mL	millilitres

Dietary Items

food consumption patterns - retrospective information collected by the FFQ on the foods consumed in the 2 weeks preceding the study.

infant feeding history - retrospective information on infant feeding practices determined by the Socio-Cultural and Infant Feeding Questionnaire. Questions on infant feeding practices included the following: 1) duration of breast-feeding, 2) the age of introduction and types of infant formula (low iron or iron-fortified), cows' milk (whole, 2%, 1%, or skim) or other milks (goats' milk, soy milk, etc.) fed from birth to the time of the study, 3) the type and amount of infant formula, cows' milk or other milks currently fed, 4) the age of introduction, duration of feeding and, where applicable, reasons for stopping feeding of solid foods including cereals, rice, pasta, breads/crackers, vegetables, fruits, legumes, dairy and other animal products (e.g. eggs, meat, poultry or fish) and fruit juices, 5) the type of infant cereal(s) introduced, the liquid(s) used to prepare infant cereals, and for those who had not yet introduced infant cereal, the reasons for not introducing an infant cereal.

Classification of Iron Status

iron deficiency/poor iron status – includes both iron deficiency anemia and low iron stores.

iron deficiency anemia - Hgb <110 g/L with a ferritin of ≤12 μg/L.

low iron stores - Hgb ≥110 g/L but with a serum ferritin of ≤12 μg/L.

normal iron status - nonanemic, iron sufficient, Hgb ≥110 g/L, a serum ferritin >12 μg/L and a white blood cell count (WBCC) ≤18 x10^9/L.

TfR - transferrin receptor values based on assays that use cellular disulfide-linked dimer cellular TfR from human placental tissue. Used in the present study.

sTfR - soluble transferrin receptor values based on an assay that uses plasma or serum sTfR monomers. Used in the present study.

Other

Infants – for the purpose of this study includes infants and young children ≤26 months.

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DEDICATION

Mom and Dad…for you both, with love.

Dad, your words provide comfort and strength to me…I know that you are there, always watching over me and believing in me.

To Tress,

There have been many happiness in my life
And that you have been one
For I have seen a fine mind come
From within a little shell that grows

It is my hope that you will find
My words of wisdom – for your lines
So sit and punch these keys with delight
As your essay you have to write

For Father's help was gladly given
As he types this in the kitchen
To see your mark for the work you've been given
Will be his reward when he goes to heaven

And when to college you must go
To seek a life with friends and foe
Remember dear old Dad at home
The one with whom you argued so

Still his thoughts and hopes you'll find
Within your heart that may entwine
First things first we must agree
An essay done for me to see ? ? ?

- Dad

Your love and the memory of your example, and your aspirations are with me always.

Mom, your amazing strength, determination, and ability to sacrifice and give to others have been a source of inspiration and strength throughout my life. You are *always* there for me…with your love and support, and for that I am so grateful.

- Patty

CHAPTER 1. INTRODUCTION

1.1 Background

The plausibility and congruence of the available animal and human evidence strongly suggest that iron deficiency anemia (IDA) has the potential to impair infant health and development. IDA in infancy has been associated with impaired growth (Auckett et al., 1986; Briend et al., 1990; Chwang et al., 1988; Latham et al., 1990), immunity (Galan et al., 1992; Thibault et al., 1993), mental (Lozoff et al., 1982, 1987, 1996; Walter et al., 1983, 1989; Idjradinata & Pollitt, 1993; Grindulis et al., 1986) and motor (Lozoff et al., 1982, 1987; Walter et al., 1983; Idjradinata & Pollitt, 1993; Grindulis et al., 1986) development, behavior (Walter et al., 1983, 1989; Lozoff et al., 1996; Lozoff et al., 1998) and educational performance later in life (Palti et al., 1985; Watkins & Pollitt, 1990; Lozoff et al., 1991; Hurtado et al., 1999). The period beginning at about 4 mths of age to the 2nd year of life is critical for iron balance because iron reserves become depleted at a time when the iron demand for growth and development is high, and there is potential for an inadequate dietary iron supply. Research into potential strategies for prevention of IDA during infancy is, therefore, of considerable public health importance.

There has been significant advancement during the last 30 years in our understanding of iron nutrition and in prevention strategies aimed at reducing the prevalence of IDA in infancy (Dallman, 1990; Yip, 1997). Despite this, IDA remains a problem in both developing and developed countries, affecting 25% of infants worldwide (deMaeyer et al., 1985; Scrimshaw, 1991; United Nations, 1989), and up to 10-12% of infants in developed countries (deMaeyer et al., 1985; Stevens, 1991). The national prevalence of IDA among infants in Canada is unknown. However, studies have shown that infants from disadvantaged families (Lehmann et al., 1992), Chinese ancestries (Chan Yip & Gray-Donald, 1987) and aboriginal communities (Moffatt et al., 1991; Cruz et al., 1990; Whalen et al., 1997; Sawchuket et al., 1996; Willows et al., 2000), and those breast-fed beyond 3-6 mths of age (Innis et al., 1997; Siimes et al., 1984; Calvo et al., 1992; Pizarro et al., 1991; Walter et al., 1993; Willows et al., 2000) may be particularly vulnerable to developing IDA.

Concern has recently been raised that IDA is a significant public health nutrition problem at 9 mths of age, and possibly into the 2nd year of life among infants in Vancouver (Lwanga, 1996; Innis et al., 1997). This is based on a 1993 study in Vancouver that found that the prevalence of IDA and low iron stores was high (8% and 25%, respectively) among Caucasian infants at 9 mths of age, and even higher (15% and 30%, respectively) among those breast-fed >8 mths

(Innis et al., 1997). In contrast to a high prevalence of 11% IDA reported for 6-12 mth old Chinese infants in Montreal (Chan-Yip & Gray-Donald, 1987), the prevalence of IDA was found to be low, affecting 4% of 9 mth old Chinese infants in Vancouver (Lwanga, 1996; Innis et al., 1997). The work by Innis et al. (1997) found that higher rates of breast-feeding were associated with a higher risk of IDA among Caucasian infants, while higher rates of feeding iron-fortified infant formula were associated with a lower risk of IDA among Chinese infants. The only other published data on the iron status of Chinese infants in Canada, that by Chan-Yip & Gray-Donald (1987), suggested that the prevalence of IDA may increase from the first to the 2nd year of life among Chinese infants. It has been documented that while the majority of Caucasian infants are fed iron-fortified infant cereal by 4-6 mths of age (Greene-Finestone et al., 1991; Zlotkin et al., 1981; Ernst et al., 1990), Chinese infants are often fed congee as their first complementary food in place of iron-fortified infant cereals, and given cows' milk early and in large quantities (Leung & Davis, 1994; Li, 1985; Chan-Yip & Gray-Donald, 1987; Hui, 1997). It is possible that the introduction of a variety of complementary foods, including iron-fortified infant cereal may decrease the risk of IDA among Caucasian infants in the 2nd year of life. Weaning practices, such as the use of congee, which tends to have low iron bioavailability, and excessive intakes of cows' milk, on the other hand, may increase the risk of IDA in the 2nd year among Chinese infants. Previous studies have reported that the majority of infants in Vancouver are introduced to iron-containing solid foods at appropriate ages (Williams et al., 1996). However, studies concerning infant feeding practices among infants in Canada have not obtained quantitative data on dietary intakes. Thus, information is lacking on the risk of IDA and low iron stores among Caucasian and Chinese infants from the latter half of the first year throughout the 2nd year of life with respect to feeding practices, dietary intakes and sources of iron and other factors influencing iron absorption, and the overall composition of the weaning diet.

Since 1979, the primary prevention of IDA in Canada has focused on the fortification of infant cereals and formulas with iron, and on the education of parents and medical professionals to promote feeding practices thought to prevent IDA. Specifically, these feeding practices are to exclusively breast-feed for at least 4 mths, use iron-fortified formula as a breast milk substitute, introduce iron-fortified infant cereals at 4-6 mths of age, delay introduction of cow's milk until 9-12 mths of age, and continue use of iron-fortified foods beyond one year of age (Canadian Pediatric Society (CPS) Nutrition Committee, 1979 & 1991; CPS, Dietitians of Canada and Health Canada, 1998). Actual infant feeding practices in Canada are now more reflective of infant feeding recommendations than the practices reported 30 years ago (Health and Welfare Canada, 1993, Health and Welfare

Canada, 1991; MacNally et al., 1985; Tanaka et al., 1987; Williams et al., 1996; Kwavnick et al., 1999). Despite the availability of iron-fortified infant foods and an overall improvement in feeding practices among Canadian infants, high rates of IDA continue to occur among vulnerable subgroups of infants. Clearly, the strategies currently being used in Canada to prevent IDA are not effective among subgroups of infants. There is a lack of information on which to base dietary recommendations for the prevention of IDA in infancy (Oski, 1993). For example, the Canadian Recommended Nutrient Intake (RNI) for iron is based on the theoretical estimated need for iron and does not take into consideration infant diets that may be low in heme iron or of low iron bioavailability. Although the primary strategy for the prevention of IDA among breast-fed infants is the introduction of iron-fortified infant cereals at 4-6 mths of age, cross-sectional studies of actual cereal intakes among infants suggest that this recommendation may not be efficacious (Zlotkin et al., 1981; Gerber Infant Nutrition Survey, 1989). Studies are needed to develop and investigate alternative strategies aimed at the prevention of IDA among infants from disadvantaged families, Chinese ancestries, aboriginal communities, and those breast-fed beyond 3-6 mths of age. Current data on dietary intakes, sources of iron and other factors influencing iron absorption for infants in Canada throughout the weaning period, however, is lacking. Traditionally, studies that have assessed iron nutrition in infancy have relied on dietary records and 24-hr recalls. Research in infant nutrition has been hampered by a lack of published studies with parents of infants which have validated dietary assessment tools, such as food frequency questionnaires (FFQs) that pose less respondent burden and cost than diet records and 24-hr recalls. FFQs for assessing iron intake have been developed and validated for use with adults (Willett, 1989), but studies on the validation of a FFQ for assessing iron nutrition during infancy and throughout the weaning period have not been published. Further advances in the prevention of IDA in infants might be achieved with instruments, such as an FFQ, that provides a rapid and easily administered means of assessing the dietary intakes and sources of iron and inhibitors and enhancers of iron absorption.

Further advances in the prevention of IDA in infancy might also be achieved by improvements in strategies for early detection. Infants in Canada with IDA are currently identified using a case-finding approach, whereby routine blood work including a complete blood count (CBC) is done, either if IDA is suspected or if the infant is being investigated for reasons unrelated to IDA. In cases where abnormal red blood cells (RBC) indicative of anemia are found, the diagnosis of iron deficiency may be confirmed with investigation of serum ferritin, or by noting a positive response to iron therapy (Canadian Task Force for Periodic Health Examination, 1994). The invasiveness and unacceptability of a blood test for parents of the otherwise healthy infant have been documented

(Mills, 1990; James et al., 1997). The Canadian Task Force for Periodic Health Examination (1994) concluded that there is insufficient evidence to recommend screening normal infants for IDA with a blood test. The idea of a first stage dietary screening tool to assess the diets of infants likely to be at risk for IDA to determine the need for a 2nd stage screening with a blood test is a possible alternate strategy. Although the Canadian Task Force for Periodic Health Examination has recommended this since 1994, only 2 studies have evaluated the use of a dietary screening tool for predicting the risk of IDA in infancy (Boutry & Needlman, 1996; Bogen et al., 2000). No standardized dietary instruments for assessing the diets of Caucasian or Chinese infants for iron nutrition, or predicting risk of poor iron status are as yet available. Further, specific dietary factors that can be used in a practical dietary based screening tool to predict poor iron status in Caucasian and Chinese infants have not been published.

Advances in the laboratory assessment of iron status in infancy might also achieve further improvements in strategies for early detection of IDA. Previous studies with adults (Skikne et al., 1990; Heubers et al., 1990; Kohgo et al., 1987; Ferguson et al., 1992), pregnant women (Carriaga et al., 1991) and children (Punnonen et al., 1994) suggest the potential value of measures of the soluble transferrin receptor (sTfR) for identifying infants with early iron deficiency erythropoiesis (IDE). sTfR may be particularly valuable for both diagnostic and screening purposes because, unlike ferritin and other laboratory indices of iron status, sTfR is not falsely elevated by infection (Ferguson et al., 1992; Punnonen et al., 1994; Pettersson et al., 1994; Thorstensen & Ramsio, 1993), and requires a small sample size (10 μL). Information on the use of sTfR for assessing iron status in infancy, however, is limited (Virtanen et al., 1999; Yeung & Zlotkin, 1997; Lönnerdal & Hernell, 1994; Kuiper-Kramer et al., 1998). Yeung & Zlotkin (1997) have provided valuable data on sTfR concentrations in infants 9 to 15 mths of age, and established reference standards based on an assay system calibrated against cellular TfR. Information on sTfR in infants older than 15 mths of age, and using a more recently available assay system based on natural plasma sTfR, however, have not been published.

1.2 Purpose of Study

The overall purpose of this cross-sectional study was to determine whether dietary assessment instruments could be used to categorize infants as having normal or poor (i.e. low iron stores or iron deficiency anemia) iron status. Dietary assessment instruments were developed and used to assess the feeding histories and the dietary intakes and sources of energy, iron, and other factors influencing iron absorption of infants aged 8 to 26 mths from Chinese and Caucasian ancestries in Vancouver. The iron status of this group of infants was determined by hematological and biochemical indices of iron status, and related to their retrospective assessment of feeding history, concurrent measures of dietary intakes, and socio-cultural background. This information was then used to make recommendations for strategies for secondary and primary prevention of iron deficiency anemia.

1.3 Study Objectives

The objectives of this study were:

1. To use a 3-day Food Record (3d-FR), food frequency questionnaire (FFQ) and FFQ Analysis Database to determine the dietary sources and intakes of energy, iron (total, heme and non-heme) and major dietary factors likely to affect iron absorption in infants aged 8-26 mths from Caucasian and Chinese ancestries in Vancouver, B.C.

2. To use a Socio-Cultural and Infant Feeding Questionnaire to determine infant feeding histories in infants 8-26 mths of age from Caucasian and Chinese ancestries in Vancouver, B.C.

3. To determine iron status among infants aged 8-26 mths from Chinese and Caucasian ancestries for whom dietary data were collected by concurrent measures of hematological (hemoglobin) and biochemical (serum ferritin, soluble transferrin receptor (sTfR) and sTfR:ferritin) indices of iron status.

4. To explore the relations between iron status of infants classified as having iron deficiency anemia, low iron stores or normal iron status and infant feeding histories, dietary sources and intakes of energy, iron (total, heme and non-heme) and major dietary factors likely to affect iron absorption, and socio-cultural background.

5. To determine which dietary variables as assessed by the Socio-Cultural and Infant Feeding Questionnaire, 3d-FR and FFQ were the best predictors of poor iron status (IDA or low iron stores) among infants aged 8-26 mths from Caucasian and Chinese ancestries.

6. To explore the relation between biochemical indices of iron status (Hgb, serum ferritin, sTfR and sTfR:ferritin) and measures of iron (total and heme) intake in infants aged 8-26 mths from Chinese and Caucasian ancestries.

7. To explore the validity of a FFQ for assessing iron nutrition among Chinese and Caucasian infants aged 8-26 mths by comparison with a 3d-FR and biochemical indices of iron status.

8. To determine the distribution of sTfR and sTfR:ferritin concentrations and the utility of the sTfR as a measure for detecting iron deficiency anemia and low iron stores in infants aged 8-26 mths.

1.4 STUDY HYPOTHESES

For the purpose of this research the null hypotheses were:

1. There is no difference in the prevalence of iron deficiency anemia and low iron stores between infants 8-12 or 13-26 mths of age in Vancouver of Caucasian compared with Chinese ancestry.

2. Dietary assessment using a Socio-Cultural and Infant Feeding Questionnaire will find no difference in the feeding histories (i.e. the duration of breast-feeding, age of introduction of cows' milk, feeding with iron-fortified infant formula, or use of iron supplements, and age of introduction or duration of feeding of iron-fortified infant cereal or meats) among infants with normal iron status and poor iron status at 8-12 or 13-26 mths of age.

3. Dietary assessment using a food frequency questionnaire (FFQ) will find no difference in the intakes of meat, poultry and fish (MPF), mixed dishes with MPF, iron-fortified infant formula or iron-fortified infant cereal, cows' milk and milk products, soy-based products or regular infant formula among infants with normal iron status and poor iron status at 8-12 or 13-26 mths of age.

4. Dietary assessment using a 3d-FR will find no difference in the intakes of iron (total, heme or non-heme), energy, vitamin C, calcium, or fibre from non-milk foods among infants with poor iron status and infants with normal iron status.

5. Dietary assessment using a Socio-Cultural and Infant Feeding Questionnaire will find no difference in the feeding histories (i.e. the duration of breast-feeding, age of introduction of cows' milk, feeding with iron-fortified infant formula, or use of iron supplements, and age of introduction or duration of feeding of iron-fortified infant cereal or meats) between infants of Caucasian and Chinese ancestry at 8-12 or 13-26 mths of age.

6. Dietary assessment using a FFQ will find no difference in the intakes of MPF, mixed dishes with MPF, iron-fortified infant formula, iron-fortified infant cereal, cows' milk and milk products, soy-based products or regular infant formula between infants of Caucasian and Chinese ancestry at 8-12 or 13-26 mths of age.

7. Dietary assessment using a 3d-FR will find no difference in the intakes of iron (total, heme or non-heme), energy, vitamin C, calcium, or fibre from non-milk foods between infants of Caucasian and Chinese ancestry at 8-12 or 13-26 mths of age.

8. Dietary assessment using a FFQ will find no relation between the intakes of total or heme iron and the biochemical indices of iron status, serum ferritin, sTfR and sTfR:ferritin, among infants 8-26 mths of age.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The present study was designed to investigate whether dietary assessment could be used to identify infants with poor iron status. Numerous studies have identified dietary risk factors for poor iron status in infancy (e.g. Pizarro et al., 1991; Innis et al., 1997; Greene-Finestone et al., 1991; Requejo et al., 1999; Mira et al., 1996). The value of dietary assessment instruments to predict the risk of poor iron status in Caucasian and Chinese infants, however, has not been investigated. Dietary assessment instruments able to measure the intake of iron and other dietary factors influencing iron absorption and to predict risk of poor iron status could have considerable value for further advances in research in iron nutrition and prevention of iron deficiency anemia (IDA) in infancy. If the dietary patterns associated with poor iron status among Caucasian and Chinese infants can be identified, then initiatives both to detect infants with these patterns, and to modify the feeding practices associated with risk can be applied in strategies for primary and secondary prevention.

The following literature review provides a background on the continuing problem of IDA among certain vulnerable subgroups of infants in developed countries, and the implications of poor iron status on infant health and development. Iron balance in infancy is examined in detail in relation to the changes that occur in the functional, transport and storage iron compartments from normal iron status to the development of IDA, and to the dietary and non-dietary determinants of iron balance. To better understand the potential use of dietary factors to identify infants at risk for IDA, the studies that have examined the amount and bioavailability of iron provided by the primary milk feedings and complementary foods, and the relations between characteristics of the diet in infancy and risk for poor iron status are reviewed in detail. The final section of this literature review examines the effectiveness of current strategies aimed at prevention of IDA among infants in Canada, and identifies the potential value of dietary assessment instruments to improve prevention of IDA and research in the area of iron nutrition in infancy.

2.2 The Importance of Iron in Human Nutrition

IDA is the most prevalent single micronutrient deficiency among infants worldwide (deMaeyer et al., 1985; Scrimshaw, 1991; United Nations, 1989). Because IDA has the potential to impair infant health and development, it is of considerable public health importance. The national prevalence of IDA in infants in Canada is unknown. Numerous studies, however, have shown that IDA is a substantial problem among specific infant populations, including infants from families of low socio-economic status (SES) (Lehmann et al., 1992), Chinese ancestries (Chan-Yip & Gray-Donald, 1987) and aboriginal communities (Moffatt et al., 1991; Cruz et al., 1990; Whalen et al., 1997; Sawchuket et al., 1996; Willows et al., 2000), as well as infants breast-fed over 3-6 mths of age not given supplemental iron (Innis et al., 1997; Siimes et al., 1984; Calvo et al., 1992; Pizarro et al., 1991). The risk of IDA is especially high during the latter half of the first year and into the 2nd year of life because the dietary iron intake may be inadequate to meet the high needs for growth and red blood cell (RBC) synthesis (Dallman, 1986).

Iron is an essential nutrient that is vital to the maintenance of normal physiological function. Iron is a component of, or cofactor for hundreds of proteins and enzymes (Beard et al., 1996), and as a result, iron deficiency affects many metabolic and enzymatic processes including oxygen transport, oxidative metabolism and cellular growth (Bothwell, 1995; Lynch, 1997). A deficiency of iron is of particular concern in infancy because in addition to the effects of the anemia, iron deficiency in infants is associated with a cascade of nonhematologic consequences, some of which may have a detrimental and irreversible impact on the central nervous system (CNS) (Dallman et al., 1978).

An adequate supply of iron is particularly critical during the period of development spanning the 2nd trimester of gestation to 18-24 mths of age. During this period, growth and CNS development (including brain growth, dendritic aborization and myelination) occur at more rapid rates than any other time in life (Dobbing, 1990). A deficiency of iron during this critical period of development places the infant at risk for impaired developmental outcomes (Lozoff et al., 1982, 1987, 1996; Walter et al., 1983, 1989; Grindulis et al., 1986; Moffatt et al., 1994; Williams et al., 1999) and educational performance (Palti et al., 1985; Watkins & Pollitt, 1990; Lozoff et al., 1991; Hurtado et al., 1999). All 7 of the available studies that included careful definitions of iron status and appropriate comparison groups reported that infants with IDA scored lower on tests of mental development before treatment when compared with iron replete age matched controls (Lozoff et al., 1982, 1987, 1996; Walter et al., 1983, 1989;

Idjradinata & Pollitt, 1993; Grindulis et al., 1986). Five of the latter studies also reported lower scores on tests of motor development (Lozoff et al., 1982, 1987; Walter et al., 1983; Idjradinata & Pollitt, 1993; Grindulis et al., 1986). Studies that have assessed infant behavior have reported that infants with IDA present with wariness, hesitancy, tiredness, inattentiveness, decreased activity and general lack of involvement with testing stimuli (Walter et al., 1983, 1989; Lozoff et al., 1996 & 1998). It is possible that the association between IDA and lower developmental test scores may be due to other coexisting factors, such as poor social and economic conditions, or other co-existing nutrient deficiencies or toxicities. Nonetheless, it is highly plausible that a deficiency of iron could delay both mental and motor development because iron plays many roles in CNS function. These involve the role of iron in dopamine metabolism (Nelson et al., 1997; Ashkenazi et al., 1982), and in synthesis of lipid components of the myelin sheaths (Connor & Menzies, 1996). Further, a brief period of severe IDA in the young, but not the adult rat has been reported to result in deficits in brain iron and learning capacity that were not corrected by iron therapy (Yehuda & Youdim, 1989; Erikson et al., 1997). Felt & Lozoff (1996) demonstrated that these effects were more pronounced in neonatal rats who developed iron deficiency in the suckling period than in the fetal period. Moreover, randomized controlled trials have demonstrated that iron supplementation with iron-fortified infant formula in place of unmodified cows' milk can prevent IDA and its associated declines in psychomotor development in the 2nd half of the first year of life (Moffatt et al., 1994; Williams et al., 1999). Evidence from epidemiological and experimental studies, however, suggests that IDA is frequently only one of many important, often co-existing factors that may result in impaired infant development.

Despite the possible confounding by socio-environmental factors, such as the family environment, information from all (Lozoff et al., 1989 & 1996; Grindulis et al., 1986; Walter et al., 1983 & 1989) except one study (Idjradinata & Pollitt, 1993) have provided evidence that treatment of IDA in infancy does not fully reverse the delays in cognitive development, i.e. language acquisition and abstract thinking. The study of Idjradinata & Pollitt (1993) found that supplementation of 13-14 mth old Indonesian infants with a hemoglobin (Hgb) of <105 g/L with 3 mg ferrous sulfate/day for 3 mths both reversed the anemia and low developmental test scores. Both Costa Rica and Chile have relatively high standards of living and are more developed than Indonesia. Thus, the infants studied by Lozoff et al. (1996) in Costa Rica and Walter et al. (1989) in Chile were probably from higher SES family backgrounds than the infants studied by Idjradinata & Pollitt (1993) in Indonesia. Further, the infants studied by Idjradinata & Pollitt (1993) had lower pretreatment scores relative to the nonanemic infants than the infants in the

2 former studies, and therefore, may have been more vulnerable to the nonhematological consequences of the IDA and had more room for improvement. While the study by Idjradinata & Pollitt (1993) suggests that the identification and treatment of anemia in infancy may be effective for preventing of the potential detrimental long-term consequences of IDA in some infants if the anemia is corrected early and is of relatively short duration, other studies suggest that detection and treatment of IDA may not be effective in all infants or under all circumstances (Lozoff et al., 1989 & 1996; Grindulis et al., 1986; Walter et al., 1983 & 1989). Lozoff et al. (1996) reported that lower mental developmental test scores in infants 12-23 mths of age with IDA persisted despite correction of the anemia. Consistent with the findings of Lozoff et al. (1996), long-term follow up studies of children treated for IDA as infants found lower test scores in mental and motor assessments up to 5-10 years later when compared with children without a history of IDA, even after adjustment for covariates (Palti et al., 1985; Watkins & Pollitt, 1990; Lozoff et al., 1991; Hurtado et al., 1999). However, the possibility cannot be discounted that differences in other environmental factors not measured or controlled for by these epidemiological and quasi-experimental studies, such as the family environment and parenting, may have accounted for the associations between anemia in infancy and learning deficits later in life.

IDA in infancy may also have deleterious effects on growth. The available evidence shows that infants with severe IDA have impaired growth, and that correction of the anemia through supplementation can result in increased growth (Auckett et al., 1986; Briend et al., 1990; Chowang et al., 1988; Latham et al., 1990). The etiology of the effect of iron deficiency on growth is not clear, but may involve the essential role iron plays in DNA synthesis, or alterations in eating behavior due to the malnutrition (Levitsky & Strupp, 1995) and behavioral disturbances (Walter et al., 1983, 1989; Lozoff et al., 1996; Lozoff et al., 1998) associated with IDA.

Walter et al. (1997) have reviewed evidence that iron deficiency may both improve and impair immune capacity and resistance to infections. Prophylactic iron has been found to increase the risk of infection in areas of the world where there is poor sanitation and disadvantaged living conditions (Murray et al., 1975a&b, 1978). The etiology of the relationship between impaired immunity and IDA is not clear, but infants with iron deficiency have been shown to have decreased levels of interleukin-2 production, which may impair cell-mediated immunity (Galan et al., 1992; Thibault et al., 1993). Evidence suggests that under usual circumstances, however, iron fortification of foods and oral iron therapy are not associated with infection, and that adequate iron status may be beneficial to immunity (Walter et al., 1997). Further research is required to clearly elucidate the relationship between iron and

infection.

Iron deficiency has also been shown to be associated with many other functional and clinical abnormalities. These include a decrease in physical work and exercise capacity in both animals and humans (Baynes & Bothwell, 1990; Beard et al., 1990; Dodd, 1992) and impaired thermoregulation, which is thought to be mediated through the role iron plays in thyroid hormone production (Beard et al., 1990; Beard et al., 1989; Finch & Cook, 1984). A number of studies have suggested that iron deficiency may be associated with abnormalities in gastrointestinal (GI) function, contributing to such conditions as stomatitis, glossitis, hypochlorhydria, malabsorptive syndromes and GI bleeding (Baynes & Bothwell, 1990; Vyas & Chandra, 1984). Other, less specific symptoms have also been shown to result from iron deficiency including fatigue, reduced appetite, knoilonychia (spoon shaped nails) and pica (Gibson, 1990). Although it is not clear whether these conditions cause or are the result of iron deficiency, most of these systemic consequences are reversible by treatment of the iron deficiency.

It is unclear how much of the association between IDA and abnormal infant behavior, growth, immunity and development is attributable to factors which are often associated with iron deficiency, such as overall poor nutrition and socio-environmental factors. Despite the lack of definitive evidence implicating iron as the causal factor, IDA in infancy is an important risk marker for poor developmental outcome (Lozoff et al., 1996; Pollitt, 1999). Iron deficiency in infancy and early childhood is clearly an important public health problem with the potential to compromise the healthy development of substantial numbers of infants and children.

2.3 Iron Compounds in the Body: Chemical Properties, Distribution and Metabolic Function

Although it is possible for iron to exist in oxidative states ranging from $^{-}2$ to $^{+}6$, iron exists only in the ferrous (Fe^{2+}), ferric (Fe^{3+}), and ferryl (Fe^{4+}) states in biologic systems. This ability to exist in multiple oxidative states allows iron to transfer electrons, reversibly bind biologic ligands and, as such, participate in a number of useful biochemical reactions (Beard et al., 1996). Iron containing compounds in the body can be categorized as: 1) functional iron compounds, 2) iron transport proteins, and 3) iron storage proteins. Functional or essential iron compounds are compounds known to serve a physiologic, metabolic or enzymatic function. Iron transport proteins are responsible for intracellular iron transport. Iron storage proteins play a critical role in the body as regulators of iron homeostasis, and as a reserve for functional iron needs (Cook & Skikne, 1989; Dallman, 1986). The distribution

of iron containing compounds is summarized in **Table 2.1**.

Table 2.1. Distribution of iron in the body.

Protein	Tissue site	Iron content (mg)			
		70 Kg man[1]	%	10 Kg infant [2,3]	%
Functional compartment					
Hemoglobin	RBC	2100-3000	67	280-320	60-70
Myoglobin	Muscle	350-400	9	30-50	7
Cytochromes, other heme and iron sulfur proteins	All tissues	50	1	20	4
Transport compartment					
Transferrin	Plasma and extravascular fluid	5	<1	5	1
Storage compartment					
Ferritin and hemosiderin	Liver, spleen, and bone marrow	0-1000	0-40	50-100	13-26
Total body iron		2505-4455		385-495	

Adapted from [1]Worwood M (1997), [2]Oski F (1989) and [3]Dallman P (1989).

2.3.1 Functional Iron Compounds

Functional iron compounds consist mainly of heme iron proteins (e.g. Hgb, myoglobin and cytochromes) and heme containing enzymes (e.g. tryptophan pyrrolase). There are also some essential non-heme containing enzymes that either contain iron (e.g. succinic dehydrogenase) or require it as a cofactor (e.g. ribonucleotide reductase) (Dallman, 1986; Bothwell, 1995). As an integral component or essential cofactor of heme and non-heme containing enzymes, iron plays a critical role in important pathways such as DNA synthesis, mitochondrial electron transport, catecholamine metabolism, neurotransmitter levels and lipid metabolism (Larkin & Roa, 1990). A reduction in essential metabolic pathways involving iron during critical periods of development may explain why some of the effects of iron deficiency on the developing brain are not fully reversible, even when the anemia is corrected.

Iron serves its essential functions in the body primarily as a component of heme. Heme is a cyclic tetrapyrrole that contains iron atoms in the Fe^{2+} state. Each heme molecule is bound to a polypeptide chain (globin) through a co-ordination bond of the Fe^{2+} atom. It is the ability of the Fe^{2+} in heme to readily associate and dissociate with oxygen, CO^2 and electrons that enables the functional iron compounds to serve their essential roles (Dallman, 1986).

Circulating Hgb accounts for 65% of total body iron and functions to transport oxygen from the lungs to the tissues. Hgb, a 65-kDa oligomeric protein found in the RBC, contains 4 globin chains and 4 heme prosthetic groups. Myoglobin accounts for 5-10% of total body iron and functions to store iron for use during muscle contraction. Myoglobin is a single 17-kDa heme containing polypeptide chain found in the cytoplasm. The remainder of the functional iron present in the body, representing <1% of total body iron, is in the form of heme and non-heme containing enzymes. Cytochromes are heme containing enzymes located primarily in the mitochondria of aerobic cells, and are responsible for production of cellular energy as adenosine triphosphate (ATP) in the electron transport chain (Dallman, 1986). Ribonucleotide reductase (required for DNA synthesis and cell differentiation) and phosphoenol-pyruvate carboxykinase (required for gluconeogenesis) are examples of iron-dependent enzymes that do not contain iron but require iron as a cofactor or activator (Dallman, 1986; Sherwood et al., 1998). Iron is also incorporated into non-heme containing enzymes, including iron-sulfur proteins and metalloflavoproteins (e.g. succinic dehydrogenase), which are also involved in oxidative metabolism (Dallman, 1986).

2.3.2 Iron Transport Proteins

Iron transport proteins include transferrin and lactoferrin. Transferrin is a 78-kDa single-chain (-1 globulin containing 2 binding sites for Fe^{3+}. Although transferrin accounts for <1% of total body iron, it is the primary protein responsible for extracellular iron transport (Beard et al., 1996). Transferrin is able to bind iron and transfer it from storage to wherever it is required in the body (Cook et al., 1974). Transferrin can exist in a mono-ferric, di-ferric or apotransferrin form depending on the number of molecules of Fe^{3+} bound. Transferrin is synthesized by the liver at a rate that is inversely proportional to the body's iron status (Sherwood et al., 1998). The primary role of transferrin is to deliver iron to the bone marrow where it is taken up for use in Hgb synthesis through receptors present on the erythropoieitc cell surface (Beard et al., 1996). In conditions of increased RBC production, such as hypoferrinemia, or when transferrin is more saturated with Fe^{3+}, the rate of iron delivery to the cells is increased

(Dallman, 1986).

Lactoferrin is an 80-kDa iron transport glycoprotein that is secreted from activated neutrophils and some glandular epithelial tissues. It is found in human milk, plasma and mucous secretions such as tears. It is thought to participate in the defense of the breast-fed infant against infection. Lactoferrin deprives bacteria of the iron needed for growth and donates iron to generate reactive oxygen radicals to enhance the microbicidal mechanism of phagocytes through its ability to sequester 2 atoms of Fe^{3+} per molecule. However, the role of lactoferrin in iron transport remains unclear (Beard et al., 1996).

2.3.3 Iron Storage Proteins

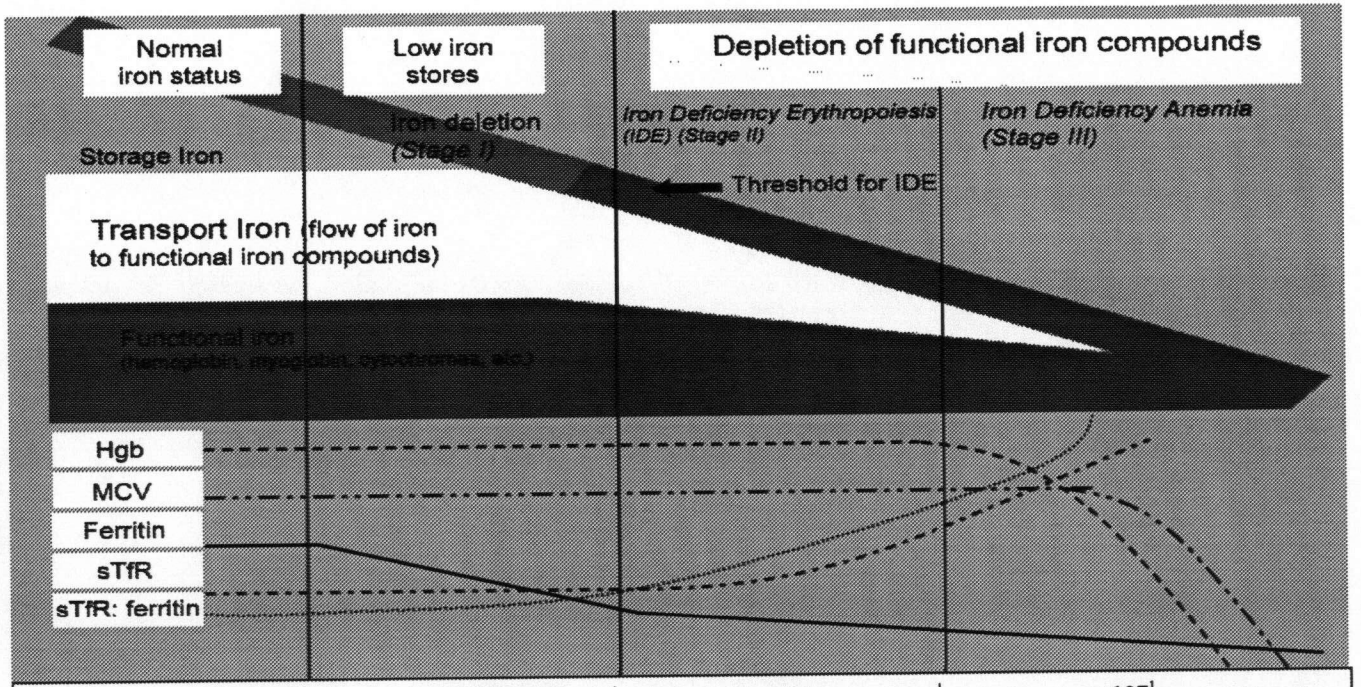
Ferritin, the primary iron storage protein, is found in the cytosol of the reticuloendothelial cells of the liver, bone marrow and spleen. The ferritin molecule consists of a 46-kDa spherical cluster of 24 polypeptide chains that surround a colloidal core, containing variable amounts (up to 4500 atoms) of iron (Beard et al., 1996; Dallman et al., 1986). Serum ferritin values have been shown to correlate significantly with total body iron stores (Cook et al., 1974). A secondary form of storage iron, hemosiderin, is found in lysosomes of Kupffer cells in the liver. Hemosiderin is formed when the ferritin molecule becomes saturated with iron and subsequently is degraded by lysosomal proteases, thus, representing ferritin in various stages of degradation. Compared to ferritin, the iron stored in hemosiderin is less chemically active and consequently not as easily mobilized from storage (Beard et al., 1996). Storage iron can vary from <5% to >30% of total body iron, depending on age, sex, weight, iron losses and previous iron nutrition. This extreme intra-individual variation in storage iron can occur without apparent impairment in body function (Dallman, 1989). In infancy, the level of storage iron is relatively low and has been estimated to be approximately 10 mg/Kg (Oski, 1989), representing about 10-20% of total body iron.

2.4 Laboratory Assessment of Iron Status among Infants

The natural history of iron deficiency is fairly well understood and involves 3 characteristic stages (Dallman et al., 1980; Cook et al., 1992; Bothwell et al., 1979; Suominen et al., 1998) **(Figure 2.1)**. Each stage reflects iron status defined in relation to the amount of iron contained in the storage, transport and functional compartments. IDA in infancy is often asymptomatic and diagnosis depends on the use of appropriate laboratory

indices of iron status. The laboratory indices used to reflect iron status may be grouped by body iron compartment. Hgb, other RBC indices, erythrocyte protoporphyrin and transferrin receptor (TfR) concentration all reflect the functional iron compartment. The tissue iron supply can be measured by serum iron, TIBC and transferrin saturation. Serum ferritin, quantitative phlebotomy and live and bone marrow tissue biopsies can be used to measure the storage iron compartment.

When the dietary intake of iron is inadequate to meet requirements, storage iron is mobilized for Hgb synthesis. This continues until the iron storage compartment becomes diminished. This depletion of storage iron commonly referred to as iron deficiency or low iron stores is reflected by a progressive decrease in serum ferritin **(Figure 2.1)**. Although indicative of risk for a deficit in functional iron and IDA, low iron stores is not, by itself, known to be associated with any functional or physiological consequences (Dallman et al., 1980). At this stage of iron depletion, all biochemical and hematological indices of iron status, except serum ferritin are normal **(Figure 2.1)**. The 2nd stage, referred to as iron deficiency erythropoiesis (IDE), is characterised by a depletion of iron stores to the point where the levels of circulating transport iron (transferrin) are decreased. During early IDE, the only indicator is an elevated TfR concentration (Suominen et al., 1998). At this stage, due to the impairment in transport iron, the iron supplied to the erythropoietic cells is reduced. Eventually, the serum iron and the saturation of transferrin, as measured by total iron binding capacity (TIBC) become decreased. Finally in the last stage, the decrease in transport iron restricts the synthesis of Hgb and anemia develops. IDA is characterised by a declining Hgb concentration and eventually microcytic (low mean cell volume), hypochromic (low mean cell Hgb) RBCs. This is accompanied by exhausted iron stores (low serum ferritin), elevated TfR levels and decreased levels of circulating iron, as in the earlier stages of low iron stores and IDE. Individuals can be categorised according to iron status through results of blood testing to reflect the 3 distinct stages in the development of iron deficiency **(Figure 2.1)**.



High (g/L)	107-1384[1]	normal	normal	<107[1] <110[2] 67[1]
MCV (fL)	67-88[2]	normal	normal	<70[2]
Ferritin (µg/L)	7-142[3]	<8 - <12	<8 - <12	<8 - <12
sTfR (mg/L)	3.0-6.55[4] 4.5-11.1[5]	normal	>6.55	>6.55
sTfR:ferritin	4.5-8.0[4] 9.4-1059[5]	normal	>8.0	>8.0

Figure 2.1. Characteristic stages in the development of iron deficiency anemia, schematic changes in selected indices of iron status and typical laboratory profile in infants.
Adapted from Dallman et al., 1980; Suominen et al., 1998; [1]NHANES II; [2]American Academy of Pediatrics; [3]Siimes et al., 1974; [4]Yeung & Zlotkin, 1997 (9-15 mths); [5]Virtanen et al., 1999 (sTfR:log ferritin).

2.4.1 Hemoglobin and Red Cell Indices

A complete blood count (CBC) provides valuable information on RBC numbers and size and the concentration of Hgb. A CBC can provide a convenient, low cost addition to diagnostic measures for iron deficiency. A decreased mean RBC volume (MCV) and Hgb concentration (MCH) reflects a decrease in the supply of iron to the bone marrow and a decrease in Hgb synthesis. However, it can take several weeks before enough microcytic cells are released from the bone marrow to alter the MCV. The RBC distribution width (RDW) is an index of the variation in the size of the RBC that increases early in the course of iron deficiency (Dallman et al., 1996). The RDW is valuable for diagnostic and screening purposes because it is increased in IDA, but not in anemias of chronic disease, and is readily available as part of the routine CBC. However, the use of RDW for screening purposes is limited as there are no clear cut-off values that can be used because results vary according to the instrument used in the analysis (Dallman et al., 1996).

Hgb is the only measure that can be used to assess the severity of the anemia, and a 10 g/L rise in Hgb after one month of a therapeutic dose of iron confirms a diagnosis of iron deficiency. Hgb concentrations have a low intra-individual variation (<5%), but show wide inter-individual variability within the physiologically normal range (Cook & Finch, 1979). Although RBC indices such as Hgb are a sensitive indicator of anemia, they lack specificity to iron deficiency and sensitivity to early deficits in functional iron (Woerner, 1988). Considering the potential consequences of IDA in infancy, screening with measures that reflect earlier stages of iron deficiency is important (Simeon & Grantham-McGregor, 1990).

Developmental changes in Hgb concentration have been reviewed by Yip (1994). At birth, the mean Hgb concentration is approximately 165 g/L, and is higher than any other period in life (Saarinen & Siimes, 1978). This initial high postnatal Hgb concentration is actually a fetal adaptation to the hypoxic environment in the uterus (Dallman, 1989). After birth, Hgb levels decrease progressively until initiation of erythropoiesis at about 2 mths of age. Upon the initiation of erythropoiesis and until about 6 mths of age, there is a gradual rise in Hgb. From about 6 to 12 mths of age, Hgb tends to plateau at a mean of 115 g/L (95% Confidence Interval (CI): 105-125 g/L) (Dallman, 1989). Emond et al. (1995) found a mean Hgb concentration of 117 g/L (95% CI: 97-136) among a randomly selected sample of 8 mth old British infants. When followed into the 2nd year of life, these infants had a mean Hgb concentration of 118 (95% CI: 100-134) and 117 g/L (95% CI: 102-130) at 12 and 18 mths of age, respectively (Sherriff et al., 1999).

2.4.2 Erythrocyte Protoporphyrin

The concentration of erythrocyte protoporphyrin (EP) increases in iron deficiency. Its use as a parameter for defining iron status is advantageous in pediatrics because it requires a small amount of blood, and is simple to measure, rapid and reproducible. However, EP is also increased in anemia of chronic disease (Worwood, 1997).

2.4.3 Transferrin Receptor

The TfR is measure of functional iron that offers a number of advantages over other laboratory measures currently used to determine iron status. Circulating levels of the soluble TfR (sTfR), a truncated form of the membrane-associated TfR, are proportional to the number of TfR on immature red cells, and thus, the rate of bone marrow erythropoiesis (Kohgo et al., 1986; Skikne et al., 1990). Expression of TfR is increased in cells where there is increased iron need and proliferation, e.g. RBC precursors and the developing placenta (Beguin et al., 1988; Baynes et al., 1994; Baynes & Cook, 1996). TfR is a transmembrane glycoprotein composed of 2 identical 95-kDa subunits linked by 2 disulfide bridges which transfers transferrin-bound iron from the circulation into the cell. Iron is taken up through receptor-mediated endocytosis of the transferrin-TfR complex, then iron is released and the remaining apo-transferrin and TfR returned to the cell surface. The number of receptors expressed on the cell surface controls the uptake of iron from the plasma into the cell (Ahluwalia, 1998).

sTfR is particularly valuable in the diagnosis of IDA in conditions in which iron stores tend to be low, i.e. childhood, adolescence or pregnancy (Skikne, 1998). TfR is more sensitive than other markers of functional iron deficiency (Cook & Skikne, 1989; Skikne et al., 1990; Cook, 1999) and has a lower biological and analytical variability (Cooper & Zlotkin, 1996). Phlebotomy studies have shown that TfR values remain normal over a broad range of iron stores, and become elevated only when stores are depleted to the point that there is a deficit in tissue iron (Skikne et al., 1990; Baynes et al., 1994). Depending on the degree of the anemia, a 1.3 to 5.8-fold increase in serum/plasma TfR levels has been observed in studies of adults with iron deficiency (Kohgo et al., 1986; Thorstensen et al., 1991; Skikne et al., 1990; Ferguson et al., 1992). The measurement of sTfR in combination with Hgb is particularly valuable for the diagnosis of IDA because, unlike other laboratory indices of iron status, sTfR remains normal in anemia secondary to overt or subclinical infection or inflammation, a condition common in infancy and early childhood (Olivares et al., 1995; Ferguson et al., 1992; Punnonen et al., 1994; Pettersson et al., 1994; Thorstensen & Ramsio, 1993).

An elevated TfR, however, is not always specific to iron deficiency as a change in erythropoiesis will affect TfR concentrations. In hemolytic disorders, concentrations of TfR are increased 4 to 6-fold in proportion to the increase in RBC production (Huebers, 1990; Kohgo et al., 1987). Elevated TfR concentrations have been found in individuals with more severe cases of megaloblastic anemia, and with thalassemia due to ineffective erythropoieisis, in those living at higher altitudes (>1600 meters) (Allen et al., 1998), and in patients treated with erythropoietin (Ahluwalia, 1998). Mild to moderate undernutrition does not influence TfR concentrations (Kuvibidila et al., 1996), but the effect of severe protein deficiency on TfR is unknown. Low TfR concentrations (30-50% of normal) are seen in conditions involving inefficient erythropoiesis such as renal disease, aplastic anemia and post-transplantation anemia (Ahluwalia, 1998; Thorstensen & Romsio, 1993).

Although several studies have involved TfR (Lönnerdal & Hernell, 1994; Virtanen et al., 1999; Yeung & Zlotkin, 1997; Anttila et al., 1997) or sTfR (Choi et al., 1999; Persson et al., 1998), information on TfR, particularly the soluble form, sTfR, in infants and children is still limited. sTfR may be particularly valuable for assessing iron status in infants because only a small volume of plasma (10 (L) is needed for the assay. Since a high sTfR is reflective of compromised iron status prior to development of anemia, it also has potential value for screening (provided less costly commercial assays become available in the future). However, information to describe the use of sTfR for defining iron status among infants in clinical settings has not yet been published. Only one study has investigated age-related differences in sTfR from the neonatal period to adulthood (Choi et al., 1999), and consistent with studies that have employed assays measuring TfR, values for infants are consistently higher than that for adults (Virtanen et al., 1999; Yeung & Zlotkin, 1997). Currently available information on TfR levels in healthy infants is inconsistent. Virtanen et al. (1999) reported a mean TfR concentration of 7.8 mg/L (95% CI: 4.7-9.2) for 12 mth old infants. Yeung & Zlotkin (1997), on the other hand, found a considerably lower mean (±SD) plasma TfR concentrations of 4.4 ± 1.1 mg/L for 9-15 mth old infants. Similar low values have also been reported for sTfR by Choi et al. (1999) for 4-24 mth old infants (i.e. 4.5 ± 1.1 mg/L; 95% CI, 2.1-6.3), and by Persson et al. (1998) for 12 mth old infants (i.e. 3.8 ± 0.6 mg/L; range, 2.5-5.7). Virtanen et al. (1999) suggested that a high TfR concentration in infants and children is a response to physiologically low iron stores and, based on this, recommended age-specific reference ranges for TfR. Yeung & Zlotkin (1997), however, found no correlation between TfR concentrations and age in 9-15 mth old infants. Data on the concentrations of TfR among healthy infants over 15 mths of age have not been published, and few published data are as yet available on concentrations of the soluble form of TfR among

healthy infants at any age.

2.4.3 Serum Iron/TIBC and Transferrin Saturation

The tissue iron supply can be reflected by several measures including serum iron, TIBC and transferrin saturation (TS). Serum iron is positively correlated with iron stores, but is decreased in the anemia of chronic disease, inflammation, and infection, and increased with iron overload. Further, the concentration of serum iron alone provides little useful information due to considerable variation from hour to hour and day to day in normal individuals (approximately 30%). Serum iron, TIBC and TS decrease in both iron deficiency and inflammation, and thus are confounded in the same way as ferritin (Cook et al., 1993; Ferguson et al., 1992).

2.4.5 Tissue Concentrations

Liver and bone marrow tissue biopsies can be used to estimate the amount of iron, either visually, using the Prussian blue reaction on tissue sections, or chemically. In the past, a bone marrow biopsy or a therapeutic trial with iron were the only means to differentiate iron deficiency from other causes of anemia. Considering the invasive nature of a biopsy, however, this is an unacceptable option for confirming a diagnosis of iron deficiency in infancy. Magnetic resonance imaging (MRI) can be used to determine liver and heart iron concentrations in iron depletion, but MRI lacks the sensitivity required to distinguish minor differences in storage iron within the range of low iron stores to normal iron status (Worwood, 1997).

2.4.6 Quantitative Phlebotomy

Quantitative phlebotomy is a direct way to measure iron stores, but requires removal of up to 500 mL of blood/week until anemia develops. Although quantitative phlebotomy can be used to determine iron stores for research purposes, it would not be an ethical option for research with infants, or an acceptable way to determine iron stores in clinical situations.

2.4.7 Serum Ferritin

The utility of ferritin has been established for screening healthy individuals for a deficit in storage iron (Cook et al., 1974; Jacobs, 1977; Lipschitz et al., 1974), and for confirming iron deficiency in overtly anemic

patients (Ali et al., 1978). Serum ferritin is the only useful biochemical indicator of low iron stores (Baynes, 1996; Beaton et al., 1989), but a number of factors complicate its use. Although a ferritin value ≤12 μg/L is a highly specific indicator of iron deficiency (Ali et al., 1978), it gives no indication of the severity of the deficit in functional iron once the stores are nearly or completely exhausted (Cook & Skikne, 1989). Serum ferritin concentrations are significantly increased in iron overload and symptomatic patients with genetic hemochromotosis have values >700 (g/L (Sherwood et al., 1998). Marginal iron reserves are characteristic of infancy (Siimes et al., 1974); 5% of a large group of infants in the U.K. had serum ferritin values (16.8, 16.2 and 12.3 μg/L at 8, 12 and 18 mths of age, respectively (Sherriff et al., 1999). A wide intra-individual variability in ferritin values of about 24% has been reported (Cooper & Zlotkin, 1996), which makes concentrations close to the cut-off for low iron stores difficult to interpret. The use of ferritin as a screening or diagnostic test is also problematic because, as an acute phase reactant, ferritin may be elevated 3 to 5-fold in infants with infection, inflammation or other chronic disease, even if iron deficiency is present (Cook et al., 1993; Lipschitz et al., 1974). Iron stores at birth have been found to have a high correlation with iron stores at 6, 9 and 12 mths of age (Michaelson et al., 1995). However, it is not known whether low iron stores in the first year of life predicts risk for IDA in the 2nd year of life. Whether iron depletion in infancy results in functional abnormalities or not also remains to be determined.

No single laboratory measure can adequately categorize an individual's iron status, thus a combination of measures that reflect the functional, transport and storage iron compartments must be used simultaneously to give the best picture of true iron status. Based on the available information, it seems likely that assessing sTfR in combination with serum ferritin and Hgb will facilitate characterization of iron status, from normal iron status in infancy through low iron stores and IDE to IDA. While serum ferritin is the best measure for establishing the size of the storage iron compartment, sTfR is the single best measure of the functional iron compartment (Baynes, 1996). Thus, in infancy the utility of sTfR as a diagnostic index for iron deficiency is improved when used in combination with serum ferritin. Other measures, including MCV, RDW and EP are less sensitive and predictable, and provide later indicators of the functional compartment depletion than sTfR (Baynes, 1996). Measures of Hgb provide an assessment of the severity of the iron deficiency, when evaluated along with measures of serum ferritin and sTfR. Although sTfR may be elevated due to conditions other than iron deficiency, ferritin as an acute phase protein, is within the reference interval or increased (Skikne, 1998). The measurement of both sTfR and ferritin, and calculation of the ratio of sTfR to ferritin concentration (sTfR:ferritin) is particularly valuable for assessing iron

status because it defines iron status over a wide range from normal iron stores to tissue iron deficiency, even in difficult situations such as rapid growth and inflammation (Cook et al., 1994; Baynes, 1996).

2.5 Iron Homeostasis and Iron Balance during Infancy

A highly efficient recycling system functions to conserve body iron. Iron is taken up from the circulation via transferrin and recirculated to iron-requiring tissues via specific receptors called TfR. The recycled iron is provided primarily by the breakdown of Hgb from the erythroid marrow, or from ferritin or hemosiderin from reticuloendothelial cells or hepatocytes. The iron accumulated during a normal full-term gestation is adequate to provide the iron needed for growth and to replace iron losses for at least the first 4 mths after birth in the breast-fed infant. Iron needs in the first 4 mths after birth are met by the mobilization of iron stores, redistribution of iron, recirculation of iron from the destruction of fetal Hgb, and the contribution of breast milk iron. After about 4 mths of age, however, the iron stores become depleted and the infant becomes dependent on an adequate supply of dietary iron to maintain iron balance (Dallman et al., 1980; Oski, 1989 & 1993).

The exogenous and endogenous determinants of iron balance during infancy are illustrated in **Figure 2.2**. Unlike most other nutrients, iron balance is regulated primarily by variations in iron absorption, rather than excretion. The individual's iron status and the iron supply from the diet and any iron-containing supplements are the primary determinants of the amount of iron actually absorbed by the gut. The infant's endowment of iron at birth, growth rate and loss of iron, all of which vary considerably from infant to infant, determine the endogenous iron requirement during infancy.

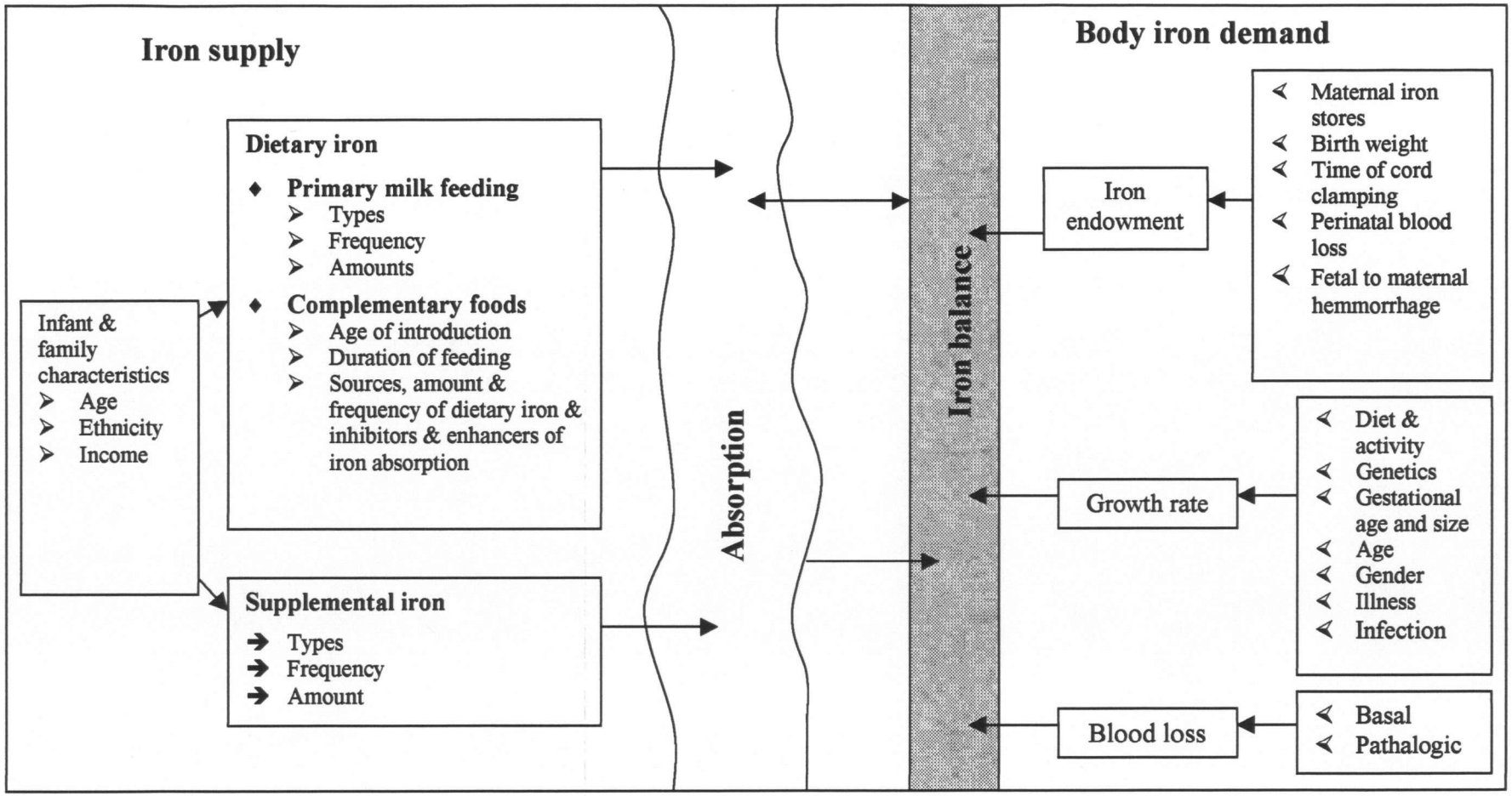


Figure 2.2 Schematic representation of the determinants of iron balance during infancy.
The directions of the arrows indicate the directions of influence.

2.5.1 Iron Endowment at Birth

The fetus accumulates iron throughout gestation, with the last trimester being the period of the greatest accumulation (1.7-2.0 mg iron/day) (Aggett et al., 1989). Transferrin bound iron is transferred against a concentration gradient from the maternal circulation to the fetus via the TfR on the placenta (Oski, 1989). In iron deficiency, upregulation of TfR synthesis in the placenta enables increased uptake of circulating iron. This is reflected by increased cord blood serum iron, transferrin saturation and ferritin concentrations. Until recently, it was believed that maternal iron deficiency, unless severe with Hgb <85 g/L, did not compromise fetal iron accumulation (Singla et al., 1978 & 1996; Rios et al., 1975). The cross-sectional studies from which this evidence was derived, however were confounded by other factors that may have influenced the iron status of the newborn. Further the studies compared indicators of iron status only at birth, and not later in infancy. More recently, a placebo-controlled iron supplementation study reported that iron deficiency during pregnancy does, in fact, adversely affect the infant's iron status (Preziosi et al., 1997). Although no differences were found in cord blood iron indices at birth, serum ferritin, Hgb, MCV and serum iron concentrations were significantly higher and erythrocyte protoporphyrin concentrations were lower at 3 mths in the infants whose mothers had been supplemented with iron than in those whose mothers had not (Preziosi et al., 1997). Other important determinants of the iron endowment at birth include factors such as birth weight, perinatal blood loss, an increase or decrease in the Hgb mass at birth resulting from late or early cord clamping, respectively (Grajeda et al., 1997) and the occurrence of fetal to maternal hemorrhage (Oski, 1989).

Assuming a blood volume of 270 mL and a Hgb concentration of 170 g/L at birth, Oski (1989) estimated the average infant with a weight of 3 Kg has approximately 163 mg (75-80%) of iron in Hgb and a total body iron content of 214 mg, equivalent to about 75 mg iron/Kg body weight. Approximately 21 mg (9%) of iron is present in myoglobin and tissue enzymes, and 30 mg (10-15%) in storage iron at birth (Heubers, 1990; Dallman et al., 1980; Oski, 1989).

2.5.2 Growth Rate

The average infant triples his or her birth weight and blood volume in the first year, and as a result a relatively large amount of iron is needed for growth, i.e. 80% of the total requirement (Oski, 1989; Dallman, 1989). Canadian experts have estimated that about 0.34 and 0.29 mg iron/day is needed to meet the needs for iron for the

synthesis of Hgb and the accretion of tissue and storage iron from 5-12 mths and 1-2 years of age, respectively (Health and Welfare Canada, 1990), lower than the 0.63 mg/day estimated by Oski (1989). Although the average iron requirement for growth can be approximated, variations in growth rates are extremely large (Siimes & Salmenperä, 1989). Thus, it follows that variations in iron requirements may also be large. The peaks in the incidences of iron deficiency in infancy and childhood correspond to peaks in growth and increments in RBC mass (Owen, 1989). Among full-term infants of normal birth weight, the available evidence suggests that the more rapid the rate of weight gain during the first year, the more depleted the iron stores and the greater the risk of iron deficiency (Siimes & Salmenperä, 1989; Sherriff et al., 1999; Emond et al., 1995; Dewey et al., 1998; Michaelson et al., 1995).

2.5.3 Iron Losses

The body has a limited capacity to excrete iron. Basal losses of iron occur primarily through the desquamation of surface cells from the skin, GI and urinary tracts (ferritin), and small amounts of normal GI blood loss (Hgb) (Bothwell, 1995). Basal losses have been estimated to be approximately 0.04 mg/Kg/day in adults (Smith & Rios, 1974). When adjusted for the smaller body surface area, this gives a requirement for elemental iron of 0.37 mg/day from 5-12 mths (based on a weight of 9 Kg) and 0.44 mg/day from 13-24 mths (based on a weight of 11 Kg) to cover basal losses (Health and Welfare Canada, 1990). In contrast, Oski (1989) estimated that 0.13 mg/day is needed to cover basal iron losses in the first 12 mths of life. Large amounts of iron may be lost due to pathologic causes, such as episodes of diarrheal disease (Oski, 1989) and occult blood loss due to ingestion of excessive amounts of cows' milk protein prior to maturation of the GI tract (Zeigler et al., 1990), which would clearly increase iron requirements.

2.5.4 Iron Absorption

The mechanism for, and mediators of the regulation of iron absorption although still not completely understood, have recently been reviewed by Beard et al. (1996) and Conrad et al. (1999). It is thought that iron absorption is regulated by mucosal cells in the upper small intestine (Bothwell, 1995). The amount of iron that is absorbed has been estimated to be about 1-2 mg/day in adults and 0.8 mg/day in infants, but actual amounts can vary about 50-fold (Dallman, 1989). Although somatic factors, such as body iron stores and rate of erythropoiesis are the

main determinants of iron absorption, intraluminal factors, such as the chemical form and oxidative state of the iron, and the presence of dietary components which inhibit and enhance iron absorption are also factors which regulate the uptake of iron into the enterocyte (Bothwell, 1995). The integrity of the mucosal surface and intestinal motility also play a role in regulating iron absorption. At physiologic intakes of iron, i.e. levels naturally occurring in food, the predominant route of absorption is by active transport that involves a series of receptors and binding proteins. At higher intakes, passive absorption via a paracellular pathway seems to play a larger role (Beard et al., 1996). It is possible that larger proportions of iron may be absorbed by passive transport in infants given high amounts of iron from iron-fortified formula or iron supplements, whereas greater proportions of iron may be absorbed by active transport in infants relying solely on the iron naturally present in food.

Iron absorption occurs through 3 distinct physiological phases (Beard et al., 1996): 1) preparation of dietary heme and non-heme iron for uptake into the enterocytes in the duodenum and upper jejunum (luminal phase), 2) transport through the enterocyte (iron uptake) and 3) release from the enterocytes to plasma (iron transfer). The absorption of heme iron occurs throughout the small intestine, whereas non-heme iron is absorbed primarily in the duodenum. In the upper GI tract, luminal secretions and dietary reducing agents and ligands prepare the dietary iron for absorption. In the stomach, hydrochloric acid and pepsin denature the protein to which the iron is bound and solubilize the released iron by reduction of the insoluble Fe^{3+} to the more soluble ferrous Fe^{2+} form. In the intestine, secretion of bicarbonate by pancreatic ducteal cells raises the pH. Although the increase in pH will theoretically decrease iron absorption, concurrent release of pancreatic proteases in the intestine chelate and solubilize the Fe^{2+} to facilitate its absorption. The lower gastric pH (about 5) in infancy also suggests that the efficiency of iron absorption be higher in infants than adults (Lönnerdal, 1991).

Various dietary and non-dietary factors can inhibit or facilitate iron absorption. Heme iron, which is found only in animal tissues (i.e. MPF), is absorbed directly by the enterocytes via receptor-mediated endocytosis. Non-heme iron, which makes up 100% of the iron in plant-based foods, dairy products, eggs and iron-fortified products, and 60% of the iron in MPF (Monsen et al., 1978) can be present in either a Fe^{3+} or Fe^{2+} state. Non-heme iron is sequestered within the lumen and solubilized by chelators, transferred to binding proteins, and then enters the enterocyte bound to a carrier protein via receptor-mediated endocytosis. The principle pathway of absorption requires reduction of Fe^{3+} to Fe^{2+} via a reductant such as ascorbic acid. Diffusion and binding by some molecules, such as mucin, may allow small amounts of Fe^{3+} to be absorbed directly. Fe^{3+} absorption, however, is usually

inhibited because Fe^{3+} is easily converted to an unstable ferric hydroxide that aggregates and precipitates in the alkali environment of the intestine (Beard et al., 1996; Conrad, 1993).

Extensive research over the last 3 decades using the extrinsic tag model to study the bioavailability of iron from single foods or meals has provided a comprehensive description of the factors that influence the absorption of heme and non-heme iron (reviewed by Lynch, 1997 and Conrad et al., 1999). Heme iron is highly bioavailable and its absorption is affected to a lesser extent by other dietary factors than for non-heme iron. Non-heme iron absorption is influenced substantially by the relative proportion of enhancers and inhibitors of iron absorption in the diet, and consequently, absorption is highly variable (Hallberg, 1974; Cook et al., 1972; Martinez-Torres & Layrisse, 1971; Turnbull et al., 1962; Conrad et al., 1966; Callender et al., 1957; Layrisse et al., 1969; Hallberg et al., 1989; Disler et al., 1975a). The currently available evidence indicates that the absorption of heme iron is enhanced only by meat, poultry and fish (MPF) (Martinez-Torres & Layrisse, 1971; Hallberg, 1981; Hallberg et al., 1992b) and inhibited by calcium (Hallberg et al., 1992a; Hallberg et al., 1991). Absorption of non-heme iron is enhanced by vitamin C (Brise & Hallberg, 1962; Hallberg et al., 1986; Rossander et al., 1979) and MPF (Martinez-Torres & Layrisse, 1971; Conrad et al., 1966; Hazell et al., 1978; Layrisse et al., 1984), and inhibited by phytate (Sandberg, 1991; Brune et al., 1992; Morris & Ellis, 1980; Reddy et al., 1996), dietary fibre (Simpson et al., 1981; Widdowson & McCance, 1942; Bjorn-Rasmussen, 1974), various polyphenols (Disler et al., 1975a&b; Gillooly et al., 1983; Disler et al., 1981; Brune et al., 1992; Macfarlane et al., 1988; Tuntawiroon et al., 1991), and calcium (Hallberg et al., 1991, Hallberg et al., 1992a,b). These factors have been shown to have a greater impact on absorption of iron in a diet that is primarily plant based and that contains no heme iron than in a mixed diet that contains heme iron (Cook et al., 1991a). The composition of the meal can also have significantly more impact on iron balance than the amount of iron, if the meal contains predominantly non-heme iron (Cook et al., 1991a).

Although iron transfer initially differs for heme and non-heme iron, iron from both sources eventually enters a common iron pool in the enterocytes. Here, the enzyme heme oxygenase facilitates the release of iron from heme. The iron derived from heme sources enters a common iron pool and is then processed in the same manner as iron from non-heme sources. Iron is transferred from the common iron pool, either to ferritin in the mucosal cell, where it is eventually lost when the cells are sloughed, or to the basolateral side of the enterocyte from where it is released into the circulation. After release into the circulation, TfR transfer iron from the circulation into the cell. The cell surface TfR bind Fe^{3+}-transferrin complexes in the plasma. The Fe^{3+} is then internalized via TfR-mediated

endocytosis. The endosomal compartment containing the transferrin-TfR complex sheds its clathrin coat in the lower pH of the cytosol and the iron is reduced to Fe^{2+} and dissociated from transferrin. The dissociated Fe^{2+} is channelled into one of 3 pathways: iron-regulatory proteins, iron-utilizing proteins, or storage iron. The remaining endosomal portion containing the TfR-apo-transferrin complex travels to the Golgi apparatus where it is packaged along with newly synthesized receptors and translocated to the cell surface. The higher pH of the cell surface then facilitates the release of apo-transferrin into the circulation (Beard et al., 1996).

TfR are found on the cell surface of virtually all mammalian cells (Thorstensen & Romsio, 1993). The expression of TfR is regulated primarily by metabolic need and intracellular iron status and secondarily by the rate of cell proliferation (Bothwell, 1995; Beard et al., 1996). As immature RBC, erythroblasts and reticulocytes mature into erythrocytes, the number of TfR on the cell surface, and thus iron uptake into the cell decreases (Beard et al., 1996). Thus, in infancy depending on the rate of growth, iron balance and the nature of the diet, the amount of iron that is actually absorbed and eventually transferred from the plasma into the cells varies considerably.

2.6 Recommendations for Iron Intake during Infancy

The current Canadian Recommended Nutrient Intake (RNI) for iron is 7 mg/day for infants 5-12 mths of age and 6 mg/day for those 12-24 mths of age (Health and Welfare Canada, 1990). The U.S. Recommended Dietary Allowance (RDA) for iron is 10 mg/day for infants from 6-24 mths of age (Subcommittee on the Tenth Edition of the RDAs, 1989). These recommendations are based on theoretical estimates for iron accretion (growth and stores) and losses during infancy, with allowances for the estimated bioavailability of iron from the diet. Various experts and expert groups have made different estimates for the endogenous iron requirement for the first year, which range from 0.7-0.9 mg/day (Stekel, 1984; Oski, 1989; Dallman et al., 1980; Health and Welfare Canada, 1990). The iron requirement during the first year of life for a hypothetical infant as estimated by Oski (1989) and Health and Welfare Canada (1990) is shown in **Table 2.2**. The amount of iron that must be supplied by the diet to meet the estimated endogenous iron need is based on the assumption that the infant consumes a mixed diet and that about 10-12.5% of the iron is absorbed (Health and Welfare Canada, 1990; Subcommittee on the Tenth Edition of the RDAs, 1989). Assuming an infant consumes 7-9 mg of iron and absorbs 10%, the endogenous iron requirement of 0.7-0.9 mg/day can be met. If the amount of iron absorbed from the diet is insufficient to meet the tissue needs, then the iron status

of the infant will become compromised, leading to decreased iron transport, Hgb synthesis and eventually, IDA. The dietary recommendation for iron is based on many approximations and assumptions concerning the iron endowment at birth, rate of weight gain, iron losses and the iron content and composition of the diet throughout infancy. The absorption of dietary iron varies from a few percent to 50%, depending on the composition of the meal and iron status of the individual. Considerable variation from infant to infant exists in all of these variables, placing some infants at risk of iron deficiency if intakes are inadequate to meet their requirements.

Table 2.2. Changes in body iron during infancy during the first year of life in a hypothetical infant and estimated requirements for endogenous and dietary iron. [1]

Age	Estimated iron Endowment at birth	Estimated body iron at one year of age	Daily iron requirement	
			Oski, 1989	Health and Welfare Canada, 1990
Weight (Kg)	3	10		
Hemoglobin (g/100 mL)	17	11		
Blood volume (mL/Kg)	90	75		
Total blood volume (mL)	270	750		
Total body hemoglobin (g)	46	82		
Hemoglobin iron (mg)	163	280		
Tissue iron (7 mg/Kg)	21	70		
Storage iron (10 mg/Kg)	30	100		
Total body iron (mg)	214	450	0.65	0.34
Totally yearly iron losses (0.13 mg/day) (ug/day)	—	47	0.13	0.37
Exogenous iron requirement (mg)	—	283	0.78	0.71
Daily dietary iron requirement (mg)[2]	—	—	8	7

[1]Adapted from Oski, 1989.
[2]Assuming an absorption of 10% of the dietary iron.

2.7 Sources, Amount and Bioavailability Dietary Iron in Infancy

The amount and bioavailability of iron in the diet varies considerably, depending on the foods consumed. Feeding practices, therefore, play a critical role in the development of poor iron status, i.e. iron deficiency anemia or low iron stores, during infancy. Cook & Bothwell (1984) have described the nature of dietary iron during infancy in relation to 3 overlapping periods (**Figure 2.3**). According to current recommendations (Canadian Pediatric Society (CPS) et al., 1998; American Academy of Pediatrics Committee on Nutrition (AAP-CON), 1999), breast milk and/or infant formula should be the sole food until 4 to 6 mths of age. Between 4 and 6 mths and continuing throughout the first year, complementary foods, starting with iron-fortified infant cereals, then vegetables, fruits, and finally MPF and alternatives are recommended. It is also recommended that breast-feeding or feeding with a commercial iron-fortified infant formula continue after the introduction of solid foods, and that iron-fortified foods continue beyond the first year to provide sufficient iron. Breast-feeding is recommended until up to 2 years of age, or beyond. For the infant who is not breast-fed, a commercial iron-fortified infant formula is recommended until 9-12 mths of age (CPS et al., 1998; AAP-CON, 1999). The process of weaning commences at 4-6 mths, with an increasing dependence on solid foods during the latter part of infancy and into the 2nd year. By one year of age, the ingestion of a variety of foods from the different food groups of Canada's Food Guide to Healthy Eating is recommended.

Full-term gestation infants are able to draw upon the storage iron laid down during gestation for at least the first 4 mths after birth, and as a result, the amount and bioavailability of dietary iron is not so important to iron balance during this time. From 4-6 mths of age to the 2nd year of life is a critical period for iron balance because these reserves become depleted, and the major sources of dietary iron are undergoing an enormous change from solely breast milk or infant formula, to a diet that includes an increasing variety and amount of complementary foods.

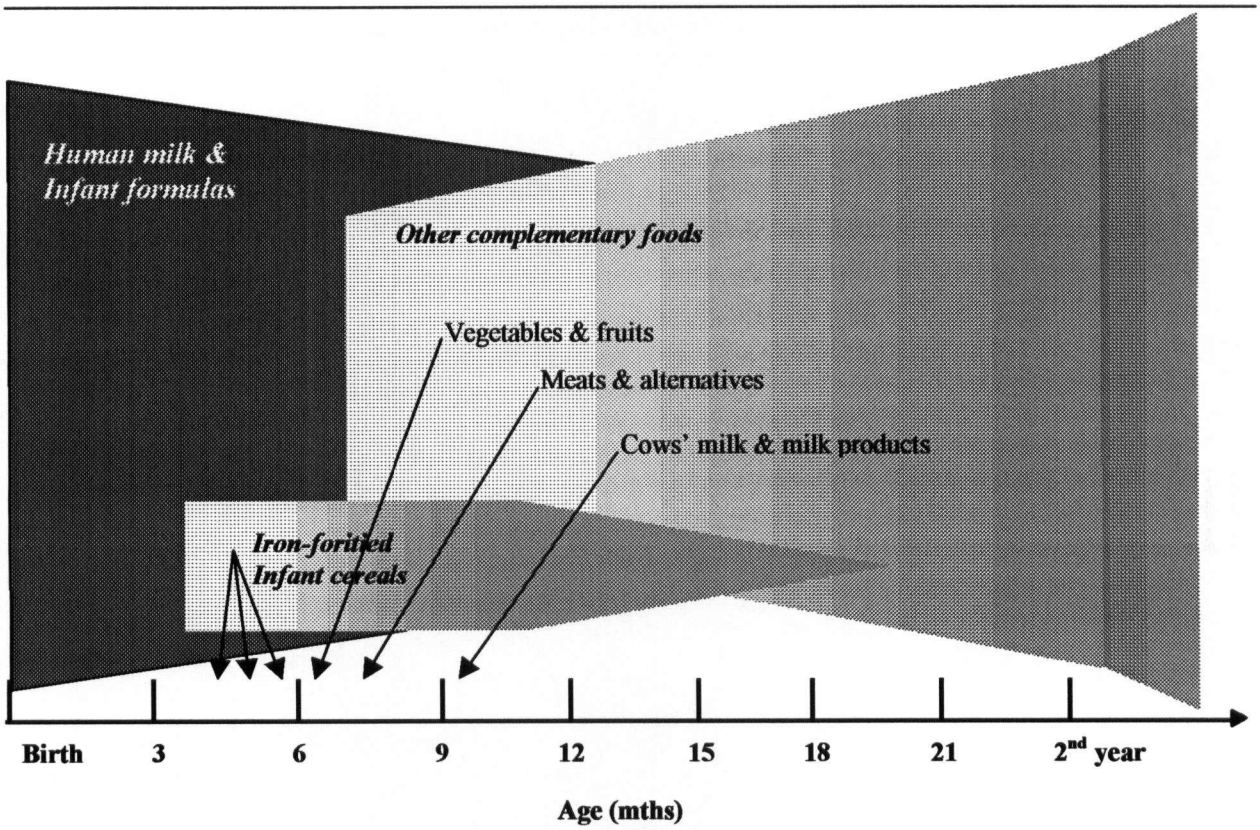


Figure 2.3. Schematic illustration of the major sources of dietary iron, and inhibitors and enhancers of iron absorption, shown with reference to the recommended patterns of food consumption during infancy.[1]
[1]Adapted from: Cook & Bothwell, pg. 119. In Sketel A. (ed) Iron Nutrition in Infancy and Childhood. Raven Press, New York, 1984; Canadian Pediatric Society, Dietitians of Canada, Health Canada, 1998.
Arrows indicate the recommended ages of introduction (CPS et al., 1998).

2.7.1 Human Milk

The iron content of human milk is relatively low and quite variable, depending on the stage of lactation. The amounts of iron in human milk range from 0.5-1.0 mg/L iron early postpartum to approximately 0.3-0.4 mg/L after the first few mths (Bates & Prentice, 1994; Fomon et al., 1993). The iron content of human milk is neither related to maternal iron intake nor influenced by iron supplementation (Bates & Prentice, 1994). Although the iron content of human milk is low and in the ferric form, the absorption of iron from an exclusive breast-milk diet is relatively high, up to approximately 50% (Saarinen et al., 1977; MacMillan et al., 1976). Recently, the iron erythrocyte incorporation method has been used to estimate iron absorption from human milk. These studies found similar rates of iron absorption of about 12% among 8 breast-fed infants aged 2-10 mths (Davidson et al., 1994a) and 14 breast-fed infants aged 5-7 mths (Abrams et al., 1997). The variability in the iron absorption from human milk, however, is wide, with a range of 3.4-37.4% (Davidson et al., 1994a). Assuming the infant is exclusively

breast-fed, an intake of 750 mL human milk/day would provide 0.26 mg, based on a human milk iron content of 0.35 mg/L. Assuming a maximum bioavailability of 50%, the amount of iron absorbed would be 0.13 mg/day, although actual intakes and amounts absorbed by infants may be considerably lower than this. The intake of iron from human milk is clearly much lower than the requirement of 0.7 mg/day that has been estimated for infants 5-12 mths of age (Health and Welfare Canada, 1990). Further, not only is the amount of iron in human milk insufficient to meet the needs of infants over 5 mths of age, feeding solid foods near the time of breast-feeding decreases the absorption of iron from human milk (Oski & Landaw, 1980).

2.7.2 Infant Formulas and Cows' Milk

The iron content of infant formulas varies considerably, and the bioavailability of the iron tends to be lower than that in human milk. Unfortified (low iron) cow's milk-based infant formulas in Canada contain approximately 1.5-3 mg/L iron in the form of Fe^{3+}, that is naturally present in cows' milk. The absorption of iron from low iron formulas is about 10% (Stekel et al., 1986; Saarinen & Siimes, 1977). Iron-fortified infant formulas typically contain 7-13 mg iron/L. The iron in iron-fortified infant formulas is in the form of $Fe^{2+}SO_4^{2-}$, ferrous sulfate, a form that is more readily absorbed when compared with other forms of iron used to fortify foods, such as elemental iron powders and phosphate compounds. The absorption of iron from iron-fortified infant formulas is generally inversely proportional to the iron content of the formula (Macmillan et al., 1977; Fomon et al., 1997). Using the erythrocyte incorporation method to estimate iron absorption, Fomon et al. (1997) found that infants absorbed 3.5% and 2.6% of the iron from formulas containing 8 and 12 mg iron/L, respectively. Iron-fortified soy protein formulas contain higher amounts of iron (12-13 mg) because it is thought that the iron from these formulas is more poorly absorbed (about 2-3%) than from cows' milk protein formula (Hertrampf et al., 1986; Brennan et al., 1989; Gillooly et al., 1984). Values for the absorption of iron from soy protein formulas, however, have been extrapolated from studies in adults. Iron absorption, based on the ^{59}Fe erythrocyte incorporation method by infants, however, is thought to be about 2-fold higher than by adults (Lönnerdal, 1990). Rios et al. (1975) and Davidson et al. (1994b) found 4-6% iron absorption from soy protein formulas in infants 3-7 mths of age. Unmodified cows' milk contains approximately 0.5 mg iron/L, with an absorption of about 10% (Saarinen & Siimes, 1979).

Although the mechanism is not entirely understood, the relatively higher absorption of iron from human milk compared with cows' milk, or soy and cows' protein infant formulas is thought to be due to the lower calcium

and protein content and the presence of lactose and lactoferrin in human milk, which are thought to facilitate iron absorption (Lönnerdal, 1990; Lynch & Hurrell, 1990; Hallberg et al., 1992a).

2.7.3 Complementary Foods

Commercial infant cereals, and in older infants other iron-fortified cereals and MPF, are the major sources of iron from complementary foods throughout the weaning period (Lynch & Hurrell, 1990). With the exception of MPF and iron-fortified products, complementary foods tend to be poor sources of iron (Zeigler & Fomon, 1996). A summary of the food and nutrient intakes from 4 national surveys in the U.S. has shown that solid foods provide over 95% of the iron in the diets of infants fed unmodified cows' milk and low iron infant formulas during the 2nd 6 mths of life (Ernst et al., 1990). The amounts and sources of iron, or inhibitors and enhancers of iron absorption from solid foods in the diet of the breast-fed infant have not been determined.

Infant cereal is the first and most commonly used complementary food (Zeigler & Fomon, 1996; Skinner et al., 1997), and is recommended as a key source of iron for late infancy (CPS Nutrition Committee, 1991; CPS et al., 1998). Infant cereals are fortified at a level of 30 and 45 mg/100 g dry cereal in Canada (Health and Welfare Canada, 1997) and the U.S. (Zeigler & Fomon, 1996), respectively. The iron in iron-fortified infant cereals has a bioavailability of only 3-4% (Fomon, 1987) because these foods contain inhibitors of iron absorption (fibre and phytate), and the iron is in the form of poorly absorbed electrolytic iron powder. Nonetheless, iron-fortified infant cereals provide most of the dietary iron for infants 7 to 10 mths of age fed cows' milk or low iron formulas (Ernst et al., 1990). Further, iron-fortified infant cereals provide >50% of the iron in the diets of infants fed iron-fortified formula at 11 to 12 mths of age (Ernst et al., 1990). Although introduction of iron-fortified infant cereals at 4-6 mths and continued feeding to at least one year of age has been recommended as the primary strategy for prevention of IDA among breast-fed infants in Canada since 1979 (CPS Nutrition Committee, 1979 & 1991; CPS et al., 1998), the practicality of this recommendation may be a problem for some infants. Yeung et al. (1981) found that although the majority of infants were introduced to iron-fortified infant cereals by the recommended age of 4-6 mths, the cereals were discontinued within one to 3 mths for a large proportion of the infants. Further, data from Walter et al. (1993) suggests that breast-fed infants have lower intakes of iron-fortified infant cereals than formula-fed infants. In a study of the feeding practices of Chinese infants 12-18 mths of age living in Northeast Edmonton, infant cereal was considered by some mothers to be a "hot" or yang food that causes constipation and was often avoided (unpublished,

Hui, 1997). Rather, congee, traditional rice gruel very popular in Chinese diets, was fed to infants as the first complementary food instead of commercial iron-fortified infant cereals (Leung & Davis, 1994; Li, 1985). The methods for preparing congee vary considerably. Although MPF is sometimes added to the congee, the MPF is usually not fed to infants. Thus, congee tends to have a low iron content and bioavailability (Dallman & Siimes, 1979a; Hallberg et al., 1977; Hsia & Yeung, 1976). Although a recent study in Vancouver suggests that most infants are introduced to iron-fortified cereals by the recommended 4-6 mths of age (Williams et al., 1996), data on the quantity and/or the duration of infant cereal feeding throughout the 2nd 6 mths of life was not collected.

In addition to having a low iron content (approximately 0.4 mg/100 g), fruits and vegetables contain non-heme iron, and have been shown to interfere with the absorption of iron from breast milk in adults (Oski & Landaw, 1980). However, Walravens et al. (1989) reported that because of the quantity consumed, fruits and vegetables actually contributed 12% and 8% of total iron intake, respectively, among infants from low-income families in Denver. Legumes, eggs and dairy products were found to contribute 5%, 5% and 4%, respectively, to the total iron intake. Although the non-heme iron in these foods may contribute substantial amounts to total iron intakes and their vitamin C contents enhance non-heme iron absorption; they contain relatively high amounts of inhibitors of iron absorption, such as dietary fibre and phytates.

An adequate intake of iron from solid foods is particularly important for infants who do not receive an iron-fortified infant formula or supplemental iron. **Table 2.3** shows the estimated amount of iron from solid foods that needs to be ingested to meet the endogenous iron requirements of infants 6-24 mths of age based on the primary milk feeding. As shown, the amount of iron that needs to be supplied by solid foods varies considerably depending on the amount of iron provided by the primary milk feedings. There are no recent published data on the intake and duration of feeding of iron-fortified infant cereals, other complementary foods, or the overall composition of the weaning diet for Canadian infants during the first to 2nd year of life.

Table 2.3. Estimated amount of iron from solid foods needed to meet the endogenous iron requirement of infants 6-24 mths of age in relation to type of primary milk feeding.

Primary milk feeding	Estimated maximum iron provided by milk[1]			Endogenous requirement not met by primary milk feeding	Estimated iron intake from solid food needed to meet endogenous requirement (mg/day)	
	Iron content (mg/L)	Estimated absorption (%)	Estimated iron absorbed (mg/day)		5-12 mths[2]	13-24 mths[3]
Breast milk	0.35	12[4]-50[5]	0.03-0.13	0.57-0.67	5.7-6.7	4.6-5.4
Low iron Formula	1.5-3.0	10[6]	0.15-0.30	0.40-0.55	4.0-5.5	3.2-4.4
Cows' milk	0.5	10[7]	0.04	0.66	6.6	5.3
Iron fortified Formula	7-13	4[8]	0.21-0.39	0.31-0.49	3.1-4.9	2.5-3.9
Soy protein-based formula	12-13	4-6[9]	0.23-0.58	0.12-0.47	1.2-4.7	1.0-2.2

[1]Assuming a maximum intake of 750 mL/day
[2]Assuming a mixed diet containing heme iron sources with an absorption of approximately 10%; based on an endogenous iron requirement of 0.7 mg/day (Health and Welfare Canada, 1990).
[3]Assuming a mixed diet containing heme iron sources with an absorption of approximately 12.5%; based on an endogenous iron requirement of 0.7 mg/day (Health and Welfare Canada, 1990).
[4]Davidson et al., 1994a; Abrams et al., 1997.
[5]Saarinen et al., 1977; MacMillan et al., 1976.
[6]Skekel et al., 1986; Saarinen & Siimes, 1977.
[7]Saarinen & Siimes, 1979.
[8]Fomon et al., 1997.
[9]Rios et al., 1975; Davidson et al., 1994b.

2.8 Adequacy of Iron Intakes in Infancy

Several studies have shown that heme iron accounts for only a small proportion (about 6%) of the total iron intake of infants and young children (Gibson et al., 1988; Raper et al., 1984; Preziosi et al., 1994; Skinner at al., 1997). Only one study has reported the dietary intake of iron among infants in China (Chen et al., 1992), and there is no published data on the intake of heme and non-heme iron intakes in Chinese infants. Data from the recent Chinese National Nutrition Survey suggest that heme iron intakes of Chinese infants may be low; although total dietary iron intakes among the study population were high, heme iron only accounted for about 3% of total iron intakes, with lower intakes in rural than urban areas (Du et al., 2000).

Despite an increase in solid food intake from the start of weaning into the 2nd year of life, a downward trend in iron intake occurs (Zeigler & Fomon, 1996; Yeung et al., 1981; Richmond et al., 1993; Brault-Debuc et al., 1983).

High within- and between-subject variation, particularly from 12 to 24 mths of age has been found for iron and vitamin C intakes of Asian children for whom weighed intake data was kept (Harbottle & Duggan, 1994). Tables 2.4-2.6 provide a summary of studies that have examined iron intakes in infancy and early childhood. Studies in the U.S. have generally shown that the intake of iron by infants has increased over the last 3 or 4 decades (Zeigler & Fomon, 1996). Despite this, studies in the U.S. (Richmond et al., 1993; Johnson et al., 1994; Zive et al., 1995) as well as Western Europe (Harbottle & Duggan, 1994; Calvo & Gnazzo, 1990; Murphy et al., 1992) have identified a high prevalence of inadequate iron intakes during infancy and early childhood. Levels of food iron fortification vary dramatically from country and country, thus comparison and extrapolation of data from other countries to Canada difficult. The levels of iron fortification of foods such as breads and cereals, infant foods, and soy protein-based products in Canada are generally considerably lower than in the U.S., and thus it would be expected that iron intakes would be lower. Few Canadian studies, however, have determined the intake and sources of iron in the diet throughout infancy (Greene-Finestone et al., 1991; Brault-Debuc et al., 1983) and early childhood (Gibson et al., 1988), and no studies conducted since 1985 have been published.

The data collected by Greene-Finestone et al. (1991) in 1985 on infants 6-18 mths of age living in Ottawa-Carlton, and by Brault-Debuc et al. (1983) in 1975-1979 on French Canadian infants living in Montreal, show that despite median iron intakes that met or exceeded the RNI, about 20-35% of the infants had iron intakes below the RNI. Similarly, Yeung et al. (1981) found that as many as 35% of 6 mth olds, and 37% of 10 mth olds in Toronto had iron intakes below the RNI, with a notable increase in the proportion of infants that did not meet the RNI for iron with increasing age. The degree of inadequacy of iron intakes in these studies has not been reported, although Brault-Debuc reported that about 10% of infants had iron intakes <77% of the RNI, an amount that is thought to be associated with a high risk of deficiency. The main reason for the declining iron intake in relation to the RNI in the infants studied in Toronto was the early withdrawal of infant cereals from the diet (Yeung et al., 1981). No data on the intakes of heme and non-heme iron, or other dietary factors influencing iron absorption among Canadian infants, or on the iron intakes or composition of the weaning diet among infants from Chinese ancestries in North America have been published. Further, the data on the intake of iron reported by Yeung et al. (1981), Greene-Finestone et al. (1991) and Brault-Debuc et al. (1983) is about 20 years old. Thus, there is currently no contemporary data on the iron intakes or food sources among infants in Canada.

Table 2.4. Summary of studies of iron intake in infancy (U.S.).

Author, yr published	Population	Time period[1]	Infants age (mths)	Characteristics	n	Iron intake (mg/day)[2]			
						Total	Heme	Non-heme	Dietary method
Raper et al., 1984	U.S. Dept. of Agriculture (USDA) Nationwide Food Consumption Survey (NFCS)	1977-78	12-24	Random U.S. sample	268	7.7	0.5	7.2	24-hr recall, 2-day food record
Martinez et al., 1985	Ross Nutrition Survey	1984	7-8	Random U.S. sample	138	FF (NIF/IF) - 14.7 (12.0/19.2)	NR	NR	24-hr recall
					54	CMF - 11.4			
			9-10		195	FF (NIF/IF) - 17.4 (12.5/17.4)			
					144	CMF - 9.6			
			11-12		109	FF (NIF/IF) - 20.5 (10.0/23.1)			
					170	CMF - 9.2			
Martinez & Ryan, 1985	USDA- NFCS	1977-78	7-9	Random U.S. sample	27	FF (NIF/IF) - 15.0 (8.4/18.6)	NR	NR	24-hr recall, 2-day food record
					108	CMF - 9.2			
			11-12		6	FF (NIF/IF) - 17.7 (-/18.4)			
					102	CMF - 6.9			
Montalto et al., 1986	National Health and Examination Survey (NHANES II)	1976-80	7-8	Random U.S. sample	20	FF - 14.9	NR	NR	24-hr recall
					51	CMF - 11.1			
			9-10		25	FF - 16.3			
					81	CMF - 8.7			
			11-12		13	FF - 13.4			
					103	CMF - 6.0			
Ernst et al., 1990	Gerber Nutrition Survey	1972 & 1986	7-8		119	FF, CMF or HMF - 16.1	NR	NR	NR
			9-10		117	FF, CMF or HMF - 13.1			
			11-12		90	FF, CMF or HMF - 11.3			
Albertson et al., 1992	U.S.	1978	2-3 years		466	11.0	NR	NR	14-day food record
		1988			349	11.3 ± 1.5			

[1]year that study was conducted; [2]Mean ± SD unless otherwise indicated.
FF, formula-fed; NIF, non-iron-fortified formula fed; IF, iron-fortified formula-fed; CMF, cows' milk fed; HMF, human milk-fed; NR, not reported, SES, Socio-economic status.

Table 2.4. Summary of studies of iron intake in infancy (U.S. continued).

Author, yr published	Population	Time period[1]	Infants age (mths)	Characteristics	n	Iron intake (mg/day)[2]			
						Total	Heme	Non-heme	Dietary method
Zive et al., 1995	San Diego, California	1988-91	48	Mexican-American	351	8.9 ± 3.3	NR	NR	2-day food record
				Anglo-American (Low to middle-income)		9.8 ± 3.4			
Ganji et al., 1995	U.S. Dept. of Agriculture (USDA) Nationwide Food Consumption Survey (NFCS)	1987-88	12-36	Random U.S. sample	537	8.4 ± 0.3 (SE)	NR	NR	3 consecutive days (1-day dietary recall, 2-days dietary records)

[1]year that study was conducted; [2]Mean ± SD unless otherwise indicated.
FF, formula-fed; NIF, non-iron-fortified formula fed; IF, iron-fortified formula-fed; CMF, cows' milk fed; HMF, human milk-fed; NR, not reported, SES, Socio-economic status.

Table 2.5. Summary of studies of iron intake in infancy (Europe/Asia).

Author, yr published	Location	Time period[1]	n	Characteristics	Infant age (mths)	Iron intake (mg/day)[2]		
						Total	Heme	Non-heme
Leung et al., 1988	Hong Kong	1984	155 152	Chinese, bottle-fed	12 18	9 ± 3 9 ± 3	NR	NR
Chen et al., 1992	China	NR		Chinese	<36	8.3	NR	NR
Harbottle & Duggan, 1994	Sheffield, England	NR	47 50	Indo-Asian	4-11 12-22	4.6 ± 2.0 4.0 ± 3.0 4.3 ± 2.7	NR	NR
Preziosi et al., 1994	France	NR	20	French	Birth-24	7.6	0.5	7.1
Pisacane et al., 1995	Italy	NR	9 21	Anemic (Hgb <110 g/L) Non-anemic (Hgb >110 g/L)	12	4.3	1.9 ± 0.7	2.4 ± 0.9

[1]year that study was conducted; [2]Mean ± SD unless otherwise indicated.
FF, formula-fed; NIF, non-iron-fortified formula fed; IF, iron-fortified formula-fed; CMF, cows' milk fed; HMF, human milk-fed; NR, not reported, SES, Socio-economic status.

Table 2.6. Summary of studies of iron intake in infancy (Canada).

Author, yr published	Population	Time period[1]	Infant age (mths)	Characteristics	n	Iron intake (mg/day)[2]			
						Total	Heme	Non-heme	Dietary method
Brault-Dubuc et al., 1983	Montreal	1975-79	9 12 15-24	French-Canadian, upper-middle SES	425	11.7 (m) 11.9 (f) 9.6 (m) 8.3 (f) 8 (m) 7.6 (f)	NR	NR	24-hr recall - 9-12 mths 3-day food record - 13-36 mths
Gibson et al., 1988	Guelph, Ontario	NR	4-6 yrs	Caucasian, preschool, upper-middle SES	106	11.3 ± 3.3 (m) 9.6 ± 2.1 (f)	0.56 ± 0.35 (m) 0.50 ± 0.29 (f)	10.7 ± 3.2 (m) 9.1 ± 2.0 (f)	3-day weighed food record
Greene-Finestone et al., 1991	Ottawa-Carlton	1984	6-18	All social classes	320	9.6 ± 0.28 (range, 2.1-30.3)	NR	NR	24-hr recall

[1]year that study was conducted; [2]Mean ± SD unless otherwise indicated.
FF, formula-fed; NIF, non-iron-fortified formula fed; IF, iron-fortified formula-fed; CMF, cows' milk fed; HMF, human milk-fed; NR, not reported, SES, Socio-economic status.

2.9 Prevalence of Iron Deficiency in Relation to Risk Factors

Iron deficiency is the most common micronutrient deficiency among infants worldwide (United Nations, 1989; deMaeyer et al., 1985; Scrimshaw, 1991). It has been estimated that 25% of infants worldwide, and up to 10-12% of infants in developed countries have IDA (deMaeyer et al., 1985; Stevens, 1991), with an even higher prevalence among certain subgroups of the population. A summary of the prevalence of IDA and low iron stores among infants in developed countries is shown in **Table 2.7**. The prevalence of iron deficiency in infancy varies considerably depending on socio-demographic factors (such as age, ethnic background and socio-economic status SES), physiologic factors (such as low birth weight, premature delivery, chronic hypoxia, perinatal bleeding, a low Hgb concentration at birth and frequent infections), and dietary factors (such as feeding history, and the intake of iron and other dietary factors influencing iron absorption).

Table 2.7. Summary of data reported on the prevalence of iron deficiency anemia and low iron stores among infants in developed countries.

Country and region		Prevalence (%)1		Authors, yr of publication
		Iron deficiency anemia	Low iron stores	
Canada				
	Halifax, Toronto, Edmonton and Montreal	4	33	Zlotkin et la. 1996
	Vancouver			
	Chinese	4	12	Innis et al., 1997
	Caucasian	8	25	Innis et al., 1997
	Montreal			
	Low SES	25	37	Lehmann et al., 1992
	Chinese	12	—	Chan-Yip & Gray-Donald,1987
	Aboriginal	32-50	—	Moffatt et al., 1991; Cruz et al., 1990; Whalen et al., 1997; Sawchuk et al., 1996; Willow et al., 2000
U.S				
	National sample (NHANES III)	3	—	Looker et al., 1997
	WIC participants	35	—	Gupta et al., 1999
Europe				
	National sample (Euro-Growth project)	10	25	Male et al., 1995

SES, socio-economic status; NHANES III, National Health and Examination Survey III; WIC, Special Supplemental Food Program for Women, Infants and Children.
[1]The criteria used to define iron deficiency anemia and low iron stores varies from study to study.

There has been an overall decline in the prevalence of IDA over the past 30 years among infants in the U.S. (Looker et al., 1997; Dallman, 1990; Yip et al., 1987a&b). The prevalence of IDA declined from 7 to 3% from 1976 to 1985 among low-income families, and from 6 to 3% from 1968 to 1973 among middle-income families from 6 states in the U.S.. The prevalence of IDA in the U.S. in 1993 was at or below 3% for children aged 1-5 (U.S. Preventive Services Task Force, 1996; Looker et al., 1997). The apparent decrease in the prevalence of IDA in the U.S. has been attributed to increases in the incidence and duration of breast-feeding and feeding with iron-fortified rather than unfortified infant formulas and cereals. These changes were in part due to the Special Supplemental Food Program for Women, Infants and Children (WIC) program in the U.S. (Yip et al., 1987a&b; Miller at al., 1985; Vazquez-Seoane et al., 1985). A report by Kwiatkowski et al. (1999) showing that 55 children between the ages of one and 3 years presented to the Children's Hospital of Philadelphia with severe IDA (Hgb ≤60 g/L) due to nutritional reasons suggested that IDA may be a more substantial problem among certain groups. A recent report by Gupta et al. (1999) also suggested that aggregate programmatic data might not accurately represent the prevalence of IDA among particularly high-risk groups, such as WIC recipients. The prevalence of anemia (defined as a Hgb ≤112 g/L) among children 6 mths to 5 years of age born to adolescent mothers of low SES was 35%, despite the mothers having received WIC services aimed at prevention of IDA and a history of use of iron-fortified infant formula which approached 100% (Gupta et al., 1999). National programs similar to WIC do not exist in Canada, and studies suggest that IDA may also be a substantial problem among certain subgroups in Canada (Lehmann et al., 1992; Chan-Yip & Gray-Donald, 1987; Innis et al., 1997; Moffatt et al., 1991; Cruz et al., 1990; Whalen et al., 1997; Sawchuk et al., 1996; Male et al., 1995).

National data are not available on the prevalence of iron deficiency in Canada. Data from the Euro-Growth project, however, found that the prevalence of IDA among 12 mth old infants from different regions of Europe, which also have no programs similar to WIC, was about 10% (Male et al., 1995). Recent data from major urban centres in Canada indicated that 4.3% of 8 to 15 mth old infants in Halifax, Toronto, Edmonton and Montreal (Zlotkin et al., 1996), and 7% of 9 mth old infants in Vancouver had IDA (Innis et al., 1997). Of concern, infants from certain subgroups in Canada appear to be more vulnerable to IDA, with prevalence rates of 24% among infants from disadvantaged families (Lehmann et al., 1992), 11.4-16.5% among infants from Chinese ancestries in Montreal (Chan-Yip & Gray-Donald, 1987) and 32-50% among infants from aboriginal communities across Canada (Moffatt et al., 1991; Cruz et al., 1990; Whalen et al., 1997; Sawchuk et al., 1996; Willows et al., 2000). The risk of IDA is

also increased among infants who are exclusively breast-fed beyond 3-6 mths (Innis et al., 1997; Siimes & Salmenperä, 1984; Calvo et al., 1992; Pizarro et al., 1991). Breast-feeding has become more common among Canadian women (Williams et al., 1996, Health and Welfare Canada, 1991; McNally et al., 1985). In Vancouver, 15% of 9 mth old infants who were breast-fed for 8 mths had IDA (Innis et al., 1997). Moreover, more Canadian families are living in disadvantaged circumstances (Canadian Council on Social Development, 1997; McIntyre et al., 1998).

Modifiable dietary factors have been shown to be important predictors of the risk for IDA in infancy (Pizarro et al., 1991; Boutry & Needlman, 1996). Dietary factors can, therefore, be targeted in initiatives aimed at preventing IDA. Socio-demographic markers of risk for iron deficiency such as age, ethnicity and SES can be used to identify infants at risk for feeding practices and dietary intakes associated with iron deficiency. Although numerous studies have identified socio-demographic and dietary factors that can be targeted in strategies aimed at prevention of IDA, a complete understanding of these factors is lacking for infants at risk for IDA in Vancouver.

2.9.1 Infant Age as a Predictor of Risk for Iron Deficiency

The risk of iron deficiency between the ages of 6 and 24 mths is high, and data from the U.S. (Sargent et al., 1996; Looker et al., 1997) and Europe (Hercberg et al., 1987) suggest a decrease in the prevalence of IDA occurs after the 2nd year of life. Whether the risk of IDA differs by age between 6 and 24 mths is less clear. Although few longitudinal studies have been done (Brault-Debuc et al., 1983), cross-sectional studies in Canada (Greene-Finestone et al., 1991; Chan-Yip & Gray-Donald, 1987) have suggested that the prevalence of IDA may increase from the first to the 2nd year of life. The prevalence of IDA was higher among infants from higher SES backgrounds in Ottawa-Carlton at 18 mths (10.5%) compared with 6 mths of age (3.5%) (Greene-Finestone et al., 1991). Similarly, Chan-Yip & Gray-Donald (1987) found that the prevalence of IDA was 11.4% at 6-12 mths and 16.5% at 19-36 mths of age among infants from Chinese ancestries in Montreal. In a study with 9 mth old infants in Vancouver, 8% of Caucasian but only 4% of Chinese infants had IDA, and 25% of the Caucasian and 12% of the Chinese infants had low iron stores (Innis et al 1997). Consistent with this and national data from 1970-72 (Vallberg et al., 1976), recent data from 4 major cities in Canada, Zlotkin et al. (1996) reported that a high prevalence of low iron stores affecting 25-30% of infants at about one year of age. Whether low iron stores are naturally corrected in the 2nd year of life as the variety and amounts of solid foods increase, or whether low iron stores persist or lead to

IDA is not clear.

2.9.2 Ethnic Background as a Predictor of Risk for Iron Deficiency

Studies reporting data on the prevalence of IDA and low iron stores in infants from Caucasian and Chinese ancestries are summarized in **Tables 2.8** and **2.9**, respectively. Based on the findings of Chan-Yip & Gray-Donald (1987) that 11.4% of Chinese infants in Montreal at 6-12 mths and 16.5% at 19-36 mths of age had IDA, the Canadian Task Force for Periodic Health Examination (1994) categorized infants from Chinese ancestries as a high risk group for IDA. Severe IDA (Hgb (60 g/L) has also been reported to be common in children from Southeast Asian ancestries in Philadelphia at one to 3 years of age (Kwiatkowski et al 1999). The only other Canadian study that examined the prevalence of IDA among Chinese infants found only 4% IDA at 9 mths of age (Innis et al., 1997). Consistent with the latter data for Chinese infants in Vancouver, Sargent et al. (1996) found low rates of iron deficiency among children 6 mths to 5 years in communities in Massachusetts with either more than 2% or less than 1% Chinese in the population (OR 1.01, CI 0.96-1.07). IDA has also been found to be uncommon among 18 mth old infants in Hong Kong, affecting only 2% of the infants (Chiou et al., 1990), although rates of IDA in rural China are reported to be much higher than in urban areas (Ge, 1995). The low prevalence of IDA among the Chinese infants in Vancouver (Innis et al., 1997) and in Hong Kong (Chiou et al., 1990) was attributed to a high prevalence of feeding with iron-fortified infant formula. Although the high prevalence of feeding with iron-fortified infant formula among Chinese infants in Vancouver protects them from IDA in the first year of life, it is possible that the latter reliance on low iron complementary foods, such as congee, and high intakes of cows' milk (Leung & Davis, 1994; Li, 1985; Chan-Yip & Gray-Donald, 1987; Hui, 1997; Kwiatkowski et al 1999; Guldan et al., 1993) places them at risk for IDA in the 2nd year of life. Alternatively, accumulation of high iron stores during the first year of life may protect these infants from later low dietary iron intakes.

The Canadian Task Force for Periodic Health Examination (1994) did not define infants from Caucasian ancestries as a group at high risk for IDA. This was based on the data of Greene-Finestone et al. (1991) and Brault-Dubuc et al. (1983) that showed a low prevalence of <5% IDA among Caucasian infants from families of high SES in Ottawa-Carlton and Montreal, respectively. More recent studies, however, found 8% IDA and 25% low iron stores among 9 mth old Caucasian infants in Vancouver (Innis et al., 1997), and 25% IDA and 37% low iron stores among 10-14 mth old infants from disadvantaged families of predominantly Caucasian ancestries in Montreal

(Lehmann et al., 1992). The high prevalence of IDA among Caucasian infants in Vancouver was associated with a high prevalence of breast-feeding for >3 mths. Although the high prevalence of breast-feeding may place Caucasian infants at risk for IDA in the first year of life, it is possible that the subsequent introduction of a variety of iron-fortified and heme iron containing complementary foods corrects and decreases the risk of IDA in the 2nd year of life.

Table 2.8. Summary of studies on iron deficiency anemia and low iron stores among full-term Canadian infants from Caucasian ancestries.

Author, yr of publication	Location	Date of Study	Study Population	Age (mths)	n	Criteria for Iron Status Classification		Prevalence (%)	
						Iron deficiency anemia	Low iron stores	Iron deficiency anemia	Low iron stores
Vallberg et al., 1976	Canada (national sample)	1970-72	Low, middle and high SES	0-48	87	Birth-12 mths - Hgb <100 g/L & ferritin <10 μg/L 2-5 yrs - Hgb <110 g/L & ferritin <10 μg/L	Ferritin ≤10 μg/L	2.3	29
Brault-Debuc et al., 1983	Montreal	1983	Upper middle class, French Canadian	3-36	425	Birth-18 mths - Hgb <100 g/L, Hct <31% 24 and 36 mths - Hgb <110 g/L, Hct <31%	Ferritin ≤10 μg/L	9 mths - 1.0 12-36 mths - 0	18 mths - 29 24 mths - 8 36 mths - 2
Gibson et al., 1988	Guelph, Ontario	NR	Caucasian, Preschool, Middle-upper middle SES	4-6	72	—	Ferritin <10 μg/L	—	3
Greene-Finestone et al., 1991	Ottawa-Carlton	1984	Low, middle and high SES	6-18	320	Hgb <110 g/L	Ferritin ≤10 μg/L with Hgb ≥110 g/L	3.5	11
Lehmann et al., 1992	Montreal	1989-90	Low-income, predominantly Caucasian	10-14	218	Ferritin ≤10 μg/L with Hgb ≤115 g/L or MCV ≤70 fL	Ferritin ≤10 μg/L	25	37 (n=62)

NR, not reported; SES, socio-economic status; Hgb, hemoglobin; Hct, hematocrit; ZEP, zinc erythrocyte protoporphyrin; TIBC, total iron binding capacity; MCV, mean cell volume; IDA, iron deficiency anemia.

Table 2.8. Summary of studies on iron deficiency anemia and low iron stores among full-term infants from Caucasian ancestries (continued).

Author, yr of publication	Location	Date of Study	Study Population	Age (mths)	n	Criteria for Iron Status Classification		Prevalence (%)	
						Iron deficiency anemia	Low iron stores	Iron deficiency anemia	Low iron stores
Zlotkin et al., 1996	4 Canadian Cities (Toronto, Halifax, Montreal, Edmonton)	NR	Representative of general population with exception of parents' education (higher)	8.6 - 15.2	428	Hgb ≤110 g/L with ferritin ≤10 μg/L or ZEP ≥100 μg/L	Ferritin ≤10 μg/L	4.3	34
Innis et al., 1997	Vancouver	1993	Predominantly middle and high SES	9	434	Hgb ≤101 g/L, or Hgb ≤111 g/L with 2 or 3 indicators of low iron status from ferritin ≤10 μg/L, TIBC >60 μmol/L, and ZEP ≥70 μmol/mol heme	Ferritin ≤10 μg/L without IDA	8.0	29

NR, not reported; SES, socio-economic status; Hgb, hemoglobin; Hct, hematocrit; ZEP, zinc erythrocyte protoporphyrin; TIBC, total iron binding capacity; MCV, mean cell volume; IDA, iron deficiency anemia.

Table 2.9. Summary of studies on iron deficiency anemia and low iron stores among full-term infants from Chinese ancestries.

Author, yr of publication	Location	Date of Study	Study Population	Age (mths)	n	Criteria for Iron Status Classification		Prevalence (%)	
						Iron deficiency anemia	Low iron stores	Iron deficiency anemia	Low iron stores
Innis et al., 1997	Vancouver	1993	Predominantly middle-class	9	81	Hgb ≤101 g/L, or Hgb ≤111 g/L with 2 or 3 indicators of low iron status from ferritin ≤10 μg/L, TIBC >60 μmol/L, and ZEP ≥70 μmol/mol heme	Ferritin ≤10 μg/L without IDA	4	12
Chan-Yip & Gray-Donald, 1987	Montreal	1977-82	Families of first generation immigrants from China and Southeast Asia	6-36	346	MCV ≤70 fL with at least one other abnormal index (low serum iron, elevated FEP or elevated TIBC and response to iron therapy with a rise in Hgb by ≥10 g/L	—	6-12 mths - 11.4 13-18 mths - 9.9 19-36 mths - 16.5	—
Leung et al., 1988	Hong Kong	1985-86	Random sample from clinic in a low SES area; predominantly bottle-fed	18	123	Hgb 110 g/L with MCV <70 fL (excluding infants with ß -thalassemia trait)	Ferritin ≤7 μg/L	18 mths - 2	18 mths - <1
Chiou et al., 1990	South Taiwan	1986-87	Random sample	6-36	160	Hgb ≤110 g/L with MCV <70 fL	Ferritin ≤12 μg/L or TS < 16% with MCH <24 pg or MCV <72 fL	6-12 mths - 17 12-24 mths - 12 24-36 mths - 10	6-12 mths - 17 12-24 mths - 25 24-36 mths - 35

NR, not reported; SES, socio-economic status; Hgb, hemoglobin; Hct, hematocrit; ZEP, zinc erythrocyte protoporphyrin; TIBC, total iron binding capacity; TS, transferrin saturation; MCH, mean cell hemoglobin MCV, mean cell volume; IDA, iron deficiency anemia.

2.9.3 Socio-economic Status as a Predictor of Risk for Iron Deficiency

Studies in both Canada (Lehmann et al., 1992; Greene-Finestone et al., 1991) and the U.S. (Yip et al., 1992; Sargent et al., 1996) have suggested that a low SES family background places an infant at risk for IDA. Among 320 infants 6 to 18 mths of age in Ottawa-Carlton, only 2-3% from high and middle SES groups had IDA compared with 8.2% from the low SES group (Greene-Finestone et al., 1991). Infants 10 to 14 mths of age from disadvantaged families in Montreal have also been found to have a high prevalence of IDA and low iron stores of 24 and 37%, respectively (Lehmann et al., 1992), while IDA affected <5% of infants 3-36 mths of age from upper-middle class families (Brault-Debuc et al., 1983). The prevalence of iron deficiency in the NHANES I study in the U.S. in 1968-73 was 21% among 12 to 36 mths old infants from low-income families but only 7% among infants from higher-income families (Dallman et al., 1984). Similarly, data from the Centre for Disease Control (CDC) Pediatric Nutrition Surveillance System (PedNSS) in 1980-91 indicated that the prevalence of IDA among low-income children in the U.S. was 20-30% (Yip et al., 1992). However, the high prevalence of IDA reported in these U.S. studies may in part have reflected preferential enrolment and retention of anemic children by public health nutrition programs. Indeed, the national prevalence of IDA reported by Yip et al. (1992) for young children in the U.S. during this same period was 5%. The higher prevalence of IDA among infants from low compared with high SES family backgrounds can reasonably be expected to involve differences in feeding practices and intakes of dietary iron (Greene-Finestone et al., 1991; Lehmann et al., 1992).

2.9.4 Primary Milk Feeding as a Predictor of Risk for Iron Deficiency

Numerous studies have shown a strong association between the risk of iron deficiency and the duration of breast-feeding and the age of introduction and extent of feeding of infant formulas or cows' milk. Numerous clinical studies have shown the efficacy of iron-fortified infant formula in preventing IDA (Moffatt et al., 1994; Daly et al., 1996; Stevens & Nelson, 1995; Irigoyen et al., 1991). Consistent with this, observational studies have shown that infants fed iron-fortified infant formula as their primary milk feeding have a low prevalence of IDA (Innis et al., 1997; Pizarro et al., 1991). In contrast, feeding with low iron formula for more than 4 mths has been associated with a higher prevalence of IDA (Innis et al., 1997). Feeding with iron-fortified, soy protein-based formula has also been shown to be as effective as iron-fortified cows' milk protein-based infant formula in the prevention of IDA during infancy (Hertremph et al., 1986). Early introduction (prior to 6-8 mths of age) (Sadowitz & Oski, 1983; Mills, 1990;

Tunnessen & Oski, 1987) and high intakes (>1 litre) (Sadowitz & Oski, 1983; Mills, 1990) of unmodified cows' milk has also been associated with an increased risk of IDA. The reasons for this include the low iron content and bioavailability of cows' milk, and the risk of occult bleeding from the gut, especially in infants fed cows' milk in the first 6 mths of life (Fuch et al., 1993a; Zeigler et al., 1990; Fomon et al., 1981).

Although the high bioavailability of iron in human milk suggests breast-feeding will protect against iron deficiency, breast-feeding beyond 3-6 mths without the introduction of iron containing foods or supplements is associated with IDA (Siimes et al., 1984; Innis et al., 1997; Calvo et al., 1992; Pizarro et al., 1991; Walter et al., 1993; Willows et al., 2000). Innis et al. (1997) found that 9 mth old infants in Vancouver who were breast-fed for more than 8 mths were at the highest risk for IDA, with a prevalence of 15% compared with a prevalence of only 3% among infants who had been breast-fed <3 mths. The lower prevalence of IDA among infants breast-fed <3 mths was associated with bottle-feeding with iron-fortified formula. A further 30% of all 9 mth old infants breast-fed for >8 mths had low iron stores without IDA (Innis et al., 1997). At least 5 other large studies have reported similar rates of IDA among breast-fed infants in the 2nd 6 mths of life (Siimes et al., 1984; Calvo et al., 1992; Pizarro et al., 1991; Walter et al., 1993; Willows et al., 2000). Together these studies suggest that current strategies for supporting adequate iron nutrition while maintaining breast-feeding are less than ideal. Several studies have found that mothers in Canada who breast-feed for longer durations tend to be Caucasian and of higher SES (Beaudry & Aucoin-Larade, 1989; Myers, 1983; Williams et al., 1996). However, an association between breast-feeding and IDA has also been found in 9 mth old Cree infants of lower SES in Northern Quebec (Willows et al., 2000). Despite the apparent increased risk of IDA associated with longer durations of breast-feeding, it is important to note that the majority of infants breast-fed beyond 3-6 mths, i.e. 85%, did so without developing IDA (Innis et al., 1997). It is not clear why some infants who are breast-fed beyond 3-6 mths develop IDA while others do not, and whether variables such as the age of introduction, duration and quantity of feeding of infant formulas, cows' milk or complementary foods can predict whether a breast-fed infant is at risk of IDA.

2.9.5 Intake of Complementary Foods as a Predictor of Risk for Iron Deficiency

The rationale for promoting cereal for iron nutrition in young infants seems to be based on its suitability as a vehicle for fortification (i.e. low cost, shelf stability), ease of preparation, low renal solute load and potential allergenicity, nutritional content and tradition as a weaning food in many populations (Hendricks & Badruddin,

1992; Walter et al., 1993; Krebs, 2000). A large double-blind trial by Walter et al. (1993) found a prevalence of 15% IDA among 8 mth old infants who were breast-fed to 4 mths of age and fed an unfortified infant cereal compared with 3% for those fed an iron-fortified cereal. Similarly, the prevalence of IDA among infants fed low iron formula and unfortified infant cereal was 15% compared with 6% for those fed the iron-fortified infant cereal. By 15 mths of age the prevalence of IDA among breast-fed infants fed the unfortified cereal was 27% compared with 12% among those fed the iron-fortified cereal, and 24% among infants fed low iron formula and unfortified cereal compared with 8% among infants fed low iron formula and iron-fortified infant cereal. Walter et al. (1993) reported that breast-fed infants consistently consumed lower amounts of cereal, with a mean of 20 g at 6 mths and 25 g at about 8 mths, than formula-fed infants who, all except for 20%, maintained an intake of 30 g/day from within 3 weeks of the initiation of cereal at 4 mths of age. A large inter-individual variation in the amount of cereal actually consumed among infants may in part explain why 12% of the breast-fed and 8% of the low iron formula-fed infants studied by Walter et al (1993) had developed IDA (Hgb<105 g/L) by 15 mths of age, despite having been fed iron-fortified infant cereal. The intakes of cereal in the latter study, however, may have been higher than would be expected in free-living infants, since the infants were visited weekly by a nutritionist and cereal consumption was encouraged. Information on the intake of iron-fortified cereal among Canadian infants has not been published since the 1991 publication of guidelines by the CPS Nutrition Committee aimed at the prevention of IDA. In 1981, a mean intake of 18-20 g infant cereal/day was reported by Yeung et al. (1981) for infants 3 to 10 mths of age in Toronto and Montreal who consumed cereal. However, approximately 10% of infants 5 to 8 mths and 25% of 10 mths of age were not fed infant cereals. Similarly, studies in the U.S. found that only 73% of infants 6-12 mths of age were fed infant cereals, with an average consumption of 19 g/day for these infants (Gerber Infant Nutrition Survey, 1989). The large inter-individual variation in the amount of cereal consumed by infants (Yeung et al., 1981; Gerber Infant Nutrition Survey, 1989; Walter et al., 1993), in addition to the poor bioavailability of the iron are reasons to question the efficacy of iron-fortified infant cereal as a public health strategy for the prevention of IDA (Fomon, 1987; Canadian Task Force on Periodic Health Examination, 1979; Fuch et al., 1993b). Studies have reported an increased risk of IDA among infants fed iron-fortified cereals for < 6 mths (Lehmann et al., 1992) and <3 mths (Greene-Finestone et al., 1991) compared with those fed iron-fortified cereals for longer durations.

The results of several studies suggest that late introduction (>9 mths) (Requejo et al., 1999) and inadequate intakes of MPF (Mira et al., 1996; Engelmann et al., 1997) may be important predictors of risk iron deficiency.

Using a case-control design, Mira et al. (1996) found that the mean daily intake of heme, but not non-heme iron, was lower in iron depleted than in iron replete infants (0.28 mg/day and 0.42 mg/day, respectively). Similarly, Engelmann et al. (1997) demonstrated that despite similar intakes of total iron, infants who consumed 27 g meat/day maintained their Hgb concentrations, whereas infants who consumed 10 g of meat/day had a significant decreases in their Hgb. Regular consumption of iron-fortified complementary foods containing meat have also proved to be effective in preventing iron deficiency in infants fed low-iron formula (Haschke et al., 1988). In contrast to these studies, Lwanga (1996) found no association between the ages of introduction of iron-fortified infant cereal or meats and the prevalence of IDA among 9 mth old infants (Lwanga, 1996; Innis et al., 1997), however, no data on the durations of feeding or the quantities of cereals or meats consumed among the 9 mth old infants were collected. Thus, whether inadequate quantities or duration of feeding are the reason that some breast-fed infants develop IDA while others do not is unknown.

2.10 Strategies for Prevention and Detection of Iron Deficiency in Infancy

There are essentially 2 approaches for addressing the problem of IDA in infancy: primary and secondary prevention. Primary prevention involves providing additional iron to the population at risk, whereas secondary prevention involves the early detection of infants at risk for IDA through screening and subsequent iron therapy. Considering the uncertainty over whether the effects of IDA on cognitive development are fully reversible, primary prevention of IDA is indisputably the safest and most prudent approach. However, identification of infants at risk for IDA is also important, particularly if those at risk can be identified prior to the onset of anemia.

2.10.1 Strategies for Primary Prevention of IDA

Several primary prevention strategies can be used to address IDA in a developed country such as Canada: increasing the iron content of the diet by fortifying selected food products, providing iron supplements to individuals at risk (Yip, 1997), and decreasing behaviors that place individuals at risk. The success of these approaches depends on the strategies available for ensuring that the recommended feeding practices and food sources of iron are affordable, accessible and culturally acceptable for all parents, acceptable to all infants, and that the strategies are effective in preventing IDA. Interventions based on food fortification are feasible in settings where the use of

commercially prepared products for infant feeding is common. Iron supplementation is appropriate where iron-rich or iron-fortified complementary foods for infants are not available or affordable (Yip, 1997). As a public health strategy, routine supplementation of all infants with iron may not be appropriate. Supplementation with 3 mg ferrous sulfate/day in infants with normal iron stores has been found to result in an increased incidence of infection and reduced growth (Idradinata et al., 1994). Further, although not thought to be a concern during infancy, the prevalence of heterozygous idiopathic hemochromatosis is estimated to be one in 300 among individuals of Caucasian ancestry and increasing iron intake has been shown to accelerate progression of the disease (Cook et al., 1992). The risks involved with supplementing iron replete infants could be avoided by supplementing only those identified with a proven deficiency (Cook et al., 1992), however, strategies for identifying infants with poor iron status are currently lacking.

Although strategies for appropriate fortification of foods with iron are safe and cost effective, current strategies may not be adequately addressing the problem of IDA among certain groups of infants in Canada. Primary prevention efforts aimed at decreasing the prevalence of IDA in Canada have included the fortification of infant cereals and formulas with iron, and the education of parents and medical professionals to promote exclusive breast-feeding for at least 4 mths, use of iron-fortified formula for infants not breast-fed, or in those receiving formula as well as breast milk, introduction of iron-fortified infant cereals at 4-6 mths of age, introduction of cows' milk not prior to 9-12 mths of age, and continued use of iron-fortified foods beyond one year of age (CPS et al., 1998). While the WIC program in the U.S. provides iron-fortified infant formula and cereals directly to infants from disadvantaged family backgrounds, Canada has no universal program that provides iron-fortified products to infants at risk for IDA. Although recent studies suggest that, in general, infants are fed according to current feeding guidelines (Williams et al., 1996; Kwavnick et al., 1999), the high prevalence of IDA among certain subgroups suggests that the CPS guidelines may not be being followed among certain groups of infants. However, recent data on the feeding practices of infants at risk for poor iron status are lacking. This information is needed to improve infant feeding recommendations and public education aimed at the prevention of IDA.

2.10.2 Strategies for Secondary Prevention of IDA

The Canadian Task Force for Periodic Health Examination (1994) concluded that there is insufficient evidence to recommend the inclusion or exclusion of routine Hgb determination for infants not considered being

"high risk". However, the Task Force recommended that physicians take particular care to determine the nutritional intake of infants at high risk and consider screening with a blood test at 6-12 mths of age, perhaps optimally at 9 mths of age (Canadian Task Force for Periodic Health Examination, 1994). "High-risk" infants include infants of low SES, Chinese or aboriginal ethnic origin, low birth weight (<2500 g), and infants fed only cows' milk during the first year of life. These "high risk" groups were defined on the basis of a higher prevalence of IDA and a greater likelihood of inability to consume iron-fortified products (Canadian Task Force for Periodic Health Examination, 1994). Similarly, CPS et al. (1998) recommend that a blood test be done for infants 6 to 8 mths of age for whom parents choose not to adhere to the current feeding guidelines. Currently, no standardized, validated method of assessing an infant's risk of IDA based on feeding is available to determine the need for a blood test as recommended by CPS et al. (1998) and the Canadian Task Force for Periodic Health Examination (1994).

Strategies for the early detection of infants at risk for IDA could play an important role in reducing IDA by enabling identification of infants prior to development of anemia and allowing resources to be targeted to the infants most at risk. There are potential problems, however, with the approach of early detection of infants at risk for IDA. Clearly, accurate identification of infants at risk of IDA, appropriate investigative follow-up, the effectiveness of subsequent prevention or therapy are essential (Beaglehole et al., 1993; Sackett, 1975). The method of identification should result in few false positives, and more importantly, few false negatives. Although assessment of the infant diet may provide a means of predicting risk for IDA (Pizarro et al., 1991; Boutry & Needlman, 1996), routine screening of the diet as a first stage, followed by a blood test for high risk infants may not be the usual practice of all physicians. Most screening programs are carried out sporadically and rarely capture more than 5-10% of those eligible (Sackett, 1994; James et al., 1997). Mills (1990) and James et al. (1997) provided evidence that the invasiveness of a blood test was not acceptable to all parents with an infant who otherwise appeared healthy. Moy & Auckett (1997), however, have suggested that a screening program aimed at 21 mth old children deemed by socio-demographic and ethnic minority factors to be at high risk for IDA was highly acceptable to 64% of the parents of the infants the program reached. Thus, a blood test following and based on assessment of the adequacy of diet may be acceptable for Canadian parents and physicians. Currently in Canada, infants with IDA are identified in a clinical setting if IDA is suspected, or from the results of a blood test for problems unrelated to the IDA. The usual practice is to screen with a CBC and, in the case of abnormal red cell indices indicative of anemia, confirm the diagnosis by measurement of ferritin or, alternatively, a trial of iron therapy (Canadian Task Force on Periodic Health

Examination, 1994).

For public health purposes, a dietary assessment tool to detect infants at high risk for IDA should be easy to administer, simple for parents to fill out, or health professionals to administer, reproducible and accurate. Boutry & Needlman (1996) assessed the usefulness of a brief dietary history as a screening tool for microcytic anemia (Hgb <110 g/L and MCV <75 fL) in a group of low-income, African-American infants aged 13 to 60 mths who had previously received nutritional support from the WIC Program. In the latter study, infants were classified retrospectively, based on documentation of a brief dietary history taken in the course of primary care visits, as 'dietary deficient' if they ate <5 servings each of meat, grains, vegetables and fruits/week, drank >16 ounces of milk/day, ate any fatty snacks or sweets, or drank >2 glasses of pop/day. In this study, 8% were found to have microcytic anemia. This classification of dietary deficiency had a sensitivity of 71% and a specificity of 79%, although the negative predictive value was 98%, and the positive predictive value was only 9%. The dietary screening tool of Boutry & Needlman (1996) was recently re-evaluated in a parent-completed dietary and health history format for infants 9-30 mths in inner city clinics in Baltimore City. This study by Bogen et al. (2000) also evaluated 15 other dietary items in the domains of infant diet, intake of solid food, intake of beverages, and participation in the WIC Program, together with 14 historical items in the domains of birth history, past health, and maternal and family history. Neither individual nor combinations of parental answers were able to predict IDA, anemia, or iron depletion well enough to serve as a screening test. A nutritional screening tool called the PEACH survey developed to detect children with nutrition or feeding problems from birth to 5 years was designed to detect behavioral feeding problems, rather than iron deficiency (Campbell & Kelsey, 1994). Whether a brief dietary assessment tool, and the dietary factors that should be included could be of value for detecting infants from Caucasian and Chinese ancestries at risk for IDA, is not known. Development of such a tool first requires a better understanding of the current dietary factors and feeding practices associated with IDA among Caucasian and Chinese infants at risk for IDA.

2.10 Research Instruments for Assessing Dietary Intakes in Infancy

Published information on the development and use of dietary assessment instruments in infancy and early childhood is limited, particularly in the area of iron nutrition. Although there is an abundance of comparative

studies, there are no universal criteria for selecting the most appropriate dietary assessment instrument for use in infancy (Frank, 1994; Willett, 1998). In general dietary assessment instruments fall into 2 categories: those based on memory (e.g. 24-hour recall, food frequencies and dietary histories) and those based on recording of actual food consumed (e.g. direct observation and dietary records). Methods based on the direct observation or recording of food consumed are better suited to providing quantitative information on an individual's intake and are considered the gold standard against which other methods are compared (Thompson & Byers, 1994; Willett, 1998). The selection of dietary assessment instruments requires consideration of factors such as the need for surrogate reporting, participant access and burden, and the usual practices and daily routines of the participants. Rapid changes in feeding practices and food habits and a high degree of intra-individual variability that increases with age (Black et al., 1983; Miller et al., 1991; Harbottle & Duggan, 1994) are characteristic of infancy, and pose additional challenges for measuring dietary intakes in this age group. Unless direct observation is being used for dietary assessment, data from other sources including surrogate reporters (often more than one and both within and away from home) is necessary (Rockett & Colditz, 1997; Baranowski, 1994; Frank, 1994) for infants. Determining the intake of breast milk in the breast-fed infant poses additional challenges. Estimating the intake of table foods may not be straightforward either as infants may eat only a small portion of the food offered. Establishing the validity and reliability of dietary intakes is often a difficult task since a "true picture" of a child's intake is often beyond reach (Persson & Carlgren, 1984).

Direct observation of dietary intakes involves considerable cost and effort and may introduce a social-desirability bias. The dietary record methodology is well-known to underestimate intakes (Thompson & Byers, 1994), requires a large number of days to quantify intakes, and is associated with increased cost, time, poor response rates, and decreased quality of recording as the number of days increase, particularly towards the end of a recording period (Persson & Carlgren, 1984). Dietary records may also cause changes in the types and quantity of food eaten (Barrett-Connor, 1991). In addition, dietary records are subject to bias towards more motivated and literate participants (Harbottle & Duggan, 1994). Dietary records, particularly those that are weighed and/or for greater than 3 days duration, have the highest refusal rate and highest percentage of subjects with unusable data (Willett, 1998). Generally, one or more days with a sample of at least 60 subjects, however, can adequately characterize a group (Farris & Nicklas, 1993). Training by both participant and interviewer, and contact and review of the dietary record on the 2nd day of recording and one day following recording to clarify and probe for forgotten foods has been shown

to enhance the accuracy of food records (Bolland et al., 1988). Because of this, dietary records are very labor intensive in terms of administration, quality control and data entry, and as a result, are very costly. Despite these limitations, dietary records are typically considered to be the referent standard for data on the intake of many nutrients (Jacques et al., 1993).

Diet histories can be used to determine usual food intakes, providing details about the characteristics of foods as consumed, and the frequency and amount of food intake. However, diet histories traditionally are meal-based, and this has limited use in infancy when defined meals are not usually eaten. The brief dietary assessment is another method that can be used to determine specific food consumption behaviors. Such measures are not quantitatively meaningful, do not encompass the whole diet, and do not allow estimates of dietary intake. Despite this, brief assessment methods have considerable application for determining feeding practices and food consumption patterns in infancy.

Food frequency questionnaires (FFQs) and 24-hr recalls have the disadvantage of the potential for individuals to inaccurately report food consumption for reasons related to memory and the interview situation. An assessment of the agreement between 12-hr observation and 12-hr recall reports of dietary intake and the mother's monthly reports of usual feeding practices in 131 low-income Peruvian infants found that consumption during the past 12-hr observation and 12-hr recall was not an accurate method to classify infant feeding practices. Exclusive breast-feeding in infants younger than 4 mths was observed 25% more often than reported, while non-human milk consumption was reported 30% more often than observed. Most of the disagreement between reported and observed practices could have been due to daily variations in feeding practices as the time periods of measurement differed (Piwoz et al., 1995). The authors suggested that single day studies may be misleading and that the current WHO recommendations regarding the use of single day, 24-h recall methods to assess infant feeding practices be reconsidered. The use of food frequency or diet history questionnaires may have a higher degree of reliability and validity, be easier to administer and more accurate (Willett, 1998). FFQs minimize respondent and administrative burden, are useful for describing average dietary intakes and ranking individuals according to their usual consumption of foods, groups of foods, and nutrient intakes, and for assessing the association between dietary intake and disease (Willett, 1998; Frank et al., 1992; Rockett et al., 1995; Blom et al., 1989). However, FFQs do not provide an accurate estimate of actual levels of intakes (Thompson & Byers, 1994). Comparison with dietary records is considered to be the best way to establish the relative validity of a FFQ because these 2 dietary assessment

methods are likely to have the fewest correlated errors (Willett et al., 1985). However, the tendency to misreport food intake and the errors inherent in the use of food composition data may be similar for both FFQs and 3d-FRs. The potential for correlated errors associated with the estimation of iron status from dietary and biochemical measures are much more likely to be independent (Jacques et al., 1993; Willett, 1998), although there are also a number of limitations associated with biochemical validation of dietary instruments. Dietary and biochemical indices measure 2 different things, the intake and circulating concentrations of a nutrient, respectively. Since biochemical indices of iron status are influenced not only by iron intake but other dietary and non-dietary factors, a correlation between a reported iron intake and an objective biochemical marker of iron status can be interpreted as the lower bound of the true questionnaire validity (Jacques et al., 1993).

Rapid growth and development are characteristic of infancy and early childhood and, result in greater intra-individual variations in food and nutrient intakes than for adults (Miller et al., 1991). Intra-individual variability in intakes influences the number of days required to accurately estimate food and nutrient intakes. In early infancy, when breast milk and infant formulas are the primary milk feedings, the variability in nutrient intakes is low. Variability can be expected to increase, however, with the progression of weaning and the introduction of complementary foods (Black et al., 1983). Based on weighed intake data from a one year cross-sectional survey of Indo-Asian children (4-40 mths of age), it has been estimated that 3-5 days of recording are needed to classify children for iron intakes, while 2 days are needed to classify children for vitamin C intakes (Harbottle & Duggan, 1994).

Research concerning iron nutrition in infancy and detection of infants at risk for iron deficiency has been hampered by the lack of dietary assessment instruments that measure the dietary intakes and sources of iron and inhibitors and enhancers of iron absorption, and are predictive of an infant's risk of IDA. Although FFQs for assessing iron intake have been developed and validated for use with adults (Willett et al., 1987), studies on the use of FFQs during infancy have not been published.

CHAPTER 3. DESIGN AND METHODS

3.1 Study Design and Ethical Approval

This was a cross-sectional study of the feeding history, food and nutrient intakes and socio-cultural background of full-term infants 8-26 mths of age from Caucasian and Chinese ancestries in relation to their iron status. The study protocol and procedures were approved by the University of British Columbia (U.B.C.) Screening Committee for Research Involving Human Subjects (**Appendix A**).

3.2. Development and Use of Dietary Assessment Instruments

For the purpose of this study, 3 dietary assessment instruments were developed. These instruments were a 36-item, 13-page Socio-Cultural and Infant Feeding Questionnaire (**Appendix B**), a 3-day Food Record (3d-FR) Package (**Appendix C**), and a 191-item, 25-page Food Frequency Questionnaire (FFQ) for Parents of Infants 8 to 26 mths of age (**Appendix D**). The Socio-Cultural and Infant Feeding Questionnaire was developed to examine the relations between feeding history and socio-cultural background with the risk for IDA and low iron stores. No FFQs designed to assess iron nutrition are currently available; thus the FFQ was developed to fill this gap in pediatric dietary assessment methodology. The FFQ was designed to identify trends in major food group consumption and to examine the value of the assessment of the intakes and food sources of energy, iron and other dietary factors influencing iron absorption to identify infants at risk for IDA. The 3d-FR was chosen as the best available comparison dietary assessment method, and for the purpose of quantifying dietary intakes of iron (total, heme and non-heme) and other dietary factors associated with risk of IDA and low iron stores. These dietary assessment instruments were also chosen to achieve a balance between minimizing respondent burden and maximizing the validity and precision of the assessment of food and nutrient intakes.

3.2.1. Food Frequency Questionnaire (FFQ)

An interview-administered FFQ was developed for the purpose of collecting information on the dietary intakes and consumption of foods from food categories representing the major sources of iron and other dietary factors that influence iron absorption, as well as provide a comprehensive assessment of energy intake. The FFQ was developed to be culturally relevant for infants 8 to 26 mths of age from Caucasian and Chinese ethnicities, and from vegetarian and

non-vegetarian families using techniques described by Teufel (1997) for improving the cultural competency of a dietary assessment tool. Input from the target groups was obtained during the development of the FFQ for the purpose of compiling a culturally relevant food list, identifying culturally specific food preparation techniques and recipes and culturally appropriate portion sizes, and to enable development of a culturally-specific food composition database. Face validity was addressed by consultation with Dietitians/Nutritionists from the Vancouver Health Department and British Columbia's Children's Hospital who work with Caucasian, Chinese and vegetarian families. Then, the FFQ was pre-tested with 12 parents who represented the target groups. The parents who participated were asked to complete the FFQ, then give their input on the appropriateness of food items, food groups and portion sizes. Following this, a pilot study (below) was conducted, during which the FFQ and a 3d-FR were completed by 30 parents who again represented the target groups of the study. Research nutritionists who could speak Cantonese, Mandarin and English were employed to increase the cultural competency of the data collection and analysis.

The FFQ consisted of 191-items considered to represent the major dietary sources of energy, iron and dietary factors that influence iron absorption and that would be eaten by infants of 8-26 mths of age. The following approaches were used to select food items for inclusion in the FFQ: 1) foods high in iron and containing factors known to influence iron absorption were taken from food lists from existing Canadian (i.e. Ontario Health Survey FFQ, Bright-See et al., 1994) and U.S. (i.e. Harvard University FFQ, Harvard Eating Survey for Children, National Health and Nutrition Examination Survey III FFQ, Thompson & Byers, 1994) FFQs, published literature (Monsen & Balintfy, 1982; Monsen et al., 1978; Fairweather-Tait, 1989; Hazell, 1985; Lynch & Hurrell, 1990) and food composition tables (Pennington, 1994; Holland et al., 1990; Stewart & Stewart, 1990; Health & Welfare Canada, 1989), and 2) foods and food categories that are lower in iron and factors known to influence iron absorption but contribute to total energy and nutrient intakes, irrespective of their relevance to iron nutrition. Examples of foods and/or brand names were provided with each food item in the FFQ to help clarify for the parents what foods should be included in that category. An open-ended question at the end of each food group section allowed parents to report any other foods eaten but not listed on the questionnaire.

The FFQ was designed to record if a particular food had been consumed in the preceding 2 weeks, and if so, the number of times per day or per week, and the quantity usually eaten. Portions were recorded as one of 3 appropriate standard size servings, e.g. whole milk: ¼ cup (2oz), ½ cup (4oz), and one cup (8oz). An open box was also provided to allow recording of a portion size other than those given. The FFQ also included questions to obtain the following information: 1) whether or not the infant was breast-fed or fed a human milk substitute at the time of the study, 2) the

frequency and usual duration of any breast-feedings, 3) the frequency and amounts of any human milk substitutes fed, 4) the types of milk feedings fed during each mth from birth to the time of the study, 5) the use of vitamin and mineral supplements given since birth to the time of the study.

A Microsoft Access (Version 2.0, Redmond, WA) database was specifically designed to analyze the dietary information collected using the FFQ through consultation with the Centre for Evaluation Sciences at B.C.'s Children's Hospital and ESHA Research (Salem, Oregon). This database is referred to as the "FFQ Analysis Database". The FFQ Analysis Database was designed to enable entry of the FFQ data as recorded, thus preserving data on usual food consumption frequency and portion sizes, and to create a database that could be imported into the Food Processor (FP®) for Windows Nutrition Analysis & Fitness Software (ESHA Research, Salem, Oregon) database for calculation of average daily food and nutrient intakes.

3.2.2. 3-day Food Record (3d-FR) Package

A 3d-FR was developed to collect detailed information on each infant's dietary intake during a 3-day period. This package had 4 components: 1) Guidelines on Keeping a Food Record, 2) Food Record Examples, 3) 3 Blank Food Record Forms, and 4) Portion Size Tools (**Appendix C**). The guidelines included instructions on how to record the times and places of eating, and how to describe the foods and beverages eaten, and the quantities (volume, weight or size) actually eaten. Parents were also asked to record the type(s), brand name(s) and the amount(s) of any vitamin and/or mineral supplements given, to record if this was a typical day for their child and if not, the reason(s), and to provide any other relevant comments.

3.2.3. Food Composition Database

The FP® was chosen as the nutrient analysis program because it contains an extensive database of Canadian and infant foods and has been rated as one of the best for research purposes (LaComb et al., 1992; Lee et al., 1995). The food composition data used in this study were derived primarily from the Canadian Nutrient File Release (1997) with some additions from USDA NDA Release No. 11, and is abbreviated as the ESHA Database. There were approximately 250 foods recorded on the 3d-FRs for which there were no comparative foods in the ESHA Database. Food composition data for these foods were obtained from Pennington (1994), Chinese Food Composition Tables (Stewart & Stewart, 1990) or the manufacturers. The food was then assigned a USER code, and the nutrient composition was added to the

FP® database. Another 146 composite food items recorded on the FFQ could not be adequately represented by single, pre-existing foods in the ESHA database. Thus, a list of foods that represented these food items was created and was termed "FFQ composite" food list. An example of a FFQ composite food list for the food item "Mixed Dishes made with Beef" is shown in **Appendix E**. The analysis of each FFQ composite food provided nutrient composition data, and this nutrient composition was then assigned a USER code and added to the FP® database (**Appendix E**). A complete list, including the assigned USER codes of all foods for which food composition data were generated and then added to the database is shown in **Appendix F**.

3.2.4. Socio-Cultural and Infant Feeding Questionnaire

The Socio-Cultural and Infant Feeding Questionnaire was developed for the purpose of collecting information on the family socio-cultural background and the infant's nutritional history. This questionnaire was based on 2 questionnaires that had been designed to collect information on family background and nutritional history in previous research with infants at 9 mths of age (Lwanga, 1996). A socio-cultural section of the questionnaire was designed to collect information on demographic characteristics and family dietary practices that might allow for identification of infants at risk for IDA or low iron stores. This section included questions on the parent's age, present living arrangement and marital status, highest level of education attained, usual occupation, ethnic background, race, number of children in the household, annual family income, the number of years the parents had lived in Canada, language spoken at home, ethnic food practices, foods excluded from the family diet, and any special dietary practices. The infant feeding history section of the questionnaire was designed to collect retrospective and current information that would allow for identification of feeding practices that might be associated with IDA or low iron stores. This section included questions on the duration of breast-feeding, the age of introduction and types of infant formula (low iron or iron-fortified), cows' milk (whole, 2%, 1%, or skim) or other milks (goats' milk, soy milk, etc.) fed from birth to the time of the study, and the types and amounts of infant formula(s), cows' milk or other milk(s) currently fed. The infant feeding section also included questions on the age of introduction, duration of feeding and, where applicable, reasons for stopping feeding of complementary foods including cereals, rice, pasta, breads/crackers, vegetables, fruits, legumes, dairy, other animal products (e.g. eggs, meat, poultry or fish) and fruit juices. This questionnaire also had questions on the type(s) of infant cereal(s) introduced, the liquid(s) used to prepare infant cereals, and for those who had not yet introduced infant cereal, the reasons for not introducing an infant cereal. Parents were also asked to rate the nutritional quality of their infant's

diets, and eating habits, and provide information on childcare outside the home and the individuals involved in the infant's food preparation.

A Microsoft Access (Version 2.0, Redmond, WA) Database was designed in consultation with the Centre for Evaluation Sciences at B.C.'s Children's Hospital specifically for analysis of the Socio-Cultural and Infant Feeding Questionnaire that would enable entry of the data as recorded and allow transformation to a computer spreadsheet.

3.2.5. Validating the Dietary Assessment Instruments

Several steps were taken to increase the face and content validity of the instruments. Local experts in nutrition and pediatrics, i.e., Vancouver Health Department Public Health Nutritionists, B.C.'s Children's Hospital Department of Nutrition Services, and Dr. Susan Barr, Faculty of Agricultural Sciences, U.B.C. were consulted to review the content validity of the questionnaires. Experts in survey design and statistics, Ruth Milner, Health Care & Epidemiology, U.B.C., and Thomas Lam (Computer Programer) and Laurie Ainsworth (Statistician), Centre for Evaluation Sciences, B.C. Research Institute for Children's & Women's Health were consulted to review the design and analysis of the dietary assessment instruments. These reviews were used to further refine the dietary assessment instruments. All the instruments were translated into Chinese (**Appendix G, H, I**), and then back into English by an independent, 2nd individual to ensure accuracy of the translation and cultural-specificity. The instruments were then pre-tested with 12 parents representative of the target populations to address face and content validity, and to ensure that they were clear. Parents were asked to complete the questionnaires and to give constructive criticism on content, clarity and appropriateness of the questions, their willingness to complete the questionnaires, and if there was anything they thought should be added. This pre-test led to several changes in the questions and wording. The revised questionnaires were then circulated for comments to the City of Vancouver Public Health Nutritionists and final revisions were made. The research nutritionists employed to assist with this study were trained to ensure consistent administration of the research instruments. Three of the research nutritionists involved in the data collection, development of the culture-specific food composition database and the data entry phases of this study were of Chinese ancestry and were fluent in Cantonese and Mandarin, in addition to English.

A pilot study with a sample of 30 parents with infants of similar age and with a similar socio-cultural background to those who would be included in the study population was undertaken from August 1995 to January 1996. The purpose of the pilot study was to ensure that the dietary assessment instruments and study protocol could

be understood and completed by the target groups. The intent of the pilot study was to identify areas of difficulty and ensure that the experience of completing each phase of the study was a positive one. Parents for participation in the pilot study were recruited from parent and infant/toddler groups offered at health units, community centres and neighbourhood houses throughout the City of Vancouver. Recruitment sites for the pilot study included Sheway Community Project for Women and Children, UBC Family Housing, and the North and South Health Units of the Vancouver Health Department. A 24-hour recall was conducted by interview with the parent and recorded on a blank food record form. This 24-hour recall procedure was used to instruct the parents on how to keep the 3d-FR. During the following week, the parents completed a 3d-FR. One week later, the FFQ was completed by a face-to face interview. Using this protocol, the 2 weeks covered by the FFQ included the 3 days over which the 3d-FR was recorded. The reliability of the dietary assessment instruments was not formally assessed.

3.3 Subjects

3.3.1. Participant Identification and Selection Criteria

A sample of infants for participation in the study was systematically identified using birth lists provided by the City of Vancouver Public Health Department. Parents' names, addresses, phone numbers and the infant's name and date of birth were provided on the birth lists. Infants who would be 9±1, 15±2 or 24±2 mths of age during the dates of the scheduled research clinics were identified from the birth lists. Infants were recruited from these 3 age groups to examine the risk of IDA and low iron stores by age from about 8 to 26 mths of age. Infants from Caucasian and Chinese family backgrounds were targeted using the family surname given on the birth list. The selection criteria were that the infant was born to parents resident in Vancouver, with an address to enable contact. Exclusion criteria included prematurity (gestational age <37 weeks), birth weight <2500 or >4500 g, history of serious or confounding illness (e.g. sickle cell anemia, blood clotting disorders, chronic bowel disease, liver disease, endocrine deficiency, blood loss, hemolytic disease, bone marrow depression, polycythemia, erythrocytosis, exposure to lead or other toxins, malignancy, chronic or congenital disorders), or a history of major surgery. For the purpose of this study, birth weights were rounded to the nearest 50 grams. Infants were also excluded if the parent was unable to speak sufficient English, Cantonese or Mandarin to allow competent completion of the informed consent and study instruments.

3.3.2. Participant Recruitment

A total of 1585 infants who would be 8-10, 13-17 or 22-26 mths of age during the dates of the scheduled research clinics were identified from the birth lists and assigned a 4-digit identification number. A letter in English and Chinese (**Appendix J and K**) was mailed to the parents of all these 1585, potentially eligible infants, using the address on the birth lists. This method of recruitment was chosen because telephone is not acceptable to the Vancouver Health Department or the U.B.C's Screening Committee for Research Involving Human Subjects as a method for first contact of research study participants. The letter sent described the study and invited parents to participate by attending a clinic offering assessment of their infant's diet and iron status. The letters were sent about 2 to 3 weeks before a potential nutrition research clinic appointment. The letter was followed by a telephone call by a trained research nutritionist approximately one week later to ask if the parent had received the letter and if they were interested in participating in the study. If the parent was interested, the eligibility criteria were reviewed with the parents. If the infant met the eligibility criteria, the requirements for participating in the study were described in detail. If the parent agreed to participate, an appointment was made to attend a scheduled clinic at a time suitable for the parent. At least 3 attempts were made to reach each infant's parents. No attempt was made to contact parents for whom a letter had been returned due to a wrong address because U.B.C. ethical approval required that parents be contacted by letter first. Eligible infants were also recruited from parent and infant/toddler groups held at health units, community centres, neighbourhood houses and immunization clinics in the City of Vancouver through collaboration with the Vancouver Health Department Public Health Nutritionists and Nurses. This allowed participation of infants meeting the eligibility criteria for whom the parents had not received the study letter. The parents attending the infant/toddler groups were asked by the Public Health Nutritionist or Nurse running the group if they would be interested in receiving information on an infant nutrition study. Upon the group's approval, the study was explained in person to the parents by the research nutritionist (PLW), and parents with eligible infants were invited to participate.

Parents who had made an appointment to attend a nutrition research clinic were telephoned one-day prior to the scheduled appointment as a reminder. At that time, the parent was asked if the infant had had any illness within the previous week, was taking any medications (e.g. antibiotics), or if there was any reason they could not attend the appointment. Those infants who had been ill in the previous week, were taking medication, or were unable to attend the appointment were rescheduled where possible. The infant's physician's name, telephone number and mailing address, birth anthropometric measures and parent's mailing address were requested and recorded on the personal data form

(**Appendix L**) during the telephone call just prior to the scheduled appointment. If the parent was not able to provide the information during the telephone call, they were asked to bring it to the clinic appointment.

3.3.3. Clinic Scheduling

Research clinics were set up at health units, community centres and neighbourhood houses at various locations throughout Vancouver to facilitate recruitment of a representative sample of the study target populations. Initially a series of 6 clinics was scheduled from February to March 1996. These clinics were at West Main Health Unit (February 6th, 1996), Kitsilano Community Centre (February 24th, 1996), Brittania Community Centre (March 9th, 1996), East Health Unit (March 18th, 1996), South Health Unit (March 22nd, 1996), and Mount Pleasant Health Unit (March 27th, 1996). A 2nd series of 5 clinics was scheduled from May to July 1996 to facilitate a greater representation of Chinese and vegetarian families. This 2nd series of clinics was held at South Health Unit (May 31st, 1996), Kiwassa Neighbourhood House (June 8th, 1996), East Health Unit (July 10th, 1996), South Health Unit (July 12th, 1996) and Kitsilano Community Centre (July 20th, 1996). Parents willing to participate but unable to attend a scheduled clinic were seen either in their home or at B.C.'s Children's Hospital. Clinics were scheduled as a full-day or half-day (morning, afternoon or evening), on week days, or as a morning or full-day clinic on weekends, each lasting 3-11 hours, with one infant seen each half-hour. Refreshments and volunteer childcare were provided. Transportation to and from the clinics was offered for parents without available transportation.

3.4. Data Collection

3.4.1. Socio-Cultural and Dietary Data

At the clinics, the study was explained to parents and informed, written consent was obtained (**Appendix M**). The 4-digit number previously assigned to each infant in the recruitment process was used on all blood tubes and the Socio-Cultural and Infant Feeding Questionnaire to ensure confidentiality of the laboratory and socio-cultural data. Any personal data not previously obtained was collected and recorded on the personal data form (**Appendix L**). Parents were then asked to complete the Socio-Cultural and Infant Feeding Questionnaire. The socio-cultural section of this questionnaire was not reviewed with the parents after completion for reasons of confidentiality. Following this, a trained nutritionist conducted a 24-hour dietary recall of the infant's intake during

the previous day (12:00 am to 11:59 pm) with the parent by a face-to-face interview and recorded the information on a blank food record form. This 24-hour food recall procedure was used to instruct the parents on how to keep the 3d-FR through illustration of how to record all foods and beverages consumed and how to describe items and portion sizes in sufficient detail. Food pictures, plastic food models, measuring utensils and containers of common commercial infant foods and serving dishes were used to instruct the parents on how to record portion sizes. Parents were then instructed to keep a record of all foods and beverages consumed by their participating infant over 3 consecutive days, one of which was to be a Saturday or Sunday. Parents were asked to provide detailed descriptions, including brand names, methods of preparation and recipes whenever possible, of all foods and beverages consumed by their infant. Parents were given the 3d-FR package, standardized plastic measuring utensils and weighing scales to take home and asked to record their infant's intake on the 3d-FR forms during the week following the first research clinic appointment. One week later, the parents attended a 2nd follow-up nutrition research clinic, or they were seen at the parent's home or the B.C.'s Children's Hospital. At this time, the 3d-FR was reviewed in detail with the parent for clarity and missing information. Then, the FFQ was administered to the parents by a trained nutritionist in a face-to-face interview, usually taking 30-70 minutes.

3.4.2 Anthropometric Measures

Anthropometric measures were obtained for all participating infants by one of 3 trained personnel at the first clinic appointment, with the parent present at all times. The measurements made were body weight, length and head circumference. These measurements were obtained to allow consideration of potential confounding effects of delayed growth in any infants found to have IDA. Infants with a body weight for length below the 5th percentile, based on the National Centre for Health Statistics percentiles (Hamill et al., 1979) were considered at potential risk for delayed growth. All of the anthropometric measures were recorded directly on the personal data form when they were taken.

3.4.2.1. Body Weight

The parent was asked to undress the infant but leave a dry diaper on (dry diapers were available if needed). The weight of the infant was then measured in duplicate. A 3rd measurement was taken if the first 2 measures differed by more than 10 g. Body weight was measured using an electronic balance accurate to 5 g (Digital baby scale model 727, Lux & Zwingenberger LTD, Lakeshore, Toronto) and immediately recorded, without adjusting for the weight of the diaper.

3.4.2.2 Length

Crown to heel length was measured in the recumbent position using a pediatric length board (Ellard Instrumentation LTD, Seattle, WA) to the nearest mm in duplicate. A 3rd measurement was made if the measures differed by more than 2 mm.

3.4.2.3 Head Circumference

Head circumference was measured using a disposable paper tape (Mead Johnson, Evansville, IN) placed over the part of the occiput which gives the maximum circumference (Gibson, 1990) to the nearest mm. Two measurements were taken, and if these differed by more than 2 mm, a 3rd measurement was made.

3.4.3 Blood Collection

A blood sample was obtained from each infant at the first clinic appointment following completion of all of the other measures. The parent was asked to hold their infant on their lap throughout and following the blood collection. A trained phlebotomist from B.C.'s Children's Hospital collected 2 tubes of capillary blood from a finger prick made using a sterilized lancet and after warming the infant's finger. First, 250 μL of blood was collected into an ethylene diamine tetra-acetic acid (EDTA)-coated microtainer tube for later complete blood count (CBC) analysis. Then, 800 μL of blood was collected into a 2nd microtainer tube coated with lithium heparin for later analysis of serum ferritin and sTfR. The tubes were labeled with the infant's 4-digit study ID number, the date and the clinic number. The EDTA-coated tubes were kept in ice until delivery to the B.C.'s Children's Hospital Hematopathology Laboratory immediately following the clinic. The lithium heparin-coated tubes were kept at room temperature, and taken to the nutrition laboratory at the B.C. Research Institute for Children's and Women's Health following completion of each clinic.

3.5 Data Analysis

3.5.1 Pilot Study

The foods recorded on the 24-hour recall and 3d-FR were reviewed following completion to determine if the FFQ included all the major sources of energy, iron and dietary factors known to influence iron absorption (meat, fish and poultry, vitamin C, calcium, phytate and fibre). Each 24-hour recall, 3d-FR and FFQ was then analysed using the FP®

(Version 6.03, ESHA Research, Salem, Oregon) to determine the mean daily intakes of iron and other nutrients of concern (energy, vitamin C, calcium and fibre). The nutrient intakes estimated from the FFQ were then compared with the intakes estimated from the 3d-FR to determine if any important food sources had been omitted from the FFQ. Any additional foods contributing to the intakes of energy, iron or dietary factors known to influence iron absorption (meat, fish and poultry, vitamin C, calcium, phytate and fibre) identified on the 24-hour recall or on the 3d-FR were added to the FFQ.

3.5.2 Socio-Cultural and Infant Feeding Questionnaire

The completed Socio-Cultural and Infant Feeding Questionnaires were entered into the Microsoft Access database, then the data were checked by one person to ensure accuracy and consistency in the way decisions regarding the data entry were made.

3.5.3 3-day Food Record and Food Frequency Questionnaire

The 3d-FRs were coded, entered into FP® and analysed, originally using FP® (Version 6.13, ESHA Research, Salem, Oregon), and subsequently using FP® (Version 7.03). Mixed dishes were disaggregated into their respective ingredients according to recipes provided, and the ingredients entered separately. Mixed dishes for which no recipe was provided were entered as the food from the ESHA database that was most similar based on judgement. After the 3d-FR data had been entered, the food list representing the foods recorded on the 3d-FR for each infant was compared to the original 3d-FR for accuracy by a 2nd person. Changes were made to the data entered as needed, and checked again. All the completed food lists were checked a final time by the same person to ensure accuracy and consistency of the decisions made in data entry. Some food items had not been described in adequate detail in the 3d-FR provided by the parents. For these foods, the closest possible food was chosen based on the best available data.

The FFQs were reviewed, coded and entered into the Microsoft Access (Version 2.0, Redmond, WA) database. Prior to data entry, each FFQ was reviewed for the purpose of categorizing and tabulating all the foods recorded in the 'other foods' options of each major food group section. A maximum of 5 of the most frequently reported 'other foods' from each of the 14 food group sections in the FFQ were added as data entry options to the FFQ Analysis Database. All the remaining 'other foods' on each FFQ were categorized into pre-existing FFQ food categories. All of the 191 food items in the FFQ and each of the 72 new foods (n=263) were then assigned either an ESHA code, (i.e. number given in

the FP® database) or a USER code (i.e. a number assigned to represent a food for which the nutrient composition had been added to the FP® database). Of the 191 food items, ESHA codes were used for 117 for which a single food in the ESHA database adequately represented the food, e.g. whole milk. One hundred and forty six foods on the FFQ were not adequately represented by a pre-existing food in the ESHA database. Thus, as previously described, a "FFQ composite", represented an average nutrient composition for foods and mixed meals not in the database, was created and the nutrient analysis for each was added to the FP® database with an assigned USER code. The nutrient compositions of infant formulas not in the FP® database were obtained from the manufacturers and added to the FP® database. The FFQ coded for all food categories is shown in **Appendix N.**

Following entry of all the 3d-FRs and FFQs, FP® Version 7.03 (ESHA Research, Salem, Oregon) that includes the recently released update of the Canadian Nutrient File (1997) and the USDA NDB (Release No. 11) was made available. These more recent food composition databases were clearly more likely to reflect the nutrient composition of the food supply during the study. Therefore, the 3d-FRs and FFQs were imported from Version 6.03 to Version 7.03 of the FP® and each new 3d-FR and FFQ food list generated by FP® was compared to the corresponding original data, and any USER codes incorrectly assigned were corrected.

After entry of the FFQ data, average daily consumption data for each infant was calculated to produce a Microsoft® Excel 97 (Microsoft Corporation, USA) database. The Excel database contained the subject numbers, ESHA and USER food codes, portion size codes and average daily amounts consumed for each food, for each infant for the 2 week period recorded on the FFQ. This Excel database was reviewed to ensure that the food items accurately represented the food items in the FFQ. Any coding errors or missing foods were corrected and the Excel database then reviewed a final time. The final Excel database was then imported into FP® using the "ESHAPort©" software (Version 1.0, 1997, ESHA Research). A FFQ food list was generated for each infant from FP®, reviewed and any food items lost during the process of importing the Microsoft® Excel 97 (Microsoft Corporation, USA) FFQ Database into FP® were added.

After completion of data entry, each FFQ and 3d-FR was analysed using FP® to calculate the average daily intakes of energy, iron (total, heme and non-heme), vitamin C, calcium and dietary fibre for each infant. The intakes of heme and non-heme iron were then estimated. To accomplish this, all foods on the FFQs and 3d-FRs were coded as either meat, poultry, fish (MPF), mixed dishes containing MPF, or foods not containing MPF. Information on MPF content of purchased infant foods was obtained from the manufacturers. For other mixed dishes, the MPF

content was estimated based on macronutrient composition data from FP®, then the iron content multiplied by the percent of total iron estimated to be from MPF, to give the estimated amount of iron from MPF. The amount of heme iron was then estimated based on the assumption that the iron in MPF is 40% heme and 60% non-heme iron (Monsen et al., 1978). Estimates of available iron were not made because the only available algorithm for estimating available iron at the time of the study (Monsen & Balintfy, 1982; Monsen et al., 1978) did not incorporate the inhibitory effects of dietary fibre, phytate, calcium or tannins on iron absorption.

The 3d-FRs and FFQs were then analysed using FP® to calculate the intakes (g/day) of food from major food categories and the iron intakes from these categories. To accomplish this, all the foods on the FFQ and 3d-FR food lists were coded as one of 21 food categories (**Appendix N**). The average food eaten (g/day) for each food category and the corresponding iron intakes from these categories were calculated for each infant. The data were entered into a Microsoft® Excel 97 (Microsoft Corporation, USA) spreadsheet with each infant coded as having eaten foods from the food category or not. For those who had consumed foods within a particular food category, the average g/day and the corresponding iron intakes were calculated.

The quantities of human milk consumed were estimated from the duration of a breast-feed, as reported on the 3d-FR and FFQ. This approach was taken because it was not practical to request breast-feeding mothers to weigh their infant before and after every feed. The amount of human milk consumed was estimated based on the assumption that 5 minutes of breast-feeding is equivalent to an intake of one fluid ounce of human milk. This estimate was derived from test-weighing 3 breast-fed infants according to the procedure described by Dewey et al. (1984), and by asking mothers in the pilot study how much formula or expressed milk their infant usually consumed during a 5 minute period of bottle-feeding.

3.5.4 Hematological and Biochemical Analysis

3.5.4.1. Hematology Analysis

The CBC was completed within 24 hours of blood collection using routine methods in the Hematopathology Laboratory at B.C.'s Children's Hospital. Hemoglobin (Hgb) concentration was determined on EDTA whole blood using a TOA Sysmex NE series 23 parameter blood counter (TOA Sysmex, Los Alamitos, CA, USA) according to the manufacturer's instructions. The counter also determined red cell indices, including mean corpuscular volume, white blood cell indices and platelet counts.

3.5.4.2. Analysis of Ferritin and sTfR

The clotted blood sample was centrifuged (DPR-6000 Centrifuge, Damon/IEC Division, Needham Hts, MASS, USA) at 3000 rpm (2000 g) at 4° C for 15 minutes to separate the serum. The serum was transferred into labelled 600 μL eppendorf tubes and then stored at -70°C for subsequent analysis of ferritin and sTfR concentrations.

Ferritin assays were conducted in 5 batches to ensure timely availability of results to parents, while decreasing the interassay variability. Ferritin was determined for each sample with a 2-site immunoradiometric assay (IRMA), as modified by Miles et al. (1974), using a commercial "fer-iron" radioimmunoassay kit (Ramco Laboratories Inc., Houston, TX, USA). Before analysis, the reagents, controls and patient sera were allowed to equilibrate to room temperature. Ten μL of serum or calibrator (prediluted ferritin calibrator standard solutions of 6, 20, 60, 200, 600 or 2000 μg/mL of human spleen ferritin) were pipetted into ferritin antibody coated plastic microtiter tubes. Ten μL for each of an anemic control and 3 different control sera (Lyphocheck, Biorad, Anaheim, CA, USA) were then pipetted into separate ferritin antibody microtitre tubes and run with each assay for quality control. Two hundred μL of radiolabeled (^{125}I) antiferritin was then pipetted into each of the tubes. The tubes were then incubated for 2 hours at room temperature in a Dubnoff shaking water bath (Precision Scientific Inc. Chicago, IL, USA) at 150 cycles/minute. The radiolabeled antiferritin binds to the ferritin in the solid phase and a "sandwich" is formed. Immediately following the 2-hour incubation period, the unbound labelled antiferritin was removed by aspirating and washing 3 times with distilled water into a sink of running water. The radioactivity in the washed microtiter tubes was then counted using a Clinigamma counter (Model 1272, LKB Wallace, Fisher Scientific, and Ottawa, Canada). The ferritin concentration was then computed by entry of calculations provided by the assay kit manufacturer into a spreadsheet (VP-Planner Plus, Stephenson Software Inc., Berkeley, CA, USA). All serum samples were analysed in triplicate, and the average of the counts was used to calculate the ferritin concentration. Any ferritin values falling outside the 95th confidence interval of the triplicate assays were discarded, and the average was based on the 2 remaining samples. Used radioactive solutions and solids were disposed of in accordance with approved regulations, as stipulated by the University of British Columbia Department of Occupational Health and Safety.

The serum remaining after analysis of ferritin was used for analysis of sTfR using a 2-site enzyme linked immunosorbent assay (ELISA) using the Quantikine™ IVD™ sTfR immunoassay (R&D Systems, Minneapolis, MN, USA), as described by Allen et al. (1998), and according to the instructions provided in the kits. The reagents, the controls and patient sera were allowed to equilibrate to room temperature for at least one hour prior to analysis. One

hundred μL of sTfR assay diluent was pipetted into wells of a microplate pre-coated with a monoclonal antibody. Then, 20 μL of standard, control or patient sera was pipetted into a well within an uninterrupted 15-minute period, covered with an adhesive strip and incubated at room temperature (18-25°C) for one hour. Three samples of immunoassay control serum (prediluted solutions of lyophilized human sTfR in buffered animal serum with preservative) representing anemic, low iron and normal iron status were run with each assay for quality control. Six prediluted sTfR calibrator solutions, 0, 3, 7, 20, 40 and 80 nmol/L of human sTfR in 0.2 ml buffered animal serum with preservative (the standards) were also run with each assay. The antibody on the wells of a pre-coated microplate binds the sTfR in the sample, thereby immobilizing sTfR to the well. Following incubation, the unbound protein was removed by filling each well with 400 μL of prepared wash buffer using an eppendorf pipette, aspirating and allowing the wells of the microplate to dry by blotting against clean paper towelling. This process was repeated 3 times for a total of 4 washes. Following the final wash, 100 μL of a second anti-sTfR monoclonal antibody conjugated to horseradish peroxidase was added to each well, covered with a new adhesive strip and incubated at room temperature for one hour. During the incubation period, the sTfR binds the antibody, thereby immobilizing the conjugate to the well. Following the incubation, the aspiration/wash procedure was repeated as described above to remove any unbound conjugated antibody. The amount of conjugate remaining in the well is proportional to the amount of sTfR initially bound. Following the 2nd wash, 100 μL of a chromogenic substrate solution was pipetted into each well while avoiding direct sunlight, covered with foil and incubated for 30 minutes at room temperature. Directly following the 30-minute incubation, 100 μL of stop solution was added to each well. The optical density of each well was determined at 470 nm using a microplate reader (BIORAD Model 3550, Aneheim, CA, USA) within 30 minutes of the addition of the stop solution. The sTfR concentration was then computed by entry of calculations provided by the manufacturer into a spreadsheet (Microsoft® Excel 7.0, Microsoft Corporation, USA). All sTfR values were determined in duplicate, and the average used to calculate the sTfR concentration.

The accuracy of the RIA and ELISA assays were checked through the serial replication of the quality control sera. All control sera fell within the manufacturers' stated limits on every assay. The inter-assay coefficients of variation for the ferritin and transferrin receptor assays were 6% and 4%, respectively, as determined by analysing the same serum samples in triplicate and duplicate, respectively, in separate assays on 2 different days. The intra-assay coefficients of variation for ferritin and transferrin receptor assays were 1% and 7.6%, respectively, as determined from the triplicate and duplicate assays of serum samples (n=145).

3.5.5 Assignment of Iron Status

A summary of the cut-off values used to classify the iron status of the infants participating in this study is given in **Table 3.1**. For this study, infants were considered to have iron-deficiency anemia if the Hgb was <110 g/L with a ferritin of ≤12 μg/L. Infants with a Hgb ≥110 g/L and a serum ferritin of ≤12 μg/L were considered to have low iron stores. Infants with a Hgb ≥110 g/L, a serum ferritin >12 μg/L and a white blood cell count (WBCC) ≤18 $x10^9$/L were considered to be nonanemic, iron sufficient, i.e. normal iron status. Infants with a Hgb ≥110 g/L, a serum ferritin >12 μg/L and a WBCC ≥18 $x10^9$/L were considered normal, due to the Hgb value in the normal range. However, due to the elevated WBCC, it is possible that the serum ferritin in these infants was elevated due to infection. All remaining infants (Hgb 102-109 g/L, ferritin >12 μg/L) were considered to have a low Hgb. These infants were classified as such because their ferritin values were >12 μg/L, i.e. consistent with normal iron status. However, ferritin, due to its role as an acute phase reactant, may have been elevated in these infants so that it fell within the normal range, even though the WBCC was normal. Whether the low Hgb in these infants was due to iron deficiency or another cause of anemia, e.g. thalassemia trait, or reflected a physiologically low normal value is not known. To avoid misclassification of infants with low iron stores as normal, these infants were classified as low Hgb and excluded from the analyses relating iron status to diet. None of these infants had a WBCC ≥18 $x10^9$/L.

Infants with Hgb ≤101 g/L were retested, and in four of the five cases, potential hemoglobinopathies were ruled out by a hematopathologist at B.C.'s Children's Hospital using manual differential morphology of blood smears and test results were confirmed. One infant was found to have coexisting beta thalassemia trait and IDA. All the infants were then treated with ferrous sulphate (3 mg/Kg per day) and retested. This was done through collaboration with each infant's doctor, and was not as part of the study. Infants with Hgb <110 g/L but >101g/L, and a serum ferritin ≤12 μg/L were not retested.

Table 3.1. Summary of cut-off values used to classify iron status of infants participating in the study.

Iron status classification	Criteria
Iron deficient anemic	Hgb <110 g/L with a ferritin of ≤12 μg/L
Low iron stores	Hgb ≥110 g/L but with a serum ferritin of ≤12 μg/L
Normal iron status	Hgb ≥110 g/L, a serum ferritin >12 μg/L & WBCC ≤18 x10^9/L.
Low hemoglobin	Hgb 102-109 g/L, ferritin >12 μg/L
Elevated sTfR[1]	>24 nmol/L
Elevated sTfR:ferritin ratio[1]	>2
Poor iron status/iron deficient	Hgb <110 g/L with a ferritin of ≤12 μg/L, or Hgb ≥110 g/L but with a serum ferritin of ≤12 μg/L; includes infants with either iron deficiency anemia or low iron stores.

Hgb, hemoglobin; WBCC, white blood cell count; sTfR, soluble transferrin receptor.
Normal cut-off criteria based on 5th percentile values from the Second National Health and Nutrition Examination Survey, excluding persons with a higher likelihood of iron deficiency.
[1]Normal cut-offs have not been established; for the purpose of classifying infants, a sTfR of <24 nmol/L and sTfR:ferritin <2, respectively, were considered normal.

3.4.5 Statistical Analysis

Statistical analyses were performed using the Statistical Packages for the Social Sciences (SPSS), release 9.0 (SPSS, Inc., Chicago, IL). A probability level of 5% was chosen as the level of statistical significance. All data were tested for normality using the Kolmogorov-Smirnov test. For data not normally distributed, a variety of normalizing transformations were applied prior to statistical treatment. These were the natural log for the biochemical parameters of MCV, serum ferritin, sTfR and sTfR:ferritin, the FFQ measures of total dietary iron, total iron from diet and supplements, dietary non-heme iron, non-heme iron from diet and supplements and vitamin C, and the 3d-FR estimates of energy and vitamin C. The square root was used for the FFQ estimates of energy, heme iron, calcium and fibre and the 3d-FR estimates of total iron, heme iron, non-heme iron and fibre. The intakes of food (g) from the major food categories on the FFQ resisted transformation; thus non-parametric statistics were used

in the analyses. Analysis of demographic and socio-cultural data included descriptive data on infant age and gender, maternal race, age, education and marital status, family income, and family food practices. Descriptive data were compared for infants grouped by age as 8-12, 13-17 and 18-26 mths for demographic and socio-cultural characteristics, and 8-12 and 13-26 mths for feeding practices.

Chi square analysis was used to determine significant differences between iron class assignment and grouped interval data for age (8-12 and 13-26 mths), race (Caucasian and Chinese) and gender. Chi square analysis or Fisher's Exact Test was used to determine potential associations between feeding history for infants grouped as: 1) breast-fed >6 mths or ≤6 mths, 2) iron supplemented or not iron supplemented, 3) cows' milk introduced <9 mths or ≥9 mths, 4) iron-fortified infant cereal introduced ≤6 mths or >6 mths or never, 5) iron-fortified infant cereal fed ≤1 mth or >1 mth, 6) MPF introduced ≤9 mths or >9 mths, and 7) MPF fed ≤1 mth or >1 mth, and for infants 8-12 and 13-26 mths of age grouped as Caucasian or Chinese ancestry and as 1) IDA, 2) low iron stores 3) normal iron status. Student's t-test for independent samples was used to test if the biochemical indices of iron status were significantly different among groups of infants when classified by gender. Analysis of variance (ANOVA), using the General Linear Model for unbalanced designs, was used to test if biochemical indices of iron status were significantly different among groups of infants when classified by age (8-12 or 13-26 mths) or race (Caucasian or Chinese) with adjustment for the confounding influence of age. When a significant F statistic was found in one-way ANOVA, the Bonferonni test was used for post-hoc comparisons. Logistic regression analysis was used to test if the percentage of infants with results below the designated cut-off criteria was significantly different among groups of infants when classified by age (8-12 and 13-26 mths) or race (Caucasian and Chinese) with adjustment for the confounding influence of age.

The Mann-Whitney U Test was used to determine if the median intakes of foods that provide the major sources of dietary iron and other factors that influence iron absorption were significantly different among groups of infants 8-12 and 13-26 mths of age when classified by iron status (poor iron status or normal iron status), by race (Caucasian and Chinese), or by gender. Descriptive statistics were used to compare the proportion of infants consuming foods that provide the major sources of dietary iron and other factors influencing iron absorption (as assessed by the FFQ) in infants 8-12 and 13-26 mths of age when classified as poor iron status or normal iron status, and by Caucasian and Chinese ancestry. Descriptive statistics were also used to compare the estimated contribution

of food groups to the total food (g/day) and iron intakes (mg/day) estimated from the FFQ for infants 8-12 and 13-26 mths of age, again classified as poor iron status or normal iron status, and by Caucasian or Chinese ancestry.

The General Linear Model for Univariate analysis was used to test for significant differences in iron intake from non-milk foods determined by the 3d-FR between groups of infants classified by iron status and ancestry, while adjusting for the confounding influence of age, total energy intake from non-milk foods, and history of iron supplementation, defined as feeding with an iron-fortified infant formula for ≥1 mth prior to the study and/or ≥3 mths at any time, or iron drops or a multivitamin supplement for ≥1 mth. The General Linear Model for Univariate analysis was used to test if the median intakes of energy, heme iron, non-heme iron, vitamin C, calcium, and dietary fibre from non-milk food sources determined by the 3d-FR were significantly different among infants 8-12 and 13-26 mths of age classified as poor iron status or normal iron status, by Caucasian and Chinese ancestry, or by gender. Fisher's Exact Test was used to determine if the proportion of infants with total iron intakes <77% of the RNI was significantly different among groups of infants classified as poor iron status or normal iron status and by Caucasian and Chinese ancestry. Descriptive statistics were also used to compare the proportion of infants classified by iron status and ancestry with a history of use of vitamin and/or mineral supplements.

Potential relations between the estimates of the intakes of total and heme iron derived the 3d-FR and FFQ, and Hgb, serum ferritin, sTfR and sTfR:ferritin ratio were examined using Spearman's Rho Correlation coefficients. To further explore the relation between the intake of dietary iron and biochemical measures, the analyses were also done excluding 16 infants who had serum ferritin concentrations >35 μg/L. This was done because inclusion of data for infants in whom ferritin may have been elevated due to infection, inflammation, or high iron absorption related to genetic factors could obscure relations between biochemical indices and dietary determinants in normal infants. The analyses were also done excluding infants who had received iron drops or a multivitamin/mineral supplements with iron, and excluding one infant with a heme iron intake >95th percentile.

Descriptive statistics were used to examine the ability of the 3d-FR and FFQ to classify study participants by quartiles of total iron intake as compared with classification by quartiles of sTfR, serum ferritin and sTfR: ferritin. Multivariate logistic regression analyses were used to determine potential predictors of IDA or low iron stores, or low iron stores without IDA. Variables in the univariate analyses with a $P \leq 0.10$, or those that were considered, based on the literature, likely to predict the risk of iron deficiency were selected for the multiple logistic regression model. The variables included in the preliminary models were: a history of breast-feeding >6 mths, no

iron-fortified formula or supplemental iron, introduction of cows' milk prior to 9 mths of age, feeding with iron-fortified infant cereals ≤2 mths and meats ≤1 mth, and having been fed <300 g/day iron-fortified infant formula, >275 g/day human milk, <30 g/day cereal, <20 g/day soy products, ≥800 g/day cows' milk or milk products, and <30 g/day meats in the previous 2 weeks. Variables with a $P>0.10$ were removed from the model. Interaction terms were considered, but since they were found to contribute little to the overall model, they were removed from the final analyses. By assigning each of the 5 variables in the final multivariate logistic regression model a 0 or 1, depending on whether the infant did or did not have the risk factor, each infant's score for their risk of IDA was calculated from the equation -3.26 + 0.88 (1) + 1.57(2) + 2.56(3) + 2.03(4) + 1.32 (5). Each infant's predictive value in the multivariate logistic regression model was then calculated from the equation 1/[1 + exp(-score)]. The predictive values for each infant were compared to various cut-off levels ranging from 0.05-0.95, and assigned to group 1, defined as IDA or low iron stores, or group 2, defined as normal iron status. Based on a comparison of each infant's actual iron status to their predicted iron status, the sensitivity, specificity, positive (PPV) and negative (NPV) predictive values were calculated. A Receiver Operating Characteristic (ROC) Curve was then generated using ROC Curve Analyzer (Version 5.01, Centor & Keightley, 1988) to determine the best cut-off value for predicting an infant's iron status. For the purpose of building a simpler predictive model that could be used in the field to identify infants at risk for iron deficiency or low iron stores, the predictive variables from the multivariate logistic regression model were analyzed using Classification and Regression Tree (CART) routine. CART analyses were generated to determine potential screening tools that might be useful to predict an infant's iron status using S-Plus (Version 3.3 for Windows, Mathsoft, Statsci Division Inc, Seattle, Washington, 1998). Variables in the multiple logistic regression model that were significant predictors for determining the risk of IDA or low iron stores, i.e. variables with an Odds Ratio >1.0 and a $P\leq0.1$, were selected for the CART analyses. The 5 variables included in the preliminary routine were infant age and the 4 key dietary patterns of whether or not the infant was fed an iron fortified infant formula or given supplemental iron, whether or not the infant was fed cows' milk prior to 9 mths of age, whether or not the infant was fed ≥800 g cows' milk or milk products/day, and whether or not the infant was fed <30 g MPF/day. For the purpose of building a simpler predictive model, the CART routine was also pruned back to 2 decision choices; whether or not the infant was fed ≥800 g cows' milk or milk products/day, and whether or not the infant was fed <30 g MPF/day. Misclassification rates were calculated based on a comparison of each infant's actual iron status with their predicted iron status.

Spearman correlations were used to determine if there was an association between individual intakes of energy, total iron, heme iron, non-heme iron, vitamin C, calcium, and dietary fibre determined by the FFQ and those determined by the 3d-FR. Spearman correlations were also used to determine if there was an association between individual food intakes from the food groups that provide major sources of iron and dietary factors that influence iron absorption as determined by the FFQ and by the 3d-FR. The Paired Student's t-test was used to test if mean nutrient and food intakes from the food groups that provide major sources of iron and dietary factors that influence iron absorption differed significantly when determined by the 3d-FR compared with the FFQ.

The General Linear Model for Univariate analysis was used to determine if the sTfR and sTfR:ferritin ratio differed among the infants classified by iron status, and to determine potential differences in sTfR and sTfR:ferritin among the infants grouped by age (8-12, 13-17 and 18-26 mths) and race (Caucasian, Chinese and Other). A Student's t-test for independent samples was used to evaluate differences in sTfR and sTfR:ferritin by gender. A histogram and fitted Gaussian distribution curve of the sTfR and sTfR: ferritin ratio was generated for infants aged 8-26 mths with normal iron status. Descriptive data for the sTfR and sTfR:ferritin ratio were generated for each infant with IDA. Pearson correlations were used to determine if there was an association between the sTfR concentration and ferritin, and between Hgb or sTfR:ferritin and Hgb. The sensitivity, specificity, positive (PPV) and negative (NPV) predictive values of specific cut-off values of the sTfR diagnosis of IDA and low iron stores were calculated. Sensitivity was defined as (TP/TP) + FN × 100 and specificity as (TN/TN) + FP × 100, where TP is true positive, FN is false negative, TN is true negative, and FP is false positive. Positive predictive value was defined as (TP/TP) + FP × 100 and negative predictive value as (TN/TN) + FN × 100. ROC Curves were generated for sTfR using ROC Curve Analyzer (Version 5.01, Centor & Keightley, 1988) compared with the diagnosis of IDA and low iron stores, based on the standard measures of Hgb and ferritin.

3.4.6 Dissemination of Results

Following the completion of the FFQ, parents were given verbal feedback on their infant's diet by a Public Health Nutritionist from the Vancouver Health Department or a Dietitian from B.C.'s Children's Hospital. Results concerning the hematological and biochemical measures of iron status were returned to the parents when normal, and sent to the primary care physician for infants with IDA. Parents of infants with low iron stores (serum ferritin ≤12 μg/L) but not IDA were telephoned, provided with nutrition advice and offered the opportunity to have their baby's iron status

retested in 2-3 mths. Two information letters, one for infants 9 to 12 mths of age, and one for infants 13 to 26 mths of age, and accompanying infant nutrition pamphlets were developed to provide appropriate individual feedback to parents who participated in the study (**Appendix P**). All parents were sent a feedback letter including a nutrient analysis of their infant's diet, and received, if appropriate, either nutrition counselling by a Public Health Nutritionist or educational materials, and a general assessment of their infant's diet.

CHAPTER 4. RESULTS

4.1 Study Population

4.1.1 Participant Recruitment

Parents of 1585 infants who would be 8-10, 13-17 or 22-26 mths of age during the dates of the scheduled research clinics were identified from the birth lists obtained from the City of Vancouver Health Department and were mailed letters inviting participation in the study. Of the 1585 letters mailed, 244 (15%) were returned marked wrong address. The remaining 1341 parents were telephoned. A total of 690 of the 1341 parents (43%) could not be reached by phone (wrong number, no answer) and 651 (41%) were successfully contacted by phone. Of these, 26 (4%, 2% of potential infants identified) did not meet the eligibility criteria, and 12 parents (1% of potential infants identified) did not speak sufficient English, Cantonese or Mandarin for participation. Of the remaining 613 parents with potentially eligible infants, 185 (30%) agreed to participate in the study and booked an appointment to attend a research clinic coinciding with when their infant would be 8-10, 13-17 or 22-26 mths of age. This represented 12% of the infants identified on the birth list. Of the 185 parents with an appointment, 142 (77%) attended a clinic with their infant. A summary of the participant recruitment and recruitment outcome from the birth lists is shown in **Table 4.1**. A further 10 parents and their infants were recruited from parent and infant/toddler groups held at health units, community centres, neighbourhood houses and immunization clinics throughout Vancouver. Of the 195 parents who made an appointment to participate, 152 parents (78%) attended a clinic with their infant. Due to appointment cancellations and subsequent rescheduling, some infants did not fall into the targeted age groups, i.e., ages 8-10, 13-17 or 22-26 mths at the time they participated in the study.

Table 4.1 Summary of participant recruitment from birth lists.

	n	% infants identified on birth list	% infants successfully contacted and eligible
Parents sent letter	1585	100	-
Letters returned/wrong address	244	15	-
Wrong telephone number, or not at home	690	43	-
Infant did not meet eligibility criteria[1]	26	2	-
Contacted, but unable to communicate with on the phone[2]	12	1	-
Contacted with effective communication	613	39	(100)
Contacted successfully, met eligibility criteria and agreed to participate in the study (booked appointments)	185	12	30
Eligible subjects who attended a booked appointment	142	9[3] 77[4]	23
Eligible subjects whose parents did not participate	1443	91	77

[1]Eligibility criteria; birth weight ≥2500 and ≤4500 g, born at 37-42 weeks gestation, resident of Vancouver, no history of serious illness (e.g. sickle cell anemia, blood clotting disorders, chronic bowel disease, liver disease, endocrine deficiency, blood loss, hemolytic disease, bone marrow depression, polycythemia, erythrocytosis, exposure to lead or other toxins, malignancy, chronic or congenital disorders), no history of major surgery or serious illness.
[2]Parents/guardians could not speak sufficient English, Cantonese or Mandarin for participation.
[3]Percent of eligible subjects recruited by letter/phone who attended a booked appointment.
[4]Percent of parents who made and kept appointments was 77% for those identified through the birth lists; 4 infants were subsequently removed from the data analysis because the birthweights were <2500 or >4500 g.

4.1.2 Nutrition Research Clinics and Attendance

A summary of the number of infants who attended the nutrition clinics and their location is shown in **Table 4.2.** Eleven clinics for each of the initial and follow-up appointments were held between February and December 1996. One hundred and fifty two infants and their parents participated in the study. The remaining parents who agreed to participate but were unable to make a prescheduled clinic were seen either at home or at B.C.'s Children's Hospital. Sixteen parents with initial appointments at clinics or B.C.'s Children's Hospital elected to have follow-up appointments at home. Of the 152 participants, 3 infants (2%) did not complete the blood testing, parents of another 5 (3%) infants completed neither the FFQ nor 3d-FR, and one other parent (1%) did not complete the 3d-FR. Serum ferritin values for one infant and sTfR values for another 2 infants were lost due to technical error. A further 4 infants were excluded because their birth weights were <2500 or >4500 g. Although the number of infants included in the data analyses was 148, complete data including all dietary and biochemical measures were available for only 136 infants.

Table 4.2. Clinic locations and number of infants who attended.

	Clinic location[1]													
	West Main HU	Kitsilano CC	Brittania CC	East HU	South HU	Mount Pleasant HU	South HU	Kiwassa NH	East HU	South HU	Kitsilano CC	Home Visits	BCCH	Total
Booked initial appointment	13	27	26	31	27	17	7	14	7	8	17	-	11	195
Attended initial appointment	11	22	20	24	23	10	4	12	6	7	14	-	9	152
Attended follow-up appointment[2]	10	3	14	21	20	5	4	9	8	7	14	19	3	147

Results shown are the number of infants; HU, Health Unit; CC, Community Centre; NH, Neighbourhood House; BCCH, British Columbia's Children's Hospital.
[1]The date and time of day of the clinics were West Main Health Unit, February 6th, 1996, day; Kitsilano Community Centre, February 24, 1996, day and July 20th, 1996, day; Brittania Community Centre, March 9th, 1996, day; East Health Unit, March 18th, 1996, day and pm and July 10th, 1996, day; South Health Unit, March 22nd, 1996, day, May 31st, 1996, day and July 12th, 1996, day; Mount Pleasant Health Unit, March 27th, 1996, pm; Kiwassa Neighbourhood House, June 8th, 1996, day.
[2]Sixteen parents with initial appointments at clinics or BCCH elected to have follow-up appointments at home.

4.1.3. Description of Study Participants

4.1.3.1. Characteristics of Study Participants

A summary of the characteristics of the study participants, as the complete group, and when grouped as 8-12, 13-17 and 18-26 mths of age is shown in **Table 4.3**. Of the 148 eligible infants who participated in the study, 62 were 8-12, 34 were 13-17 and 52 were 18-26 mths of age. There were 77 boys (52%) and 71 girls (48%). None of the infants who participated had a body weight for length below the 5th percentile (Hamill et al., 1979) (data not shown).

Consistent with the method of recruitment, which selectively targeted potential Caucasian and Chinese parents, the maternal ancestry of 132/148 of the infants was either Caucasian (n=84) or Chinese (n=48). The maternal ancestry of the other participants was South Asian, n=3, South East Asian, n=2, Japanese, n=2, Filipino, n=1, Nicaraguan, n=1, mixed race (reported more than one race) n=4, and unknown, n=3. Most of the parents (78%) were over 30 years of age. The parents who participated had a wide range of income levels with an annual family income <$19,999 reported by 20 (13%), $20-29,999 by 19 (13%), $30-49,999 by 35 (24%), $50-69,999 by 25 (17%), and >$70,000 by 37 (25%). Twelve participants did not report annual family income. Almost all of the mothers (94%) had at least a high school education, and 101 (68%) had completed college, technical school, or a university undergraduate or graduate degree. Most of the parents (95%) were married or living common-law. Only 7/148 of the parents reported that they lived alone (separated, divorced or never married). One parent did not report their marital status (**Table 4.3**).

Table 4.3. Demographic and socio-cultural characteristics of study participants.

	8-26 mths (n=148)	8-12 mths (n=62)	13-17 mths (n=34)	18-26 mths (n=52)
Age (mths)[1]	15.4 ± 6.4	9.1 ± 1.2	14.8 ± 1.7	23.3 ± 2.1
Gender (m/f)	77/71 (52/48)	37/25 (60/40)	16/18 (47/53)	24/28 (46/54)
Maternal race				
Caucasian	84 (57)	36 (58)	20 (59)	28 (54)
Chinese	48 (32)	16 (26)	12 (35)	20 (38)
South Asian	3 (2)	2 (3)	1 (3)	0
South East Asian	2 (1)	1 (2)	0	1 (2)
Mixed	4 (3)	2 (3)	0	2 (4)
Other	4 (3)	3 (5)	0	1 (2)
Maternal age (y)				
<20	3 (2)	1 (2)	0	2 (4)
20-30	26 (18)	12 (19)	5 (15)	9 (17)
>30	115 (78)	48 (77)	28 (82)	39 (75)
Annual family income ($)				
<19,999	20 (13)	6 (10)	4 (12)	10 (19)
20-29,999	19 (13)	8 (13)	4 (12)	6 (11)
30-49,999	35 (24)	21 (34)	7 (21)	7 (13)
50-69,999	25 (17)	11 (18)	4 (12)	9 (17)
>70,000	37 (25)	10 (16)	9 (26)	16 (31)
Highest level of maternal education obtained				
<High school[2]	8 (5)	1 (2)	0	7 (13)
High school only	39 (26)	15 (24)	9 (26)	15 (29)
>High school	101 (68)	45 (73)	25 (71)	28 (54)
Marital status				
Married/common-law	140 (95)	58 (94)	32 (94)	49 (94)
Single, divorced or separated	7 (5)	3 (5)	1 (3)	3 (6)

Results shown are the number of infants, with the % of all infants within a given category shown in brackets. Some questions were not answered by all of the parents, thus some percentages do not total 100.

[1]mean ± SD

[2]<High school, those not completing high school.

A summary of the self-reported family food practices is shown in **Table 4.4**. Forty one percent of the parents characterized their family food practices as Western/North American, 26% as Chinese, and 23% reported more than one type of ethnic food practice, which was classified as mixed ethnic food practice. Of the 61 parents who reported that they followed Western/North American food practices, 60 (98%) were of Caucasian ancestries. Of the 39 parents who reported Chinese food practices, 37 (95%) were of Chinese ancestries. Twenty Caucasian (24%) and 9 Chinese parents (19%) reported that they usually followed more than one type of ethnic food practice.

Eighty three percent of the parents reported that they followed an omnivorous diet. Of the 27 parents (18%) who reported that they followed a vegetarian type of diet, 10 (7%) reported that they followed a vegetarian diet most of the time, but not strictly, another 4 (3%) excluded only beef, 8 (5%) excluded beef, pork and chicken, 4 (3%) followed a lacto-vegetarian diet and one (1%) followed a vegan diet. Twenty-three (27%) of the 84 Caucasian parents, but only 3 of the 48 Chinese parents (6%) reported that they followed a vegetarian diet (**Table 4.4**).

In summary, consistent with the study objectives and the method of recruitment, the study population consisted of infants predominantly from Caucasian and Chinese ancestries with family food practices generally consistent with their ethnic background. Over 70% of the Caucasian and over 90% of the Chinese families followed mixed non-vegetarian diets. The infants in this study were predominantly from older, higher education, 2-adult families with a wide range of family income levels.

Table 4.4. Self-reported family food practices.

	All infants (n=148)	Caucasian ancestry (n=84)	Chinese ancestry (n=48)	Other ancestries (n=13)
Ethnic food practices[1]				
Western/North American	61 (41)	60 (71)	0	1 (8)
Chinese	39 (26)	0	37 (77)	2 (15)
Mediterranean	2 (1)	1 (1)	0	1 (8)
Mixed	34 (23)	20 (24)	9 (19)	5 (38)
Other	5 (3)	1 (1)	0	4 (31)
Vegetarian-related food practices				
Non-vegetarian	118 (83)	61 (73)	45 (94)	12 (92)
Vegetarian tendencies[2]	10 (7)	10 (12)	0	0
Excluded beef	4 (3)	2 (2)	2 (4)	0
Excluded beef/pork and chicken	8 (6)	8 (9)	0	0
Lacto-ovo vegetarian	4 (3)	2 (2)	1 (2)	1 (8)
Vegan	1 (1)	1 (1)	0	0

Results shown are the number of infants, with the % of infants within a given category given in brackets. Information on ethnic food practices was not reported for 4 infants; mother's race was not reported for 3 infants.
[1]Western/North American includes Canadian, American and Western European; mixed ethnic food practices includes those reported as mixed, or more than one ethnic food practice; other includes Japanese, n=2, Filipino, and Nicaraguan.
[2]Those who followed a vegetarian diet most but not all the time were classified as "vegetarian tendencies".

4.1.3.2. Feeding Practices of Study Participants

Table 4.5 shows the feeding practices determined from the Socio-Cultural and Infant Feeding Questionnaire for the infants grouped as 8-12 or 13-26 mths of age. For the analysis of the Socio-Cultural and Infant Feeding Questionnaire, infants were classified as exclusively breast-fed if they had been breast-fed with an intake of formula or other milk by bottle or cup of not >8 ounces/week. If the infant was fed formula and breast-feeding was discontinued within 7 days of birth, then the infant was classified as never breast-fed. Infants for whom there was an overlap of breast-feeding and feeding with infant formula beyond 7 days after birth were classified as having mixed feeds from birth.

Sixty-one infants (40%) were exclusively breast-fed >6 mths (**Table 4.5**). Of the 62 infants aged 8-12 mths, 28 (45%) were breast-fed >6 mths. In the group of 86 infants 13-26 mths of age, 33 (38%) were breast-fed >6 mths. Twelve infants (8%) were classified as having received mixed feeds from birth, with 8 fed an iron-fortified formula, 5 fed a low iron formula and one fed both iron-fortified and low iron formula together with breast-feeding. Twenty-one infants (14%) were never breast-fed; of these, 13 were fed an iron-fortified formula, and 7 a low iron formula from birth. Fifty-five infants (37%) had not been fed an iron-fortified infant formula at the time of the study. A low iron "milk" was introduced to 28 infants (19%) prior to 9 mths of age, while 52 infants (35%) had not been fed a low iron "milk" (**Table 4.5**). Of the infants not fed low iron milk at the time of the study, 7 (8%) were 13-26 mths of age, however 45 (73%) were only 8-12 mths of age. Seven infants were given cows'/goats' milk prior to 9 mths of age (not shown).

The recommended age for introduction of iron-fortified infant cereals is 4-6 mths of age. Most of the infants (76%) had been introduced to iron-fortified infant cereal at 4-6 mths, 16 infants (11%) were introduced to iron-fortified infant cereal before 4 mths of age. Nineteen infants (13%) had not been given an iron-fortified infant cereal until at least 7 mths of age, with 2, 8-12 mth old and 5, 13-26 mth old who had not been introduced to iron-fortified infant cereal at the time of the study (**Table 4.5**).

The recommended age for introduction of meats is 7-9 mths of age. Most of the infants (69%) had been introduced to meats by 9 mths of age, but 44 (30%) had not (**Table 4.5**). Of 11 infants (7%) who had not been introduced to meats at the time of the study, 5 were 8 mths of age, one was 9 mths, one was 10 mths, 2 were 11 mths, and 2 were 13-26 mths of age.

Table 4.5. Feeding practices of study participants grouped as 8-12 and 13-26 mths of age as reported on the Socio-Cultural and Infant Feeding Questionnaire.

	All infants (n=148)	8-12 mths (n=62)	13-26 mths (n=86)	χ^2	*P*
Duration of breast-feeding[1]					
never breast-fed	21 (14)	5 (8)	16 (19)	0.723	0.485
mixed feeds[2,3]	12 (8)	5 (8)	7 (8)		
≤3 mths	22 (15)	11 (18)	11 (13)		
>3-6 mths	32 (22)	13 (21)	19 (22)		
>6-8 mths	23 (15)	14 (23)	9 (10)		
>8-11 mths	20 (13)	13 (21)	7 (8)		
≥12 mths	18 (12)	1 (2)	17 (20)		
Age iron fortified formula introduced					
0-7 days	14 (9)	5 (8)	9 (10)	0.109	0.863
7 days ≤3 mths	20 (13)	10 (16)	10 (12)		
>3-6 mths	29 (20)	11 (18)	18 (21)		
>6-8 mths	16 (11)	7 (11)	9 (10)		
>8-11 mths	3 (2)	1 (2)	2 (2)		
≥12 mths	1 (1)	0	1 (1)		
not yet	55 (37)	24 (39)	31 (36)		
mixed feeds[2]	8 (5)	4 (6)	4 (5)		
Age low iron "milk" introduced[4]					
0-7 days	8 (5)	1 (2)	7 (8)	1.525	0.236
7 days ≤3 mths	6 (4)	2 (3)	4 (5)		
>3-6 mths	7 (5)	3 (5)	4 (5)		
>6-8 mths	7 (5)	2 (3)	5 (6)		
>8-11 mths	14 (9)	6 (10)	8 (9)		
≥12 mths	48 (32)	2 (3)	46 (53)		
not yet	52 (35)	45 (73)	7 (8)		
mixed feeds[2]	5 (3)	1 (2)	4 (5)		
Age iron fortified infant cereals introduced					
<4 mths	16 (11)	5 (8)	11 (13)	0.952	0.456
4-6 mths	113 (76)	51 (82)	62 (72)		
>6 mths	12 (8)	4 (6)	8 (9)		
not yet	7 (5)	2 (3)	5 (6)		
Age meat, poultry or fish introduced					
≤6 mths	42 (28)	21 (34)	21 (24)		
>8-9 mths	61 (41)	31 (50)	30 (35)	1.644	0.275
>9-11 mths	11 (7)	1 (2)	10 (12)		
≥12 mths	22 (15)	0	22 (26)		
not yet	11 (7)	9 (14)	2 (2)		

Results shown are the number of infants, with the % of all infants within a given category given in brackets; Information on the age of introduction of iron-fortified formula, low iron "milk" and meat, poultry or fish was not given for 2, one and 3 infants, respectively, thus some percentages do not total 100. Infants were included in more than one category across categories of feeding practices due to overlap in feeding practices, e.g. an infant can be classified as breast-fed while having been introduced to iron-fortified infant cereals. No significant associations between infant age and feeding practices were found using Fisher's Exact Test for infants 8-12 compared with 13-26 mths of age. Statistical analysis for age MPF introduced excluded infants ≤9 mths of age, and was based on n=17 9-12 mth old infants.

[1]Infants were considered breast-fed as long as the intake of formula or other milk by bottle or cup did not exceed 8 oz/wk.

[2]Infants for whom there was an overlap of breast-feeding and formula feeding exceeding 7 days from birth.

[3]Includes one infant for whom there was an overlap of breast-feeding and feeding with both iron-fortified formula and low iron formula from 7 days from birth.

[4]Includes low iron formula, cows' milk and goats' milk.

Table 4.6 shows the history of vitamin and/or mineral supplement use reported on the FFQ. A history of supplement use was defined as having received a vitamin and/or mineral supplement for ≥1 mth. Only 7 infants in the study had received iron supplements. One 12 mth old from one to 2 mths of age, and one 23 mth old from 17 mths of age to the time of the study had received Fer-In-Sol®, 5 infants had been given a multivitamin/mineral supplement containing iron, and 43 (29%) had received a multivitamin supplement without iron, most commonly Tri-Vi-Sol® or Poly-Vi-Sol®. Only 5 infants (3%), all 13-26 mths of age, had received supplements of vitamin C, 36 (24%) had received supplemental vitamin D in the form of D-Vi-Sol, and 8 (5%) had received a fluoride supplement.

Table 4.6. History of use of vitamin and/or mineral supplements among study participants as reported on the FFQ.[1]

Vitamin and/or mineral supplement	Yes	No
Iron	2 (1)	140 (94)
Multivitamin/mineral + iron	5 (3)	137 (93)
Multivitamin/mineral	43 (29)	99 (67)
Vitamin C	5 (3)	137 (93)
Vitamin D	36 (24)	106 (72)
Fluoride	8 (5)	134 (90)

Results shown are the number of infants, with the % of all infants given in brackets, n=148. Information on supplement use was not given for 6 infants. Infants could receive more than one type of supplement.
[1]History of supplement use was defined as supplement received for ≥1 mth.
None of the infants who had received an iron or a multivitamin/mineral supplement containing iron had iron deficiency anemia or low iron stores (see **Table 4.20**).

4.2. Iron Status of Study Participants

4.2.1. Prevalence of Indices of Iron Status Indicative of Iron Deficiency Anemia and Low Iron Stores Among Infants 8-26 Mths of Age.

The hematological and biochemical indices of iron status among the infants who participated in this study, and the percentage of infants in each age group with values below the designated cut-off for normal are shown in **Table 4.7**. There were no differences in hematological and biochemical indices of iron status between male and female infants, with the exception that the mean corpuscular volume (MCV) of the male infants was lower than for the female infants (76.5 ± 5.5 fL, 78.8 ± 3.8 fL, respectively, P=0.008. There were no significant differences in the hematological and biochemical indices of iron status between infants aged 13-17 mths and 18-26 mths (**Appendix Q, Table 5.1**), thus, the results were combined for all infants aged 13-26 mths for analyses. Infants 8-12 mths of age had a significantly lower median for Hgb (P<0.001), with a trend (P<0.1) to lower medians for MCV and sTfR than infants 13-26 mths of age.

Consistent with the above findings, logistic regression analysis showed that a higher percentage (P<0.05) of infants 8-12 mths of age than 13-26 mths of age had low Hgb (<110 g/L) results. However, a higher percentage (P<0.05) of infants 13-26 mths than 8-12 mths of age had low (≤12 μg/L) serum ferritin results. There was no difference in the percentage of 8-12 and 13-26 mth old infants with abnormal results for MCV, sTfR and sTfR:ferritin (**Table 4.7**).

Table 4.7. Hematological and biochemical indices of iron status among infants participating in the study and the percentage of infants with biochemical indices below cut-off points.

	8-26 mths (n=148)	8-12 mths (n=62)	13-26mths (n=86)
Hemoglobin (g/L)	120.1 ± 8.8	116.5 ± 9.5	122.6 ± 7.4[+]
	(121.0, 92.0 – 139.0)	(118.5, 92.0 – 133.0)	(123.0, 105.0 – 139.0)
No. (%) below cut-off	*13 (9)*	*10 (16)*	*3 (3)*[δ]
Mean corpuscular volume (fL)	77.6 ± 4.9	76.7 ± 5.2	78.2 ± 4.6[f]
	(78.3, 55.5 - 87.6)	(77.3, 55.5 - 87.2)	(78.7, 56.8 - 87.6)
No. (%) below cut-off	*5 (3)*	*3 (5)*	*2 (2)*
Serum ferritin (μg/L)	20.8 ± 16.9	20.8 ± 16.1	20.8 ± 17.5
	(17.0, 1.0 - 104.9)	(18.7, 1.0 - 93.3)	(15.1, 2.5 - 104.9)
No. (%) below cut-off	*47 (32)*	*15 (24)*	*32 (37)*[δ]
sTfR (nmol/L)	21.4 ± 8.2	23.2 ± 10.5	20.1 ± 5.6[f]
	(20.4, 9.7 – 67.1)	(21.0, 11.4 - 67.1)	(20.2, 9.7 - 32.7)
No. (%) below cut-off	*45 (30)*	*23 (37)*	*22 (26)*
sTfR:ferritin	2.4 ± 6.0	3.1 ± 9.0	1.9 ± 2.1
	(1.1, 0.1 - 67.1)	(1.1, 0.2 - 67.1)	(1.1, 0.1 - 12.5)
No. (%) below cut-off	*46 (31)*	*19 (31)*	*17 (20)*

Values shown are mean ± SD (median, range) and in italics, the number (%) of infants below the designated cut-off of normal values. sTfR, soluble transferrin receptor; data not available for 2 infants at 8-12 mths of age and 2 at 13-26 mths of age.

Normal cut-off criteria: Hgb, ≥110 g/L; MCV, ≥67 fL; ferritin >12 μg/L; a sTfR of <24 nmol/L and sTfR:ferritin ratio <2, respectively, as described in methods, page 79 were considered normal.

General Linear Model for Univariate analysis showed significant differences from value for 8-12 mths by [+], F-statistic=19.366, $P<0.001$; [f], F-statistic=3.113 and 3.489 for MCV and sTfR, respectively, $P=0.05$-0.1.

Logistic regression showed significant differences in the proportion of infants with values below cut-offs compared with infants 8-12 mths of age by [δ], $P<0.05$.

The number of infants with IDA, low iron stores, normal iron status and low Hgb is shown in **Table 4.8**. The prevalence of IDA, defined as a Hgb <110 g/L + ferritin ≤12 μg/L, was 6% (9/145). A further 26% (n=38) had low iron stores, defined as a serum ferritin ≤12 μg/L without IDA and 3% had a Hgb of 102-109 g/L with a serum ferritin >12 μg/L. Since ferritin is an acute phase reactant, it is possible that serum ferritin was falsely elevated by infection in some or all of these infants. To avoid misclassification or confounding effects in subsequent analysis, infants with a Hgb 102-109 g/L with a ferritin >12 μg/L were classified as low Hgb and excluded from the analyses relating iron status to diet. Sixty five percent of the infants had a Hgb ≥110 g/L, serum ferritin >12 μg/L and a WBCC ≤18 $X10^9$/L and were classified as normal iron status (non-anemic, iron sufficient). Within the group of infants with normal iron status, 5/40 at 8-12 mths, 5/19 at 13-17 mths, 5/35 at 18-26 mths of age had a Hgb >110 g/L and ferritin >35 μg/L. In summary, 6% of the infants studied had IDA, 26% had low iron stores, 3% had low Hgb levels and 65% had normal iron status.

The prevalence of IDA was highest in the group of 8-12 mth old infants (12%), with 4 infants at 8 mths, 2 at 9 mths and one at 10 mths of age found to have met the criteria for IDA **(Table 4.8)**. One infant 13 mths and one 22 mths of age also met the criteria for IDA. The prevalence of low iron stores was 40% (14/35) among 13-17 mth old infants, with 1/6 at 13 mths, 3/8 at 14 mths, 6/8 at 15 mths and 4/10 at 16 mths of age found to have low iron stores. At 18-26 mths of age, 15/51 infants (29%) had low iron stores.

Table 4.8. Number of infants with iron deficiency anemia, low iron stores, normal iron status and low hemoglobin.

	8-26 mths (n=145)	8-12 mths (n=59)	13-17 mths (n=35)	18-26 mths (n=51)
Iron deficiency anemia[1]	9 *(6, 3-10)*	7 *(12, 4-20)*	1 *(3, 0-9)*	1 *(2, 0-6)*
Low iron stores[2]	38 *(26, 19-33)*	9 *(15, 6-24)*	14 *(40, 24-56)*	15 *(29, 17-41)*
Normal iron status[3]	94 *(65, 57-73)*	40 *(68, 49-87)*	19 *(54, 38-70)*	35 *(69, 56-82)*
Low hemoglobin[4]	4 *(3, 0-6)*	3 *(5, 0-10)*	1 *(3, 0-9)*	0 -

Results shown are the number of infants, and in italics in brackets the % of infants within a given iron class assignment, 95% confidence interval.
[1]Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L.
[2]Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L.
[3]Normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L; 15 infants (5/40 at 8-12 mths, 5/19 at 13-17 mths and 5/35 at 18-26 mths of age) had a Hgb >110 g/L + ferritin >35 μg/L.
[4]Low Hgb, Hgb 102-109 g/L + ferritin >12 μg/L.
Significant association between iron status and infant age (χ^2=13.051, df=2, *P*=0.001).

4.2.2. Prevalence of Iron Deficiency Anemia and Low Iron Stores Among Infants Classified by Ancestry

The hematological and biochemical indices of iron status among Caucasian and Chinese infants 8-12 and 13-26 mths of age, and the percentage of infants in each subgroup with values below the designated cut-off for normal are shown in **Table 4.9**. The General Linear Model for Univariate Analysis with infant age as a covariate showed that infants from Caucasian ancestries had a significantly lower median for Hgb ($P<0.005$) and serum ferritin ($P<0.05$), and a higher median for MCV ($P<0.005$), sTfR ($P<0.005$) and sTfR:ferritin ratio ($P<0.01$) compared with infants from Chinese ancestries. The higher median MCV among Caucasian infants compared with Chinese infants was due to 3 Chinese infants with MCV values <66 fL, the lowest value for Caucasian infants, and 3 Caucasian infants with a MCV >86 fL; the highest value among the Chinese infants was 84 fL. Logistic regression analysis with infant age as a covariate showed a higher percentage of low ferritin values ($P<0.005$), high sTfR values ($P<0.005$) and high sTfR:ferritin ratios ($P<0.001$) among infants from Caucasian ancestries than among infants from Chinese ancestries. There was also a trend ($P<0.1$) toward a higher percentage of low Hgb results among Caucasian than Chinese infants, and low MCV results among Chinese than Caucasian infants.

Table 4.9. Hematological and biochemical indices of iron status among Caucasian and Chinese infants and the percentage of infants with biochemical indices below normal cut-off points.

	8-26 mths (n=148)	8-12 mths (n=62)	13-26mths (n=86)
Hemoglobin (g/L)			
Caucasian§	118.3 ± 8.8	114.2 ± 8.9	121.3 ± 7.6
	119.0 (92.0 - 136.0)	114.5 (92.0 - 129.0)	121.0 (105.0 - 136.0)
Chinese	123.4 ± 7.1	120.0 ± 8.0	125.1 ± 6.0
	124.0 (95.0 - 139.0)	121.5 (95.0 - 130.0)	125.0 (115.0 - 139.0)
No. (%) below cut-off			
Caucasian[a]	*10 (12)*	*7 (19)*	*3 (6)*
Chinese	*1 (2)*	*1 (6)*	*0*
Mean corpuscular volume (fL)			
Caucasian§	78.8 ± 3.6	78.2 ± 3.9	79.2 ± 3.4
	78.8 (65.8 - 87.2)	78.8 (65.8 - 87.2)	78.8 (69.2 - 87.6)
Chinese	76.3 ± 5.8	75.2 ± 5.9	76.8 ± 5.7
	77.4 (56.6 - 84.5)	76.3 (56.6 - 82.0)	77.9 (56.8 - 84.5)
No. (%) below cut-off			
Caucasian[a]	*1 (1)*	*1 (3)*	*0*
Chinese	*3 (6)*	*1 (6)*	*2 (6)*
Serum ferritin (μg/L)			
Caucasian[δ]	18.6 ± 16.8	19.5 ± 15.9	17.9 ± 17.5
	14.1 (1.0 - 104.9)	16.4 (1.0 - 93.3)	12.3 (3.2 - 104.9)
Chinese	23.2 ± 15.4	23.3 ± 10.8	23.2 ± 17.4
	19.9 (2.5 - 67.0)	22.1 (4.1 - 49.5)	17.7 (2.5 - 67.0)
No. (%) below cut-off			
Caucasian[b]	*32 (38)*	*10 (28)*	*22 (46)*
Chinese	*10 (21)*	*1 (6)*	*9 (28)*
Soluble transferrin receptor (sTfR) (nmol/L)			
Caucasian§	22.7 ± 8.7	24.8 ± 11.5	21.1 ± 5.4
	21.6 (9.8 - 67.1)	21.9 (12.9 - 67.1)	21.4 (9.8 - 32.7)
Chinese	18.4 ± 5.9	18.1 ± 6.0	18.6 ± 5.9
	17.1(9.7 - 35.0)	16.1 (11.4 - 35.0)	17.2 (9.7 - 31.3)
No. (%) below cut-off			
Caucasian[b]	*29 (34)*	*14 (39)*	*15 (31)*
Chinese	*8 (17)*	*2 (12)*	*6 (19)*
sTfR:ferritin			
Caucasian*	2.9 ± 7.7	4.1 ± 11.8	2.0 ± 1.7
	1.4 (0.2 - 67.1)	1.2 (0.2 - 67.1)	1.5 (0.2 - 9.4)
Chinese	1.6 ± 2.4	1.3 ± 2.0	1.8 ± 2.7
	0.8 (0.1 - 12.5)	0.8 (0.3 - 8.5)	1.1 (0.1 - 12.5)
No. (%) below cut-off			
Caucasian[c]	*31 (37)*	*12 (33)*	*19 (40)*
Chinese	*8 (17)*	*1 (6)*	*7 (22)*

Values shown are mean ± SD (median, range) and the number (%) of infants affected in italics for 81 Caucasian infants, with n=34 of 8-12 mths, n=47 of 13-26 mths, and for 48 Chinese infants with n=16 of 8-12 mths, n=32 of 13-26 mths; data not available for 2 infants at 8-12 mths and 2 at 18-26 mths of age; sTfR, soluble transferrin receptor; Normal cut-off criteria: Hgb, ≥110 g/L; MCV, ≥67 fL; ferritin >12 μg/L; a sTfR of <24 nmol/L and sTfR:ferritin ratio <2, respectively, as described in methods, page 79 was considered normal. Value for Caucasian infants different from value for Chinese infants denoted by symbols for General Linear Model for Univariate analysis (with infant age as a covariate) §F-statistic=10.595, 9.856 and 10.517, $P<0.005$ for Hgb, MCV and sTfR, respectively; [δ] F-statistic=3.956, $P< 0.05$; [*] F-statistic=7.867, $P<0.01$; Proportion of Caucasian infants with values below cut-offs significantly different than Chinese infants denoted by letters for logistic regression analysis (with infant age as a covariate) [a], P=0.05-0.1; [b], $P<0.005$; [c], $P<0.001$.

The number of infants of Caucasian and Chinese ancestries with IDA, low iron stores, normal iron status and low Hgb is shown in **Table 4.10**. Chi-square analysis showed a significant association between iron status and infant ancestry, with 7/81 Caucasian infants found to have IDA compared with only 1/48 of the Chinese infants. One infant of Nicaraguan ancestry had IDA. The prevalence of low iron stores without anemia was also higher among Caucasian infants affecting 24/81 infants compared with only 9/48 of the Chinese infants. At 8-12 mths of age, one Chinese infant (6%) and 5 Caucasian infants (15%) had IDA. None of the Chinese infants aged 13-17 or 18-26 mths had IDA, but one Caucasian infant aged 13 mths and one 22 mths had IDA. The prevalence of low iron stores was higher at 13-17 mths of age than at 8-12 or 18-26 mths of age. Again, the prevalence of low iron stores was higher among Caucasian infants aged 13-17 mths with 10/20 infants affected compared with only 3/12 of the Chinese infants.

The number of infants with IDA, low iron stores, normal iron status and low Hgb was not different between male and female infants (**Appendix Q, Table 5.2**). Among the 7 infants 8-12 mths of age with IDA, however, 5 were male and 2 female. Both of the 13-26 mth old infants with IDA were female.

Table 4.10. Number of infants with iron deficiency anemia, low iron stores, normal iron status, and low hemoglobin grouped by ancestry and age.

	8-26 mths (n=142)	8-12 mths (n=60)	13-17 mths (n=33)	18-26 mths (n=52)
Iron deficiency anemia[1]				
Caucasian	7/ 81	5/34	1/20	1/27
Chinese	1/48	1/16	0/12	0/20
Other	1/13	1/8	0/1	0/4
Low iron stores[2]				
Caucasian	24/ 81	5/34	10/20	9/27
Chinese	9/48	0/16	3/12	6/20
Other	5/13	4/8	1/1	0/4
Normal iron status[3]				
Caucasian	47/ 81	22/34	8/20	17/27
Chinese	38/48	15/16	9/12	14/20
Other	7/13	3/8	0/1	4/4
Low hemoglobin[4]				
Caucasian	3/ 81	2/34	1/20	0/27
Chinese	0/48	0/16	0/12	0/20
Other	1/13	1/8	0/1	0/4

Results shown are the number of infants, and in brackets the % of infants by ancestry and age within a given iron class assignment for 81 Caucasian infants, with n=34 of 8-12 mths, n=20 of 13-17 mths, n=27 of 18-26 mths, for 48 Chinese infants with n=16 of 8-12 mths, n=12 of 13-17 mths, and n=20 of 18-26 mths, and for all other infants, n=13, with n=8 of 8-12 mths, n=1 of 13-17 mths, and n=4 of 18-26 mths of age; mother's race was not given for 2 infants with normal iron status and one with low hemoglobin; mother's race was reported as 'Other' for one infant with iron deficiency anemia, and as South Asian, n=1, South East Asian, n=2 and 'Other', n=2 for the 5 infants with low iron stores, and as South Asian, n=2, 'mixed' n=4 and 'Other', n=1 for the 7 infants with normal iron status grouped as 'Other' ancestries.

[1]Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L.

[2]Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L.

[3]Normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L.

[4]Low hemoglobin, Hgb 102-109 g/L + ferritin >12 μg/L.

Chi Square analysis demonstrated a $P< 0.05$, $\chi^2=13.051$, df=2, significant association between iron status and infant ancestry.

4.3. Relation of Feeding History Determined by the Socio-Cultural and Infant Feeding Questionnaire of Infants 8-26 Mths of Age to Iron Status and Ancestry.

4.3.1. Infant Feeding History as Reported on the Socio-Cultural and Infant Feeding Questionnaire Among Infants Grouped by Iron Status.

The relations between feeding practices that are considered to be associated with increased risk of iron deficiency and iron status among infants 8-12 mths and 13-26 mths of age are shown in **Tables 4.11** and **4.12**, respectively. Chi-square analysis showed a significant association between iron status and the duration of breast-feeding ($P<0.05$) for infants 8-12 mths of age, but not 13-26 mths of age. Of the 7 infants 8-12 mths of age with IDA, 6 (86%) had been exclusively breast-fed >6 mths. Of the 23 infants aged 8-12 mths who had been exclusively breast-fed >6 mths, 26% of these had IDA (**Table 4.11**). In contrast, of the 34 infants aged 8-12 mths who had been exclusively breast-fed for ≤6 mths, only one had IDA who was an infant breast-fed for 6 mths (data not shown). Of the 32 infants aged 13-26 mths who were exclusively breast-fed >6 mths, 2 (6%) had IDA, 41% had low iron stores and 34% had normal iron status (**Table 4.12**). None of the 60 infants 13-26 mths of age who were exclusively breast-fed ≤6 mths had IDA, but 28% had low iron stores and 58% had normal iron status (data not shown).

Chi-square analysis also found a significant association ($P<0.005$) between iron status in 8-12 mth old infants and feeding with supplemental iron from iron-fortified infant formula or an iron supplement (**Table 4.11**). None of the 7 infants with IDA had received supplemental iron. However, 5/9 (66%) of the 8-12 mth old infants with low iron stores and 29/41 (71%) of those with normal iron status had received supplemental iron from formula or mineral supplements. No significant association was found between feeding with supplemental iron and iron status in the infants aged 13-26 mths (**Table 4.12**). Neither of the 2 infants aged 13-26 mths with IDA and 35 of the 53 infants aged 13-26 mths with normal iron status had no reported history of feeding with supplemental iron. However, 17 of the 29 of the infants with low iron stores had received supplemental iron (**Table 4.12**).

There were no significant associations between the age of introduction or the duration of feeding of iron-fortified infant cereals, or meats, poultry or fish (MPF) and iron status among either the 8-12 or 13-26 mth old infants. All 7 of the infants 8-12 mth old infants and one of the 2 infants aged 13-26 mths with IDA had been introduced to an iron-fortified infant cereal at the recommended age of 4-6 mths. The other 13-26 mth old infant with IDA had not been fed an iron-fortified infant cereal. All 9 of the 8-12 mth old infants and 26/29 (90%) 13-26 mth olds with low iron stores

had been introduced to an iron-fortified infant cereal at 4-6 mths. Only 19 of all the 148 infants in this study had been introduced to an iron-fortified infant cereal later than 6 mths of age, or not at all (not shown). Of these 19 infants, one had IDA, 3 had low iron stores (16%) and 13 (68%) had normal iron status. Of the 129 infants who had been introduced to an iron-fortified infant cereal by 6 mths of age, 8 (6%) had IDA, 35 (29%) had low iron stores and 67 (66%) had normal iron status.

A significant association ($P<0.001$) was found between iron status and the age of introduction of cows' milk in the 8-12 mth old infants. None of the infants with normal iron status, but 29% and 33% of infants with IDA and low iron stores, respectively, had been fed cows' milk prior to the recommended age of 9 mths.

Table 4.11. Summary of feeding history reported on the Socio-Cultural and Infant Feeding Questionnaire among infants 8-12 mths of age grouped by iron status.

	n	Iron deficient anemic (n=7)	Low iron stores (n=9)	Normal iron status (n=41)	$\chi 2$	*P* value
Breast-fed[1] >6 mths	23	6 (86)	3 (33)	14 (34)	6.06	<0.05
Not iron supplemented[2]	23	7 (100)	4 (44)	12 (29)	12.50	<0.005
Iron-fortified infant cereal introduced >6 mths or never fed	4	0 -	0 -	4 (10)	1.68	0.57
Iron-fortified infant cereal fed ≤2 mths	6	1 (14)	0 -	5 (12)	0.43	0.66
MPF[3] introduced >9 mths or never fed	10	2 (29)	1 (11)	7 (17)	0.85	0.65
MPF fed ≤1 mth	27	5 (71)	2 (22)	20 (49)	3.94	0.14
Cows' milk introduced <9 mths	5	2 (29)	3 (33)	0 -	14.04	<0.001

Results shown are the number of infants, with the percent of infants within a category of iron status given in brackets; Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L; Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L; Normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L; 3 infants were classified as low hemoglobin and biochemical data was not available for 2 infants (data not shown). Significant associations between iron status and feeding practices were determined using Chi Square Statistic with comparisons between infants with iron deficiency anemia, low iron stores and normal iron status.

[1]Breast-feeding was defined as breast-feeding with the intake of formula or other milk by bottle or cup not >8 oz/wk; Infants for whom there was an overlap of breast-feeding and feeding with infant formula exceeding 7 days from birth were omitted from analysis.

[2]Iron supplemented if fed an iron-fortified formula for ≥1 mth prior to the study and/or a history of feeding with an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin/mineral supplement for ≥1 mth.

[3]Meats, poultry or fish.

Table 4.12. Summary of feeding history reported on the Socio-Cultural and Infant Feeding Questionnaire among infants 13-26 mths of age grouped by iron status.

	n	Iron deficient anemic (n=2)	Low iron stores (n=29)	Normal iron status (n=53)	$\chi 2$	*P* value
Breast-fed[1] >6 mths	32	2 (100)	12 (41)	18 (34)	0.46	0.26
Not iron supplemented[2]	44	2 (100)	7 (59)	35 (66)	2.69	0.15
Iron-fortified infant cereal introduced >6 mths or never fed	13	1 (50)	3 (10)	9 (17)	0.25	0.76
Iron-fortified infant cereal fed ≤2 mths	9	1 (50)	2 (7)	6 (11)	0.05	1.00
MPF[3] introduced >9 mths or never fed	33	1 (50)	10 (34)	22 (41)	0.19	0.82
MPF fed ≤1 mth	3	0 -	0 -	3 (6)	1.76	0.55
Cows' milk introduced <9 mths	2	1 (50)	0 -	1 (2)	0.16	0.60

Results shown are the number of infants, with the percent of infants within a category of iron status given in brackets; Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L; Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L; Normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L; one infant was classified as low hemoglobin and biochemical data was not available for 1 infant (data not shown). No significant associations between iron status and feeding practices using Fisher's Exact Test with comparisons between infants with either iron deficiency anemia or low iron stores and those with normal iron status.

[1]Breast-feeding was defined as breast-feeding with the intake of formula or other milk by bottle or cup not >8 oz/wk; Infants for whom there was an overlap of breast-feeding and feeding with infant formula exceeding 7 days from birth omitted from analysis.

[2]Iron supplemented if fed an iron-fortified formula for ≥1 mth prior to the study and/or a history of feeding with an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin/mineral supplement for ≥1 mth.

[3]Meats, poultry or fish.

4.3.2. Frequency of Infant Feeding History Associated with Risk of Iron Deficiency Anemia and Low Iron Stores as Reported on the Socio-Cultural and Infant Feeding Questionnaire Among Infants from Caucasian and Chinese Ancestries.

The number of infants with feeding practices likely to be associated with risk of iron deficiency anemia (IDA) and low iron stores among 8-12 and 13-26 mth old Caucasian and Chinese infants is shown in **Table 4.13**, and **Table 4.14**, respectively. Significantly ($P<0.05$) more Caucasian than Chinese infants aged 8-12 mths had not been introduced to MPF by age 9 mths. There was no significant association between the introduction of iron-fortified infant cereal >6 mths of age, the proportion of infants breast-fed >6 mths, supplemented with iron, fed iron-fortified infant cereals ≤2 mths or MPF ≤1 mth, or introduced to cows' milk before age 9 mths at 8-12 mths and ancestry (**Table 4.13**). No differences were found in the feeding histories of the Caucasian and Chinese infants aged 13-26 mths (**Table 4.14**).

Table 4.13. Frequency of feeding history associated with risk for iron deficiency among infants 8-12 mths of age from Caucasian and Chinese ancestries.

	n	Caucasian (n=38)	Chinese (n=17)	$\chi 2$	*P* value
Breast-fed[1] >6 mths	26	17 (45)	9 (53)	0.04	1.00
Not iron supplemented[2]	23	17 (45)	6 (35)	0.43	0.57
Iron-fortified infant cereal introduced >6 mths or never fed	4	1 (3)	3 (18)	3.98	0.08
Iron-fortified infant cereal fed ≤2 mths	6	3 (8)	3 (18)	1.18	0.36
MPF[3] introduced >9 mths or never fed	8	8 (22)	0 -	4.20	<0.05
MPF fed ≤1 mth	26	21 (58)	5 (31)	3.25	0.13
Cows' milk introduced <9 mths	4	4 (11)	0 -	1.93	0.30

Results shown are the number of infants, with the percent of infants within a category of ancestry given in brackets. Significant associations between ancestry and feeding practices were determined using Fisher's Exact Test.
[1]Breast-feeding was defined as breast-feeding with the intake of formula or other milk by bottle or cup not >8 oz/wk; Infants for whom there was an overlap of breast-feeding and feeding with infant formula exceeding 7 days from birth were omitted from analysis.
[2]Iron supplemented if fed an iron-fortified formula for >1 mth prior to the study and/or a history of feeding with an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin/mineral supplement for ≥1 mth.
[3]meats, poultry or fish.

Table 4.14. Frequency of feeding history associated with risk for iron deficiency among infants 13-26 mths of age from Caucasian and Chinese ancestries.

	n	Caucasian (n=46)	Chinese (n=31)	$\chi 2$	*P* value
Breast-fed[1] >6 mths	28	20 (43)	8 (26)	1.75	0.22
Not iron supplemented[2]	27	16 (35)	11 (35)	0.00	1.00
Iron-fortified infant cereal introduced >6 mths or never fed	13	6 (12)	7 (22)	1.24	0.36
Iron-fortified infant cereal fed ≤2 mths	8	5 (10)	3 (9)	0.02	1.00
MPF[3] introduced >9 mths or never fed	32	20 (42)	12 (37)	0.20	0.82
MPF fed ≤1 mth	3	2 (4)	1 (3)	0.07	1.00
Cows' milk introduced <9 mths	2	2 (4)	0 -	1.39	0.51

Results shown are the number of infants, with the percent of infants within a category of ancestry given in brackets. No significant associations were found between ancestry and feeding practices using Fisher's Exact Test.
[1]Breast-feeding was defined as breast-feeding with the intake of formula or other milk by bottle or cup not >8 oz/wk; Infants for whom there was an overlap of breast-feeding and feeding with infant formula exceeding 7 days from birth were omitted from analysis.
[2]Iron supplemented if fed an iron-fortified formula for >1 mth prior to the study and/or a history of feeding with an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin/mineral supplement for ≥1 mth.
[3]meats, poultry or fish.

4.4 Relation of the Intakes of Major Food Sources of Iron and Dietary Factors Influencing Iron Absorption Determined by the FFQ Among Infants 8-26 Mths of Age to Iron Status and Ancestry.

4.4.1 Intakes of Major Food Sources of Iron and Dietary Factors Influencing Iron Absorption Determined by FFQ Among Infants Grouped by Iron Status.

The intakes of major food sources of iron and dietary factors influencing iron absorption were determined using an interviewer administered FFQ that covered the previous 2 weeks. For the FFQ analyses, infants were classified as iron-fortified infant formula fed if they had been fed iron-fortified formula during the 2 week period recorded in the FFQ and as breast-fed if they were receiving any breast milk at all, regardless of the intake of formula or other milks. Note that in the infant feeding history, infants were classified as iron supplemented if they had been fed an iron-fortified formula for ≥1 mth prior to the study, for ≥3 mths at any time, or had been given an iron supplement for ≥1 mth, and as exclusively breast-fed if they had not consumed >8 ounces/day formula or other milk by bottle or cup. Thirty-three infants were classified as fed an iron-fortified infant formula and 41 as breast-fed by the FFQ. The number of infants with a history of iron supplementation was 74 and 115 were classified as breast-fed by the Socio-Cultural and Infant Feeding Questionnaire (see pages 105/106 and 93, respectively). To explore the relations between dietary factors and iron status, all infants with a serum ferritin ≤12 μg/L were classified as poor iron status (i.e. both IDA and low iron stores) and infants with a serum ferritin ≥14 μg/L as normal iron status. Infants with a serum ferritin >12 -<14 μg/L were excluded to more clearly differentiate infants with normal iron status from those with low iron stores. The Mann-Whitney U test found no differences in the median daily intakes of food (g/day) from the different FFQ food categories between boys and girls at 8-12 or 13-26 mths of age (data not shown), therefore, data for male and female infants were combined for subsequent analyses.

The proportions of infants classified as poor iron status and normal iron status who ate foods from the food categories representing the major dietary sources of iron and other factors influencing iron absorption, together with the median daily intakes and amounts of iron from the different food categories for infants 8-12 and 13-26 mths of age are shown in **Tables 4.15** and **4.16**, respectively. Infants 8-12 mths of age with poor iron status had significantly lower median intakes of MPF ($P<0.05$) and iron-fortified infant formula ($P<0.001$), and higher intakes of human milk ($P<0.005$) and milk and milk products ($P<0.05$) than infants with normal iron status (**Table 4.15**). Among the 8-12 mth old infants, 75% of those with normal iron status and 6% of those with poor iron status were fed an iron-

fortified formula. The median intakes of iron-fortified formula for the 8-12 mth old infants with poor iron status and normal iron status was 0 g and 464 g/day, respectively. The mean intake of iron-fortified infant formula for the one 8-12 mth old infant with poor iron status who had received iron-fortified formula was 26 g/day for the 2 weeks covered by the FFQ. Of the 16 infants with poor iron status, 81% were breast-fed at the time of the study compared with 44% of the infants with normal iron status. Moreover, 87% of the infants with poor iron status but 69% of those with normal iron status were fed cows' milk and milk products (**Table 4.15**). Further, significantly ($P<0.05$) more 8-12 mth old infants with low iron stores than with normal iron status were fed ≥800 mL cows' milk at the time of the study, n=3/39 and n=0/41, respectively (not shown). Further exploratory analysis that excluded 5 infants previously classified as poor iron status but who had a serum ferritin >10- ≤12 μg/L and 3 infants previously classified as normal iron status but who a serum ferritin ≥14-<16 μg/L did not change the statistical interpretation.

The 13-26 mth old infants with poor iron status had significantly lower median intakes of MPF, other cereals, and soy-based products ($P<0.05$), but not human milk ($P=0.06$) than the infants with normal iron status (**Table 4.16**). Although all of the 13-26 mth old infants with poor iron status and 98% of those with normal iron status were fed MPF at the time of the study, the median intake of MPF for the infants with poor iron status was 20 g/day, representing only 59% of the median intake of 34 g/day of the infants with normal iron status ($P<0.05$). Further, 90% of the infants with normal iron status but 67% of the infants with poor iron status were being fed other cereals, with median intake values of 25 and 5 g/day, respectively, $P<0.05$ (**Table 4.16**). Moreover, significantly more ($P<0.05$) 13-26 mth old infants with low iron stores than with normal iron status were fed ≥800 mL cows' milk at the time of the study, n=10/29 and n=6/42, respectively (not shown). Further exploratory analysis that excluded 7 infants previously classified as poor iron status but who had a serum ferritin >10- ≤12 μg/L and 4 infants previously classified as normal iron status but who a serum ferritin ≥14-<16 μg/L did not change the statistical interpretation with the exception of breast milk, $P=0.03$, and soy-based products, $P=0.09$.

Table 4.15. Median daily intakes of food and iron from different food categories determined by the FFQ for infants 8-12 mths of age classified according to iron status.

	Poor iron status (n=16)			Normal iron status (n=36)			*P* value
	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	
Meat, poultry and fish*	11 (69)	0 (0-19)	0 (0-0.4)	27 (75)	8 (0-89)	0.1 (0-1.7)	0.02
Mixed dishes with meat, poultry and fish	12 (75)	22 (0-166)	0.03 (0-0.8)	27 (75)	40 (0-802)	0.07 (0-0.40)	0.33
Iron-fortified infant formula*	1 (6)	0 (0-26)	0 (0-0.3)	27 (75)	464 (0-1094)	4.1 (0-11.0)	<0.001
Regular formula	1 (6)	0 (0-17)	0 -	4(11)	0 (0-633)	0 (0-1.9)	0.53
Breast milk*	13 (81)	306 (0-677)	0.1 (0-0.2)	16 (44)	0 (0-553)	0 (0-0.2)	<0.005
Iron-fortified infant cereal	13 (81)	8 (0-47)	3.8 (0-10.9)	29 (80)	15 (0-67)	4.5 (0-30.1)	0.61
Other cereals	10 (62)	9 (0-75)	1.0 (0-5.0)	20 (55)	3 (0-64)	0.3 (0-10.0)	0.35
Fruit and fruit juice	16 (100)	200 (12-379)	0.3 (0-1.8)	36 (100)	110 (13-380)	0.3 (0-1.2)	0.31
Milk and milk products*	14 (87)	70 (0-1509)	0.1 (0-0.8)	25 (69)	22 (0-732)	0 (0-0.4)	0.01
Soy-based products	5 (31)	0 (0-74)	0 (0-6.0)	16 (44)	0 (0-74)	0 (0-6.5)	0.53

Results shown are number of infants, and in brackets, the percent of infants within a given iron status category consuming food, and for intake are median (range); FFQ, food frequency questionnaire. Data not included for 8 infants with serum ferritin >12-<14 μg/L.

*Significant difference in median intake (g/day) between infants with poor iron status and normal iron status (Mann-Whitney U Test); Statistical analysis that excluded 8 infants with serum ferritin >10-<16 μg/L, poor iron status n=5, normal iron status n=3 did not change the statistical interpretation.

Table 4.16. Median daily intakes of food and iron from different food categories determined by the FFQ for infants 13-26 mths of age classified according to iron status.

	Poor iron status (n=31)			Normal iron status (n=42)			*P* value
	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	
Meat, poultry and fish*	29 (100)	20 (3-85)	0.2 (0-1.2)	41 (98)	34 (0-229)	0.4 (0-3.5)	0.01
Mixed dishes with meat, poultry and fish	28 (97)	42 (0-772)	0.5 (0-3.8)	37 (88)	67 (0-1127)	0.6 (0-8.3)	0.43
Iron-fortified infant formula	1 (3)	0 (0-13)	0 (0-0.1)	4 (9)	0 (0-744)	0 (0-9.9)	0.30
Regular formula	0	0 -	0 -	0	0 -	0 -	1.00
Breast milk	8 (28)	0 (0-492)	0 (0-0.1)	4 (9)	0 (0-344)	0 (0-0.1)	0.06
Iron-fortified infant cereal	5 (17)	0 (0-22)	0 (0-10.0)	4 (9)	0 (0-25)	0 (0-11.3)	0.31
Other cereals*	21 (67)	5 (0-189)	0.6 (0-5.8)	38 (90)	25 (0-166)	1.9 (0-14.3)	0.04
Fruit and fruit juice	29 (100)	191 (4-606)	0.6 (0-2.0)	42 (100)	252 (21-599)	0.8 (0-2.3)	0.35
Milk and milk products	29 (100)	611 (164-1231)	0.4 (0.1-1.1)	41 (98)	537 (0-1025)	0.3 (0-1.0)	0.26
Soy-based products*	12 (41)	0 (0-56)	0 (0-4.9)	26 (62)	2 (0-475)	0.1 (0-10.4)	<0.05

Results shown are number of infants, and in brackets, the percent of infants within a given iron status category consuming food, and for intake are median (range); FFQ, food frequency questionnaire. Data not included for 9 infants with serum ferritin >12-<14 μg/L.

*Significant difference in median intake (g/day) between infants with poor iron status and normal iron status (Mann-Whitney U Test); Statistical analysis that excluded infants with serum ferritin >10-<16 μg/L, poor iron status n=7, normal iron status n=4 did not change the statistical interpretation with the exception of breast milk *P*=0.03 and soy-based products *P*=0.09.

The contribution of the different food groups to the median intakes of food and iron of the infants with poor iron status (serum ferritin ≤12 μg/L) or normal iron status (serum ferritin ≥14 μg/L) at 8-12 mths of age is shown in **Figures 4.1 and 4.2**, respectively. Infants 8-12 mths of age with poor iron status consumed more of their daily food as human milk, 42%; fruits and vegetables, 37%; and milk and milk products, 10%; and less as iron-fortified infant formula, 0% than infants with normal iron status (0%, 24%, 3% and 63% of the food intake, respectively) (**Figure 4.1**). With respect to the intake of iron, the infants with poor iron status consumed 57% of their iron intake from iron-fortified infant cereals, 15% from other cereals, and 13% from breads, pasta and rice with 0% from iron-fortified infant formula, whereas the infants with normal iron status consumed 43%, 3%, 3% and 41%, respectively of their iron from these food groups (**Figure 4.2**).

The contribution of the different food groups to the median intakes of food and iron of the 13-26 mth old infants with poor iron status and with normal iron status is shown in **Figures 4.3 and 4.4**, respectively. Infants 13-26 mths of age with poor iron status consumed more of their daily food as milk and milk products, 61% than those of normal iron status, 49% (**Figure 4.3**). With respect to the intake of iron, the infants with poor iron status consumed 34% from breads, pasta and rice, with 13% from other cereals compared with the infants with normal iron status (24%, 30%, respectively) (**Figure 4.4**).

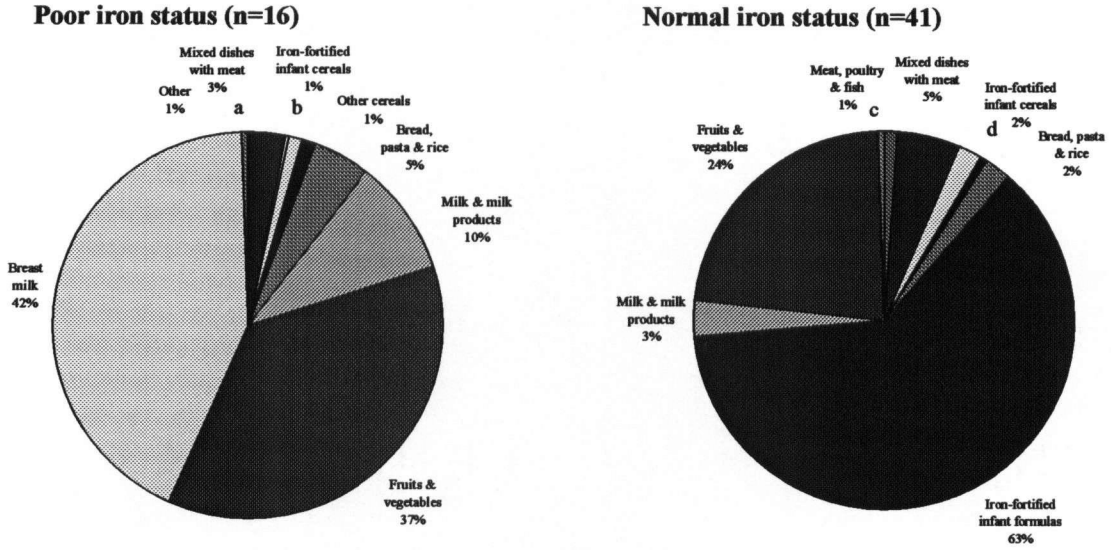


Figure 4.1. Estimated contribution of food groups to the total intake of food (g/100 g/day) determined by FFQ among infants 8-12 mths of age who were poor iron status or had normal iron status.
Results shown are the percent contribution (g/100 g/day) of the median intake of each food group to the median total food intake; food groups contributing <0.5% of total median intake are indicated by superscripts, [a]meat, poultry & fish, [b]nuts, legumes & eggs, [c]other cereals, [d]other. The median food intake for infants with poor iron status was 527 g/day and for infants with normal iron status was 670 g/day.

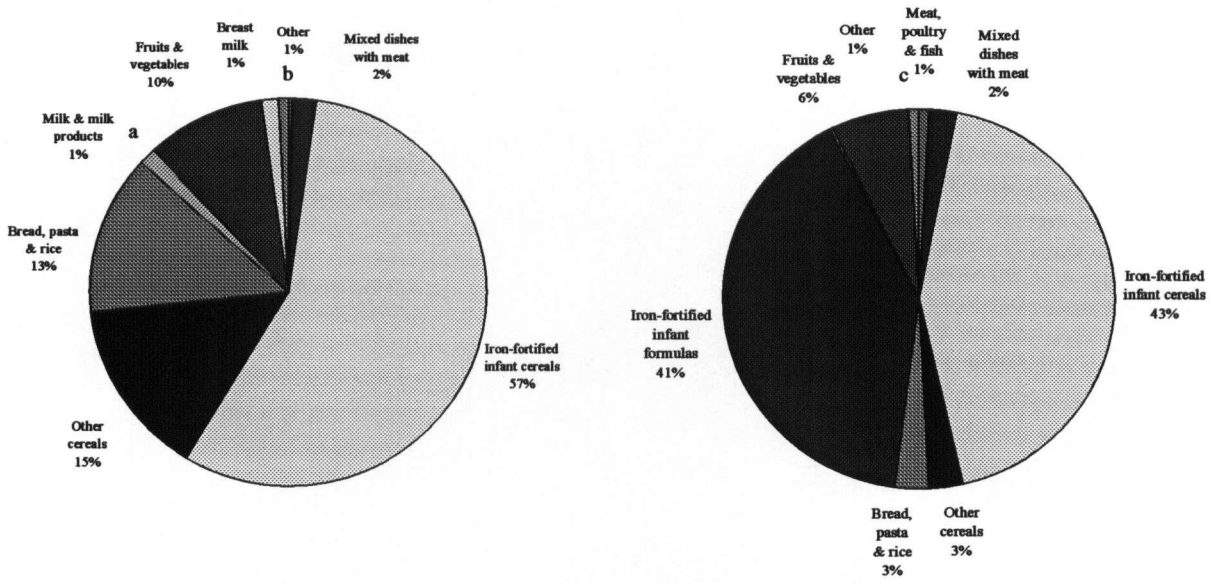


Figure 4.2. Estimated contribution of iron by food groups to the total iron intake (mg/100 mg/day) determined by FFQ among infants 8-12 mths of age who were poor iron status or had normal iron status.
Results shown are the percent contribution (mg/100 mg/day) of the median intake of each food group to the total iron intake; food groups contributing <0.5% of total median intake indicated by superscripts, [a]nuts, legumes & eggs, [b]meat, poultry & fish, [c]milk & milk products. The median iron intake for infants with poor iron status was 5.5 mg/day, and for infants with normal iron status was 9.7 mg/day.

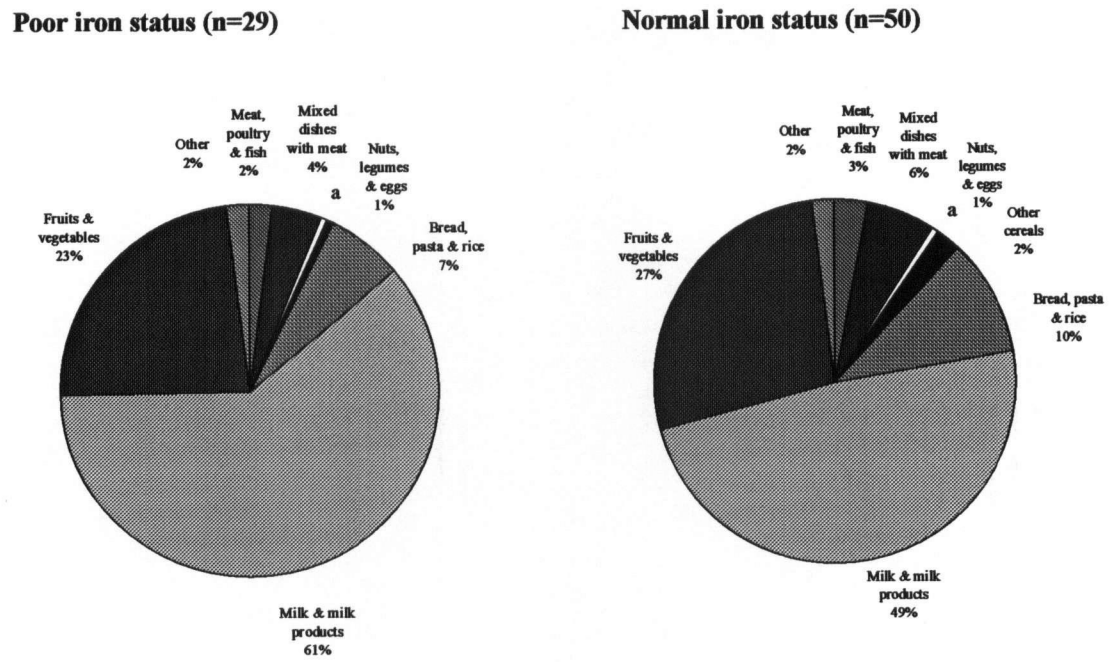


Figure 4.3. Estimated contribution of food groups to the total intake of food (g/100 g/day) determined by FFQ among infants 13-26 mths of age who were poor iron status or had normal iron status.
Results shown are the percent contribution (g/100 g/day) of the median intake of each food group to the median total food intake; Food groups contributing <0.5% of total median intake indicated by superscripts, [a]other cereals. The median food intake for infants with poor iron status was 1075 g/day, and for infants with normal iron status was 1070g/day.

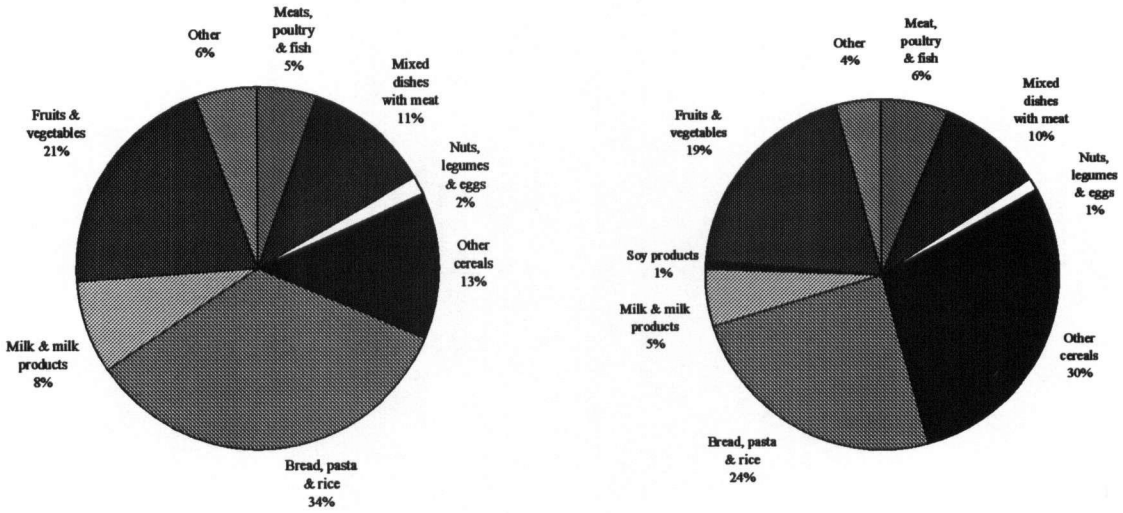


Figure 4.4. Estimated contribution of iron by food groups to the total iron intake (mg/100 mg/day) determined by FFQ of infants 13-26 mths of age who were poor iron status or had normal iron status.
Results shown are the percent contribution (mg/100 mg/day) of the median intake of each food group to the total iron intake. The median iron intake for infants with poor iron status was 4.5 mg/day, and for infants with normal iron status was 6.7 mg/day.

4.4.2. Intake of Foods Providing Major Sources of Iron and Factors Influencing Iron Absorption Determined by the FFQ Among Infants from Caucasian and Chinese Ancestries.

The proportions of Caucasian and Chinese infants who ate foods from the food categories that provide the major dietary sources of iron and factors that influence iron absorption, together with the median daily intakes and the amounts of iron from the different food categories for infants 8-12 and 13-26 mths of age are shown in **Tables 4.17** and **4.18**, respectively. Caucasian infants 8-12 mths of age had significantly lower median intakes of MPF ($P<0.005$), mixed dishes with MPF ($P<0.01$) and iron-fortified infant formula ($P<0.001$), and higher intakes of human milk ($P<0.001$) and other cereals ($P<0.05$) than Chinese infants (**Table 4.17**). All of the 8-12 mth old Chinese infants were fed MPF and mixed dishes with MPF, whereas 69% of the Caucasian infants were fed MPF and 64% were fed mixed dishes with MPF. Ninety-four percent of the Chinese infants had been fed iron-fortified formula, with a median intake of 641 g/day, for the 2 weeks covered by the FFQ. Only 36% of the Caucasian infants had been fed iron-fortified formula, with a median intake of 0 g/day. At the time of the study, 2 of the 16 Chinese and 29/36 of the Caucasian infants aged 8-12 mths were breast-fed. Further, 72% of Caucasian and 44% of Chinese infants aged 8-12 mths were fed other cereals with a median intakes of 9 and 0 g/day, respectively (**Table 4.17**).

The 13-26 mth old Caucasian infants had significantly lower median intakes of mixed dishes with MPF ($P<0.001$) and iron-fortified infant formula ($P<0.05$), but higher intakes of human milk ($P<0.05$), other cereals ($P<0.001$) and fruits and fruit juices ($P<0.005$) than the Chinese infants (**Table 4.18**). Although 77% of the Caucasian and 74% of the Chinese infants aged 13-26 mths were fed mixed dishes with MPF at the time of the study, the median intake among Caucasian infants was 24 g/day, equivalent to only 15% of the median intake of 180 g/day of the Chinese infants, $P<0.001$. Only 2% of the Caucasian and 12% of the Chinese infants aged 13-26 mths were being fed iron-fortified formula at the time of the study, $P<0.05$. Although the intake of iron-fortified formula of the Caucasian and Chinese infants was significantly different ($P<0.05$), the median intake of both groups was 0 g/day, with a range of 0-100 g/day for the Caucasian and 0-744 g/day for the Chinese infants (**Table 4.18**). Twelve of the 48 Caucasian and 2 of the 32 Chinese infants aged 13-26 mths were breast-fed during the 2 weeks covered by the FFQ, $P<0.05$. other cereals and fruit and fruit juices were consumed by 85% and 92%, with median intakes of 31 g/day and 28 g/day, respectively of the Caucasian infants, while other cereals and fruit and fruit juices were consumed by 48% and 74%, with median intakes of 3 g/day and 165 g/day, respectively of the Chinese infants (**Table 4.18**).

The percent contributions of the different food groups to the median food and iron intakes of the Caucasian and Chinese infants aged 8-12 and 13-26 mths are shown in **Figures 4.5** and **4.6**, respectively. Caucasian infants 8-12 mths of age consumed 49% of their daily food intake as breast milk, 35% as fruits and vegetables with 0% from iron-fortified formula and 0% from congee with meat, compared with 0%, 9%, 66% and 17% from breast milk, fruits and vegetables, iron-fortified infant formula and congee with meat, respectively for Chinese infants of similar age (**Figure 4.5**). Iron-fortified infant cereals contributed 58% of the median iron intake among the 8-12 mth old Caucasian infants but only 11% among the Chinese infants. In contrast, iron-fortified infant formula but did not contribute to the total iron intake among the 8-12 mth old Caucasian infants but contributed 68% among the Chinese infants (**Figure 4.6**).

The analysis of the contribution of food groups to the total food intakes of the 13-26 mth old infants found that Chinese infants consumed >3 times more of their daily food intake as MFP and mixed dishes with MPF than Caucasian infants (**Figure 4.7**). Caucasian infants, on the other hand, consumed a greater proportion of their daily food intake as fruits and vegetables than Chinese infants did (32% and 20%, respectively). The major food sources of iron were other cereals, 33%, breads, pasta and rice, 28%, and fruits and vegetables, 20%, among 13-26 mth old Caucasian infants (**Figure 4.8**). Similarly, fruits and vegetables, and breads, pasta and rice contributed 25% and 18%, respectively to the total iron intake among Chinese infants, but other cereals contributed only 10%. Chinese infants aged 13-26 mths consumed >2-fold more of their daily iron intake as MPF, and almost 5-fold more as mixed dishes with MPF than Caucasian infants.

Table 4.17. Median daily intakes of food and iron from different food categories determined by the FFQ for infants 8-12 mths of age from Caucasian and Chinese ancestries.

	Caucasian (n=36)			Chinese (n=16)			*P* value
	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	
Meat, fish and poultry*	25 (69)	3 (0-60)	0 (0-0.8)	16 (100)	12 (4-89)	0.2 (0-1.7)	<0.005
Mixed dishes with meat, fish and poultry*	23 (64)	7 (0-166)	0.1 (0-1.6)	16 (100)	275 (4-802)	1.2 (0-3.9)	<0.01
Iron-fortified infant formula*	13 (36)	0 (0-814)	0 (0-9.6)	15 (94)	641 (0-1094)	4.8 (0-11.0)	<0.001
Regular formula	4 (11)	0 (0-633)	0 0-1.9	2 (12)	0 (0-422)	0 0-1.2	0.84
Breast milk*	29 (81)	277 (0-692)	0.1 (0-0.2)	2 (12)	0 (0-277)	0 (0-0.1)	<0.001
Iron-fortified infant cereal	29 (81)	8 (0-67)	3.8 (0-30.1)	10 (62)	2 (0-45)	0.7 (0-10.5)	0.26
Other cereals*	26 (72)	9 (0-75)	0.9 (0-5.0)	7 (44)	0 (0-22)	0 (0-10.0)	0.03
Fruit and fruit juice*	35 (97)	125 (0-380)	0.3 (0-1.8)	16 (100)	65 (13-241)	0.2 (0-0.6)	0.05
Milk and milk products	26 (72)	32 (0-799)	0 (0-0.4)	12 (75)	10 (0-732)	0 (0-0.4)	0.27
Soy-based products	13 (36)	0 (0-74)	0 (0-6.5)	9 (56)	1 (0-13)	0 (0-0.4)	0.48

Results shown are number of infants consuming food, and in brackets, the percent of infants within a given iron status category, and for intake are median (range); FFQ, food frequency questionnaire.

*Significant difference in median intake of food (g/day) between Caucasian and Chinese infants infants (Mann-Whitney U Test).

Table 4.18. Median daily intakes of food and iron from different food categories determined by the FFQ for infants 13-26 mths of age from Caucasian and Chinese ancestries.

	Caucasian (n=48)			Chinese (n=32)			*P* value
	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	Infants consuming food n (%)	Intake (g)	Iron intake (mg)	
Meat, poultry and fish	42 (88)	26 (0-121)	0.3 (0-1.9)	31 (74)	26 (2-229)	0.4 (0.3-3.5)	0.52
Mixed dishes with meat, poultry and fish*	37 (77)	24 (0-317)	0.2 (0-3.8)	31 (74)	180 (8-1127)	1.1 (0.1-8.3)	<0.001
Iron-fortified infant formula*	1 (2)	0 (0-100)	0 (0-1.2)	5 (12)	0 (0-744)	0 (0-9.9)	0.03
Regular formula	0	0 -	0 -	0	0 -	0 -	1.00
Breast milk*	12 (25)	0 (0-861)	0 (0-0.3)	2 (5)	0 (0-344)	0 (0-0.1)	0.03
Iron-fortified infant cereal	8 (17)	0 (0-25)	0 (0-11.3)	3 (7)	0 (0-5)	0 (0-1.9)	0.24
Other cereals*	41 (85)	31 (0-189)	2.2 (0-14.3)	20 (48)	3 (0-157)	0.4 (0-6.0)	<0.001
Fruit and fruit juice*	44 (92)	281 (57-606)	1.0 (0.2-2.0)	31 (74)	165 (4-579)	0.5 (0-2.3)	0.004
Milk and milk products	43 (90)	514 (0-1109)	0.3 (0-1.1)	31 (74)	639 (70-1231)	0.4 (0.1-1.0)	0.20
Soy-based products	21 (44)	0 (0-192)	0 (0-8.9)	22 (52)	2 (0-475)	0.1 (0-4.9)	0.21

Results shown are number of infants consuming food, and in brackets, the percent of infants within a given iron status category, and for intake are median (range); FFQ, food frequency questionnaire.

*Significant difference in median intake of food (g/day) between Caucasian and Chinese infants (Mann-Whitney U Test).

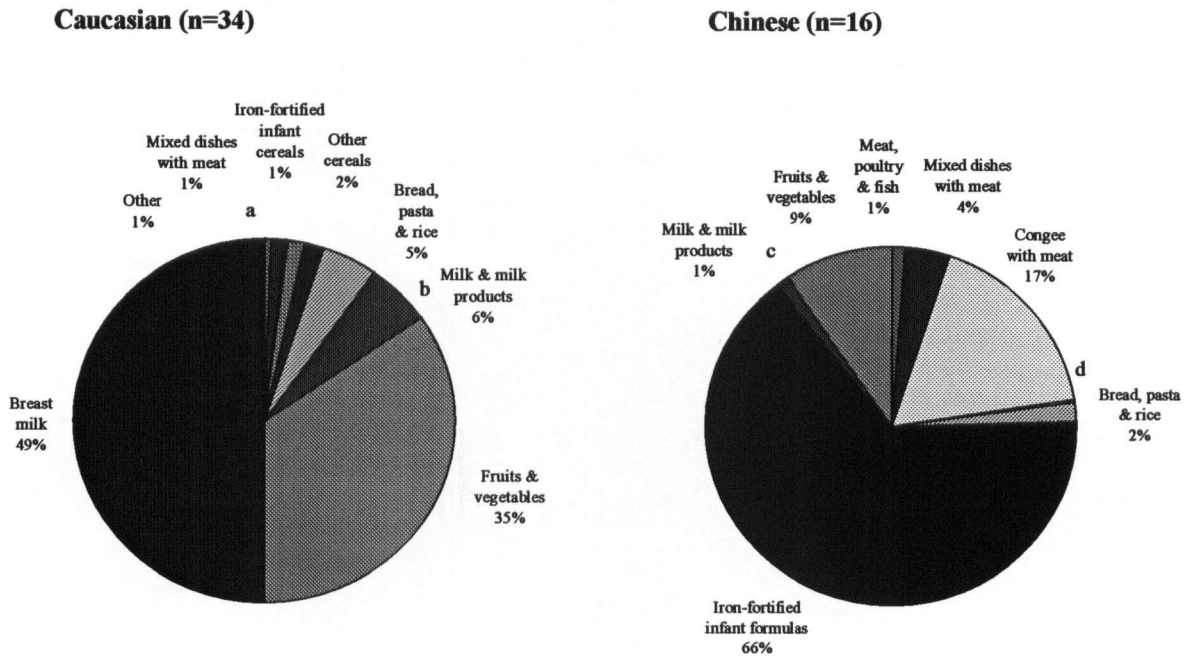


Figure 4.5. Estimated contribution of food groups to the total intake of food (g/100 g day) determined by FFQ among infants 8-12 mths of age from Caucasian and Chinese ancestries.
Results shown are the percent contribution (g/100 g day) of the median intake of each food group to the median total food intake; food groups contributing <0.5% of total median intake indicated by superscripts, [a]meat, poultry & fish, [b]nuts, legumes & eggs, [c]other products, [d]iron-fortified infant cereals; the median food intake for Caucasian infants was 1050 g/day, and for Chinese infants was 1101 g/day.

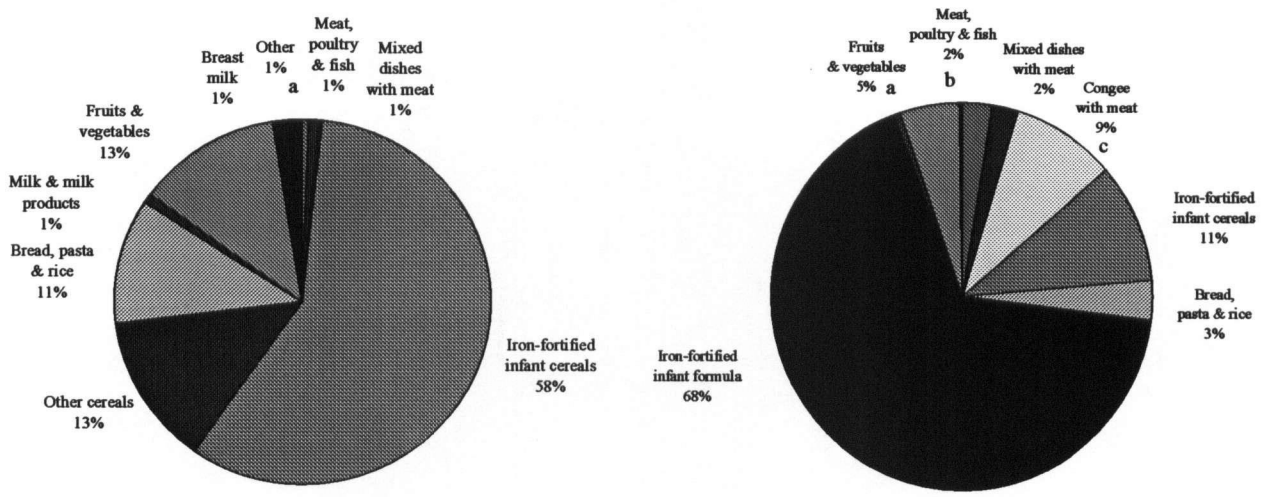


Figure 4.6. Estimated contribution of iron by food groups to the total iron intake (mg/100 mg/day) determined by FFQ among infants 8-12 mths of age from Caucasian and Chinese ancestries.
Results shown are the percent contribution (mg/100 mg/day) of the median intake of each food group to the total iron intake; food groups contributing <0.5% of total median intake indicated by superscripts, [a]nuts, legumes & eggs, [b]other products, [c]milk & milk products, [d]soy products; the median iron intake for Caucasian infants was 6.6 mg/day, and for Chinese infants was 3.4 mg/day.

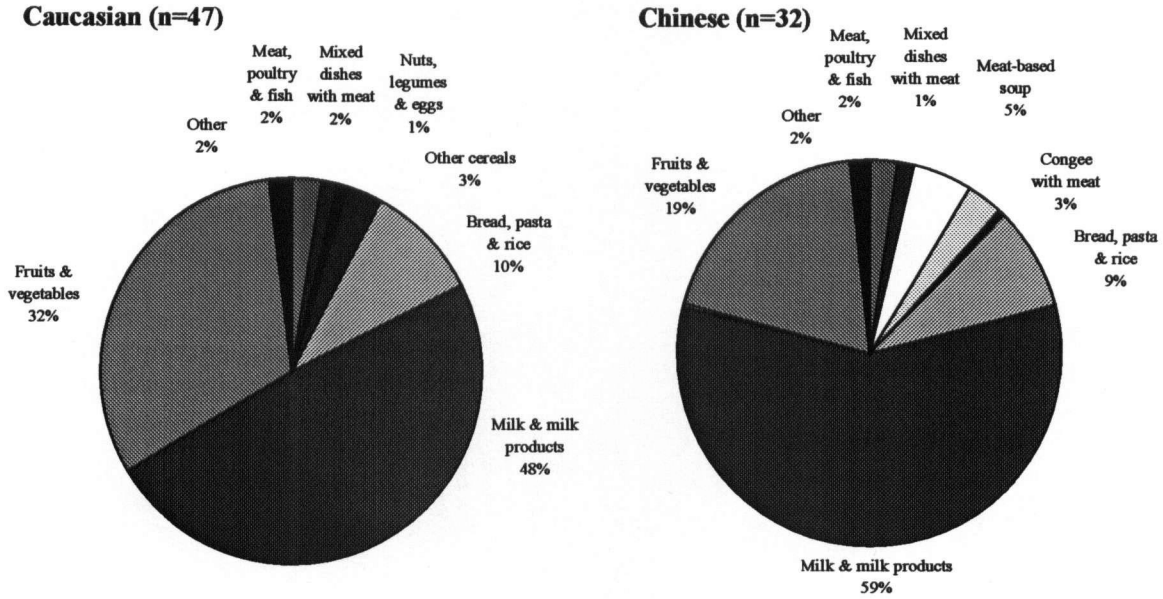


Figure 4.7. Estimated contribution of food groups to the total intake of food (g/100 g/day) determined by FFQ among infants 13-26 mths of age from Caucasian and Chinese ancestries.
Results shown are the percent contribution (g/100 g/day) of the median intake of each food group to the median total food intake; the median food intake for Caucasian infants was 561 g/day, and for Chinese infants was 984 g/day.

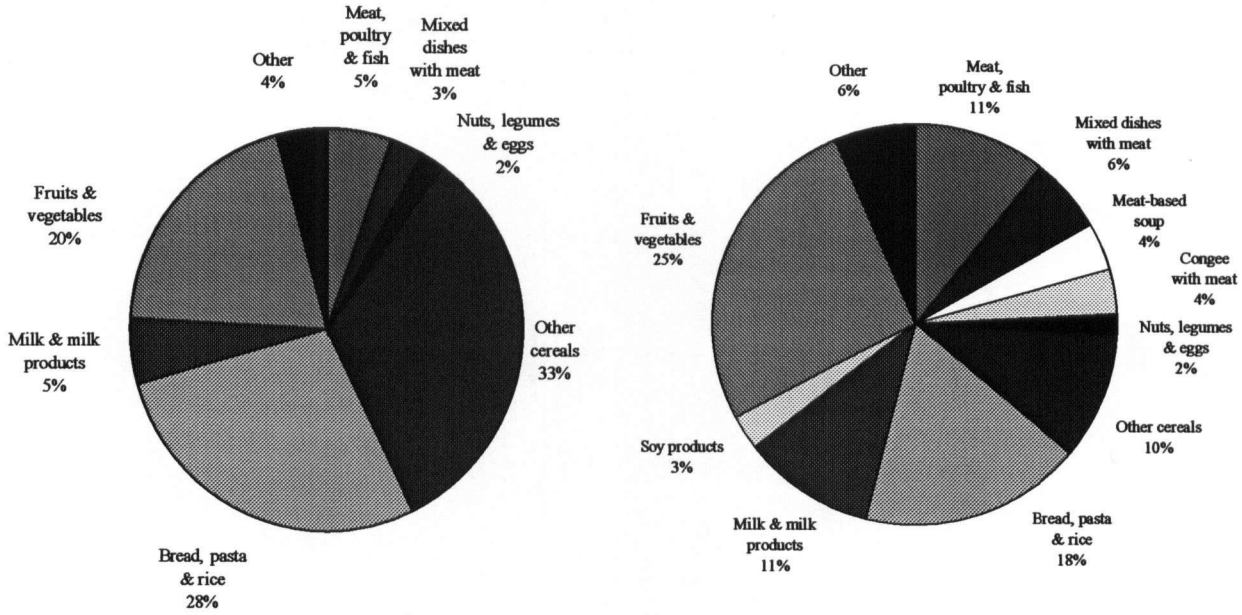


Figure 4.8. Estimated contribution of iron by food groups to the total iron intake (mg/100 mg/day) determined by FFQ among infants 13-26 mths of age from Caucasian and Chinese ancestries.
Results shown are the percent contribution (mg/100 mg/day) of the median intake of each food group to the total iron intake; the median iron intake for Caucasian infants was 6.5 mg/day, and for Chinese infants was 7.2 mg/day.

4.5 Relation of Estimated Intakes of Iron and Factors Known to Influence Iron Absorption From Non-milk Foods Determined by 3d-FR of Infants 8-26 Mths of Age to Iron Status and Ancestry.

4.5.1. Intakes of Iron and Dietary Factors Known to Influence Iron Absorption From Non-milk Foods Determined by 3d-FR Among Infants Grouped by Iron Status.

The intakes of iron and dietary factors known to influence iron absorption were also determined using a 3d-FR because this methodology can be expected to give a better estimate of actual quantities of nutrient intakes than a FFQ. Infants were classified as breast-fed/fed low iron "milk", or as fed with an iron-fortified formula or an iron supplement to examine the importance of the infant's primary milk feeding. Infants were classified as breast-fed/fed low iron "milk" if they were fed 2 or more breast-feedings or >250 mL/day low iron formula, cows' milk or goats' milk/day. Infants were classified as iron supplemented if they had been fed >250 mL/day iron-fortified formula for ≥1 mth prior to the study or an iron-fortified formula for ≥3 mths, or given iron drops or a multivitamin/mineral supplement with iron for ≥1 mth. The infants were classified as poor iron status if they had a serum ferritin ≤12 μg/L and normal iron status if they had a serum ferritin ≥14 μg/L. Significant positive associations were found between age and the intakes of energy (r=0.64, $P<0.001$), heme iron (r=0.34, $P<0.001$), vitamin C (r=0.58, $P<0.001$) and dietary fibre (r=0.37, $P<0.001$), but not total iron, non-heme iron, or calcium (**Appendix Q, Figures 5.1-5.7**). Thus, the intakes of energy, heme iron, vitamin C and dietary fibre were further analyzed with age as a covariate. Whether or not the infant had been supplemented with iron was also included as a covariate in analyses of total and non-heme iron intake and iron status.

Table 4.19 shows the intakes of iron from non-milk foods determined by the 3d-FR among infants classified as breast-fed or fed low iron "milk", or supplemented with iron and in relation to iron status. None of the infants with IDA were classified as iron supplemented; thus all of the infants who had been supplemented with iron and who were in the poor iron status group had low iron stores, but not IDA. There were no significant differences in the median total iron intake from non-milk foods between infants with poor iron status and normal iron status, with the analysis undertaken with transformed data, and with iron supplementation, infant age and total energy intake from non-milk foods as covariates ($P=0.441$). The infants 8-12 mths of age with poor iron status and classified as breast fed/low iron "milk" fed had a median iron intake of 3.5 mg/day (range 3.0-16.0 mg/day) from non-milk foods compared with 9.0 mg/day (range 1.1-22.8 mg/day) among those with normal iron status (**Table 4.19**). The infants

13-26 mths of age with poor iron status and classified as breast fed/low iron "milk" fed had a median iron intake of 4.4 mg/day (range 0.8-20.8 mg/day) from non-milk foods compared with 8.5 mg/day (range 2.2-15.1 mg/day) among those with normal iron status. Statistical analysis excluding infants with serum ferritin >10-<16 μg/L, 8-12 mths, n=7 breast-fed or fed low iron "milk", n=3 iron supplemented; 13-26 mths, n=4 breast-fed or fed low iron "milk", n=6 iron supplemented, and low Hgb, n=4, did not change the statistical interpretation, $P>0.1$.

The history of iron supplement use among the study participants grouped by iron status is given in **Table 4.20**. None of the infants who had received iron from Fer-In-Sol® or a multivitamin/mineral supplement containing iron had IDA or low iron stores. Of the 94 infants with normal iron status, 7 (7%) had received iron from Fer-In-Sol® or a multivitamin with iron; 35% of infants with normal iron status, 18% with low iron stores and 22% with IDA had received a multivitamin/mineral supplement without iron. Five infants had received a supplement of vitamin C; of these, one (11%) had IDA, 2 (5%) had low iron stores and 2 (2%) had normal iron status.

The intakes of iron estimated from the 3d-FR as a percent of the RNI is shown in **Figure 4.9**. More infants with poor iron status (34%) than with normal iron status (16%) had an iron intake <77% of the RNI (7 mg/day and 6 mg/day for infants 8-11 and 12-26 mths of age, respectively) ($P=0.01$).

The intakes of energy, heme iron, non-heme iron, vitamin C, calcium and dietary fibre from non-milk foods among infants grouped by iron status for infants 8-12 mths, and 13-26 mths of age is shown in **Table 4.21 and 4.22**, respectively. The General Linear Model for Univariate analysis with iron supplementation, infant age and total energy intake from non-milk foods as covariates found no significant differences in the intakes of the latter nutrients between infants with poor iron status and normal iron status at any age. However, when infants with a serum ferritin >10-<16 μg/L or a low Hgb were excluded from the analysis, the intake of heme iron was significantly higher among those with normal iron status than among those with poor iron status, $P<0.05$.

Table 4.19. Intakes of iron from non-milk foods determined by the 3d-FR among infants with poor iron status and normal iron status who were breast-fed or fed low iron "milk", or iron supplemented.

	8-12 mths		13-26 mths	
	Breast-fed[1] or fed low iron "milk "[2] (n=20)	**Iron supplemented[3] (n=32)**	**Breast-fed or fed low iron "milk" (n=27)**	**Iron supplemented (n=47)**
Poor iron status (ferritin ≤12 μg/L)	3.5 (3.0 – 16.0) *n=11*	7.2 (3.0 – 11.9) *n=5*	4.4 (0.8 – 20.8) *n=14*	6.2 (2.2 – 16.0) *n=17*
Normal iron status (ferritin ≥14 μg/L)	9.0 (1.1 - 22.8) *n=9*	7.2 (1.2 – 26.6) *n=27*	8.5 (2.2 – 15.1) *n=13*	5.8 (1.6 – 13.7) 6.2[4] (2.8 – 19.0) *n=30*

Results shown are median (range); 3d-FR, 3-day food record. Data not shown for 17 infants with ferritin >12-<14 μg/L; 8-12 mths, n=5 breast-fed or fed low iron "milk", n=3 iron supplemented; 13-26 mths, n=2 breast-fed or fed low iron "milk", n=7 iron supplemented; 4 infants could not be classified as either breast-fed/low iron "milk" or iron supplemented.

[1]Breast-fed defined as receiving an average of ≥2 breast-feedings/day.

[2]Low iron "milk" includes low iron formula, cows' milk and goats' milk.

[3]Iron supplemented includes infants fed an iron fortified formula for one mth preceding the study and/or fed an iron-fortified infant formula for ≥3 mths at any age, or given iron drops or a multivitamin/mineral supplement containing iron for ≥1 mth at any age.

[4]Includes iron intake from iron drops or multivitamin/mineral supplements. No 8-12 mth old infants with poor iron status, or normal iron status had received iron from iron drops or multivitamin/mineral supplements; 6 infants 13-26 mths of age with normal iron status had received supplements of iron at the time of the study.

No statistically significant difference (F-statistic=0.598, P=0.44) was found between the iron intake from non-milk foods between the 2 iron status groups using the General Linear Model for Univariate analysis and including whether or not the infant was iron supplemented, total energy intake from non-milk foods and infant age as covariates). Statistical analysis excluding infants with serum ferritin >10-<16 μg/L, 8-12 mths, n=7 breast-fed or fed low iron "milk", n=3 iron supplemented; 13-26 mths, n=4 breast-fed or fed low iron "milk", n=6 iron supplemented, and low hemoglobin, n=4, (results not shown) did not change the statistical interpretation (F-statistic=1.025, P=0.31).

Table 4.20. History of supplements use among study participants grouped by iron status.

	All (n=148)	Iron deficient anemic (n=9)	Low iron stores (n=38)	Normal iron status (n=94)	Low hemoglobin (n=4)
Infant supplementation (yes)					
Iron	2	0	0	2 (2)	0
Multivitamin/mineral + iron	5	0	0	5 (5)	0
Multivitamin/mineral	43	2 (22)	7 (18)	33 (35)	1 (25)
Vitamin C	5	1 (11)	2 (5)	2 (2)	0

Results shown are number of infants, with the percent of infants within a given category of iron status given in brackets; information on supplement use not available for n=2 with low iron stores, and n=3 with normal iron status. History of use defined as use of supplement for ≥1 mth.

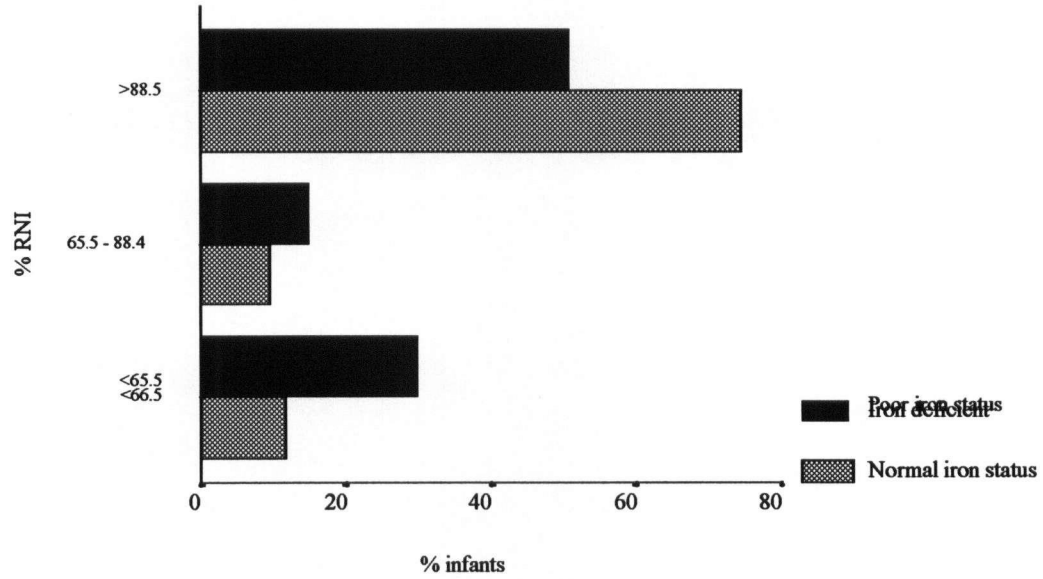


Figure 4.9. Distribution of infants with poor iron status and normal iron status with iron intakes determined by 3d-FR expressed as a percent of the RNI.
Data plotted are the percent of infants at each percentage interval of the RNI of 7 and 6 mg/day for infants 8-11 and 12-26 mths of age, respectively; Iron deficient, includes infants with poor iron status anemia and low iron stores, n=45, normal iron status, n=90; RNI, Canadian Recommended Nutrient Intake.
Fisher's Exact Test showed significant differences in the proportion of infants classified as iron deficient and normal iron status with iron intakes <77% of the RNI, χ^2=6.406, *P*=0.01. Statistical analysis excluding infants with serum ferritin >10-<16 μg/L and low hemoglobin (results not shown) did not change the interpretation (χ^2= 6.076, *P*=0.02).

Table 4.21. Intakes of energy, heme iron, non-heme iron, vitamin C, calcium and dietary fibre from non-milk foods determined by the 3d-FR among infants 8-12 mths of age grouped by iron status.

Iron status	n	Energy (kcal)	Heme iron (mg)	Non-heme iron (mg)	Vitamin C[1] (mg)	Calcium (mg)	Fibre (g)
Poor iron status (ferritin ≤12μg/L)	16	371 (37 – 790)	0.02 (0 – 0.39)	4.7 (0.3 – 16.0)	23 (3 – 108)	223 (14 – 633)	4.5 (0.3 – 12.0)
Normal iron status (ferritin ≥14μg/L)	36	396 (150 – 985)	0.06 (0 – 0.47)	7.3 (1.1 – 26.6)	37 (1 – 117)	261 (30 – 870)	3.9 (0.4 – 12.5)

Results shown are median (range); 3d-FR, 3-day food record; there were no 8-12 mth old infants who had received iron drops or a multivitamin supplement. Data not shown for n=8 infants with either low hemoglobin or ferritin >12-<14 μg/L.
[1]Not including vitamin C intake from supplements.
General Linear Model for Univariate analysis (with age as a covariate) found no significant differences between iron status groups. Statistical analysis excluding infants with serum ferritin >10-<16 μg/L and low hemoglobin (n=5 poor iron status, n=4 normal iron status) (results not shown) did not change the interpretation.

Table 4.22. Intakes of energy, heme iron, non-heme iron, vitamin C, calcium, and dietary fibre from non-milk foods determined by the 3d-FR among infants 13-26 mths of age grouped by iron status.

Iron status	n	Energy (kcal)	Heme iron (mg)	Non-heme iron[1] (mg)	Vitamin C[2] (mg)	Calcium (mg)	Fibre (g)
Poor iron status (ferritin ≤12μg/L)	31	741 (256 – 1614)	0.13 (0 – 0.77)	5.9 (0.8 – 20.4)	84 (9 – 285)	256 (27 – 1426)	6.6 (0.8 – 19.5)
Normal iron status (ferritin ≥14μg/L)	45	826 (321 – 1754)	0.25 (0 – 3.09)	6.1[3] (1.9 – 19.0) 5.9 (1.9 – 14.5)	90 (7 – 347)	210 (86 – 468)	5.6 (1.2 – 14.7)

Results shown are median (range); 3d-FR, 3-day food record. Data not shown for n=9 infants with ferritin >12-<14 μg/L.
[1]Includes iron intake from diet only unless otherwise indicated.
[2]Not including vitamin C intake from supplements.
[3]Including iron intake from supplements; there were no infants with poor iron status who had received iron drops or a multivitamin supplement.
General Linear Model for Univariate analysis (with age as a covariate) found no significant differences between iron status groups. Statistical analysis excluding infants with serum ferritin >10-<16 μg/L and low hemoglobin (n=7 poor iron status, n=8 normal iron status) (results not shown) did not change the interpretation with the exception of heme iron (F statistic=4.029, P=0.049) and calcium (F statistic=3.139, P=0.08).

4.5.2. Intakes of Iron and Dietary Factors Known to Influence Iron Absorption Determined by 3d-FR Among Infants from Caucasian and Chinese Ancestries.

Analyses were undertaken to explore the potential relations between infant ancestry and dietary intakes of energy, iron and factors likely to influence iron absorption. Significant positive associations between infant age and intake were found for Caucasian and Chinese infants for energy, r=0.71, $P<0.001$, r=0.48, $P=0.001$, respectively; vitamin C, r=0.57, $P<0.001$, r=0.65, $P<0.001$, respectively; dietary fibre, r=0.51, $P<0.001$, r=0.30, $P=0.042$, respectively; and heme iron, r=0.38, $P=0.001$, for Caucasian infants. Thus, all further analyses for these nutrients included age as a covariate. There was no significant association between age and heme iron intake among the Chinese infants, or between age and the intakes of total iron, non-heme iron or calcium from non-milk foods for either the Caucasian or Chinese infants (**Appendix Q, Figures 5.8-5.14**).

The intakes of iron from non-milk foods determined by the 3d-FR for the infants from Caucasian and Chinese ancestries grouped by age and whether they were being breast-fed/fed low iron "milk" or supplemented with iron are shown in **Table 4.23**. The General Linear Model for Univariate analysis, found the total iron intake from non-milk foods was significantly higher among the Caucasian than the Chinese infants, $P=0.001$ (**Table 4.23**). Infants 8-12 mths of age from Caucasian ancestries who were breast-fed/ fed low iron "milk" had a median iron intake of 5.4 mg/day, range, 0.3-22.8. Only one 8-12 mth old Chinese infant was breast-fed/fed low iron "milk"; this infant had an iron intake of 2.5 mg/day. The 8-12 mth old Caucasian infants who had been iron supplemented had a median iron intake of 7.5 mg/day (range, 0.2-26.6 mg/day) compared with 5.5 mg/day (range, 1.2-9.8 mg/day) among Chinese infants. Similarly, infants 13-26 mths of age from Chinese ancestries had lower median iron intakes (3.2 and 4.4 mg/day for infants breast-fed/low iron "milk" fed, or iron supplemented, respectively) than Caucasian infants (10.6 and 8.8 mg/day, respectively).

The history of iron supplement use among the Caucasian and Chinese infants is given in **Table 4.24**. None of the Chinese infants had received iron as Fer-In-Sol® or a multivitamin/mineral supplement containing iron, whereas 6 of the 84 Caucasian infants had received iron as Fer-In-Sol® or a multivitamin with iron. Seventy-six percent of Caucasian infants and 45% of Chinese infants had received supplements not containing iron.

The intakes of iron estimated by the 3d-FR as a percent of the RNI for Caucasian and Chinese infants are shown in **Figure 4.10**. Thirty percent (n=14) of the Chinese and 20% (n=16) of the Caucasian infants had iron intakes <77% of the age-specific RNI, $P>0.05$.

The intakes of energy, heme iron, non-heme iron, vitamin C, calcium, and dietary fibre from non-milk foods determined by the 3d-FR for infants 8-12 and 13-26 mths of age are shown in **Tables 4.25** and **4.26**, respectively. The General Linear Model for Univariate analysis found that the Chinese 8-12 mth old infants had a significantly higher median intake of heme iron (P=0.001), and lower intakes of non-heme iron (P=0.03), vitamin C (P=0.02), calcium (P=0.02), and dietary fibre (P<0.001) from non-milk foods than the Caucasian infants. The Chinese 13-26 mth old infants had significantly lower median intakes of energy (P<0.001), non-heme iron (P=0.002), vitamin C (P=0.03), calcium (P=0.002), and dietary fibre (P<0.001) and a higher intake of heme iron (P=0.03) from non-milk foods than the Caucasian infants.

Table 4.23. Intakes of iron from non-milk foods determined by 3d-FR among infants from Caucasian and Chinese ancestries grouped by age and whether or not they had been breast-fed/low iron "milk" fed or had received supplemental iron.

	8-12 mths		13-26 mths	
	Breast-fed[1] or fed low iron "milk"[2]	Iron supplemented[3]	Breast-fed or fed low iron "milk"	Iron supplemented
Caucasian[a]	5.4 (0.3 – 22.8) *(n=20)*	7.5 (0.2 – 26.6) *(n=16)*	10.6 (3.6 – 21.8) *(n=18)*	8.1 (2.2 – 16.0) 8.8[4] (2.2 – 19.0) *(n=35)*
Chinese	2.5 - *(n=1)*	5.5 (1.2 – 9.8) *(n=16)*	3.2 (0.8 – 11.4) *(n=9)*	4.4 (1.6 – 13.7) *(n=23)*

Results shown are median (range); n= 78 Caucasian infants, n= 47 Chinese infants; 3d-FR, 3-day food record; 4 infants could not be classified as either breast-fed/fed low iron "milk" or iron supplemented.

[1]Breast-fed defined as receiving an average of ≥2 breast-feedings/day.

[2]Low iron "milk" includes low iron formula, cows' milk and goats' milk.

[3]Iron supplemented includes infants fed an iron-fortified formula for one mth preceding the study and/or fed an iron-fortified infant formula for ≥3 mths at any age, or given iron drops or a multivitamin/mineral supplement containing iron for ≥1 mth.

[4]Including iron intake from iron drops or multivitamin/mineral supplements; there were no Chinese infants, or 8-12 mth old Caucasian infants who had received iron from iron drops or multivitamin/mineral supplements; 6 Caucasian infants 13-26 mths of age were receiving supplemental iron at the time of the study.

[a]General Linear Model for Univariate analysis including whether or not the infant was iron supplemented, infant age and total energy intake from non-milk foods as covariates found the total iron intake from non-milk foods of the Caucasian infants was significantly different from Chinese infants, F-statistic=12.648, P=0.001.

Table 4.24. History of supplement use among Caucasian and Chinese infants.

	All (n=145)	Caucasian (n=84)	Chinese (n=48)
Infant supplementation (yes)			
Iron	2 (1)	2 (2)	0
Multivitamin/mineral + iron	5 (3)	4 (5)	0
Multivitamin/mineral	42 (29)	28 (33)	13 (27)
Vitamin C	5 (3)	5 (6)	0
Vitamin D	36 (25)	27 (32)	5 (10)
Fluoride	8 (5)	4 (5)	4 (8)

Results shown are the number of infants, with the percent of infants within a given category of ancestry.
Information on supplement use not available for n=4 Caucasian, n=1 Chinese, and n=1 Other infants.
History of use defined as use of supplement for ≥1 mth.

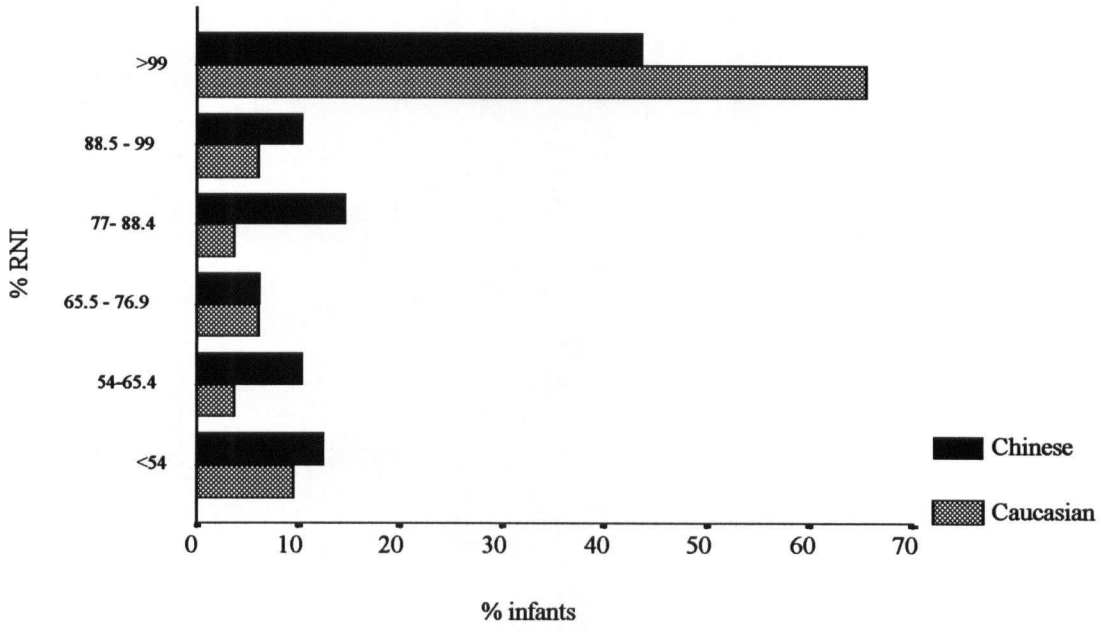


Figure 4.10. Distribution of Caucasian and Chinese infants with iron intakes determined by 3d-FR expressed as a percent of the RNI.
Data plotted are the percent of infants at the given percentage interval of the RNI of 7 and 6 mg/day for infants 8-11 and 12-26 mths of age, respectively; n=78 Caucasian infants, n=47 Chinese infants; RNI, Recommended Nutrient Intake.
Fisher's Exact Test showed no significant differences in the proportion of Caucasian and Chinese infants with iron intakes <77% RNI, χ^2=1.477, P=0.28.

Table 4.25. Intakes of energy, non-heme iron, heme iron, vitamin C, calcium and dietary fibre from non-milk foods determined by a 3d-FR among infants 8-12 mths of age from Caucasian and Chinese ancestries.

	n	Energy (kcal)	Heme iron (mg)	Non-heme iron (mg)	Vitamin C (mg)	Calcium (mg)	Fibre (g)
Caucasian	35	342 (37-985)	0.02 (0-0.39)	6.7 (0.2-26.6)	45 (0-117)	261 (4-870)	4.3 (0.3-12.5)
Chinese	16	432 (181-692)	0.13 (0.01-0.47)	4.2 (1.1-9.8)	33 (1-71)	152 (30-554)	2.3 (0.6-6.6)
F-statistic		1.396	11.67	5.171	5.525	6.226	14.856
***P* value**		0.24	0.001	0.03	0.02	0.02	<0.001

Results shown are median (range); 3d-FR, 3-day food record.
General Linear Model for Univariate analysis including whether or not the infant was iron supplemented, total energy intake from non-milk foods and infant age as covariates found statistically significant differences in intake between the Caucasian and Chinese infants.

Table 4.26. Intakes of energy, non-heme iron, heme iron, vitamin C, calcium, and dietary fibre from non-milk foods as determined by a 3d-FR among infants 13-26 mths of age from Caucasian and Chinese ancestries.

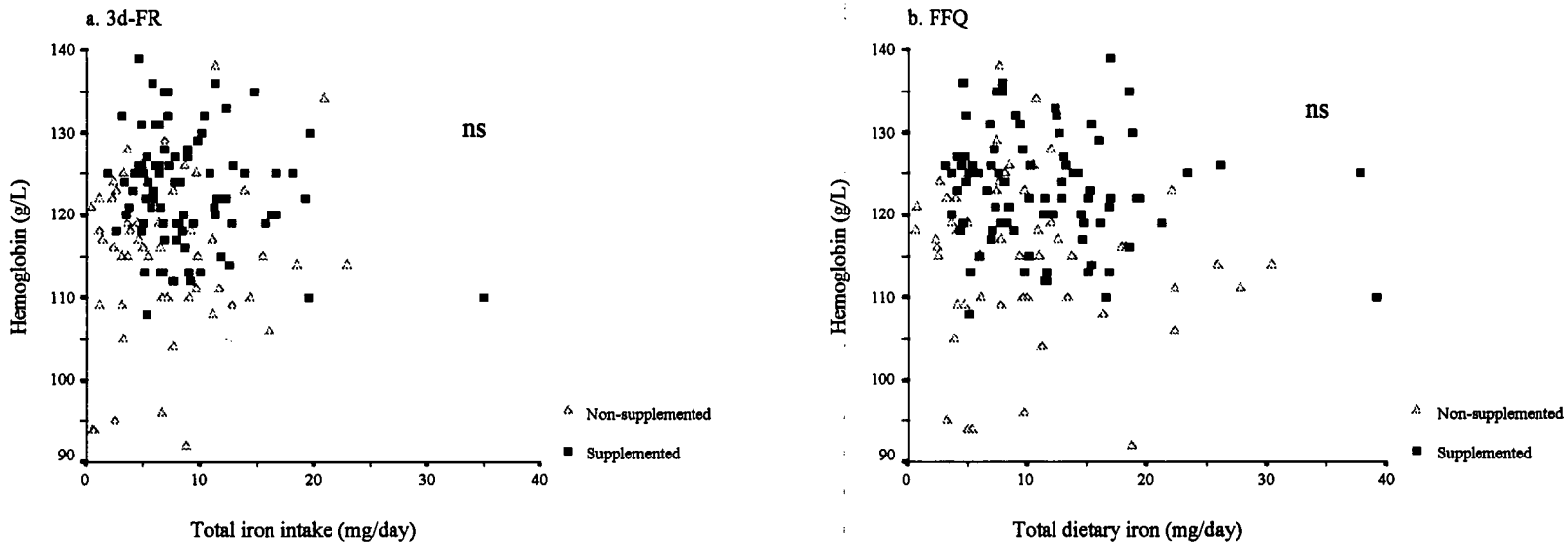
	n	Energy (kcal)	Heme iron mg)	Non-heme iron (mg)	Vitamin C (mg)	Calcium (mg)	Fibre (g)
Caucasian	44	890 (395-1614)	0.20 (0-0.64)	8.9[1] (1.9-20.4) 8.5[2] (1.9-20.4)	96 (9-347)	317 (76-1426)	8.6 (3.0-19.5)
Chinese	31	660 (256-1754)	0.19[3] (0.01-3.09)	3.6 (0.8-13.2)	65 (7-167)	132 (27-350)	3.6 (0.8-12.1)
F-statistic		18.644	12.649	10.122	5.203	10.323	21.413
***P* value**		<0.001	0.001	0.002	0.03	0.002	<0.001

Results shown are median (range); 3d-FR, 3-day food record.
[1]Includes iron intake from diet and supplements, n=6 Caucasian infants aged 13-26 mths were receiving supplemental iron at the time of the study.
[2]Does not include intake from supplemental iron.
General Linear Model for Univariate analysis included whether or not the infant was iron supplemented, total energy intake from non-milk foods and infant age as covariates and found statistically significant differences in intake between the Caucasian and Chinese infants.
[3]Statistical analysis excluding the infant with a heme iron intake of 3.09 mg/day did not change the interpretation ($F=5.202$, $P=0.026$).

4.6. The Value of the 3-day Food Record and Food Frequency Questionnaire in Predicting Hematological and Biochemical Indices of Iron Status Among Infants 8-26 Mths of Age.

Analyses were undertaken to examine the potential relation between the intakes of total and heme iron from all food sources as determined by the 3d-FR and FFQ and Hgb, serum ferritin, sTfR and sTfR:ferritin ratio and are shown in **Figures 4.11-4.14**. No significant associations were found between total iron intake determined by the 3d-FR or FFQ and Hgb, either when the 6 infants who took iron drops or a multivitamin with iron were included or excluded from the analyses (**Figure 4.11**). Hgb was significantly related to the intake of heme iron determined by both the 3d-FR, r=0.21, *P*=0.01, and the FFQ, r=0.26, *P*=0.002, **Figure 4.11**. One infant had a heme iron intake of 3.1 mg/day as determined by the 3d-FR (>95th percentile of all intakes); removal of data for this infant did not change the interpretation of the results, r=0.19, *P*=0.024. To further explore the relation between the intake of iron and hematological and biochemical measures of iron status, the analyses were also done excluding 16 infants who had serum ferritin concentrations >35 μg/L. This was done because of the possibility that high serum ferritin values that may be due to infection, inflammation, or high iron absorption related to genetic factors could obscure relations between the biochemical indices and dietary determinants in normal infants. Exclusion of data for these infants, however, did not change the interpretation of significant relations between heme iron and Hgb as assessed by either the 3d-FR, r=0.26, *P*=0.003 or the FFQ, r=0.30, *P*=0.001.

Total iron



Heme iron

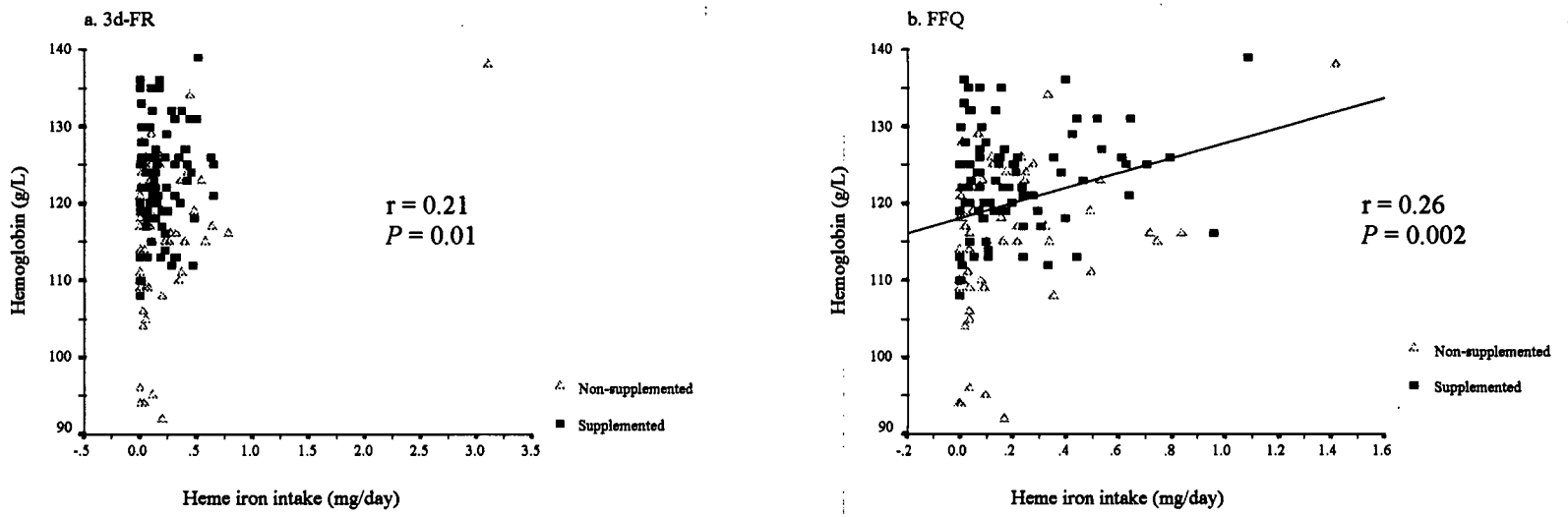
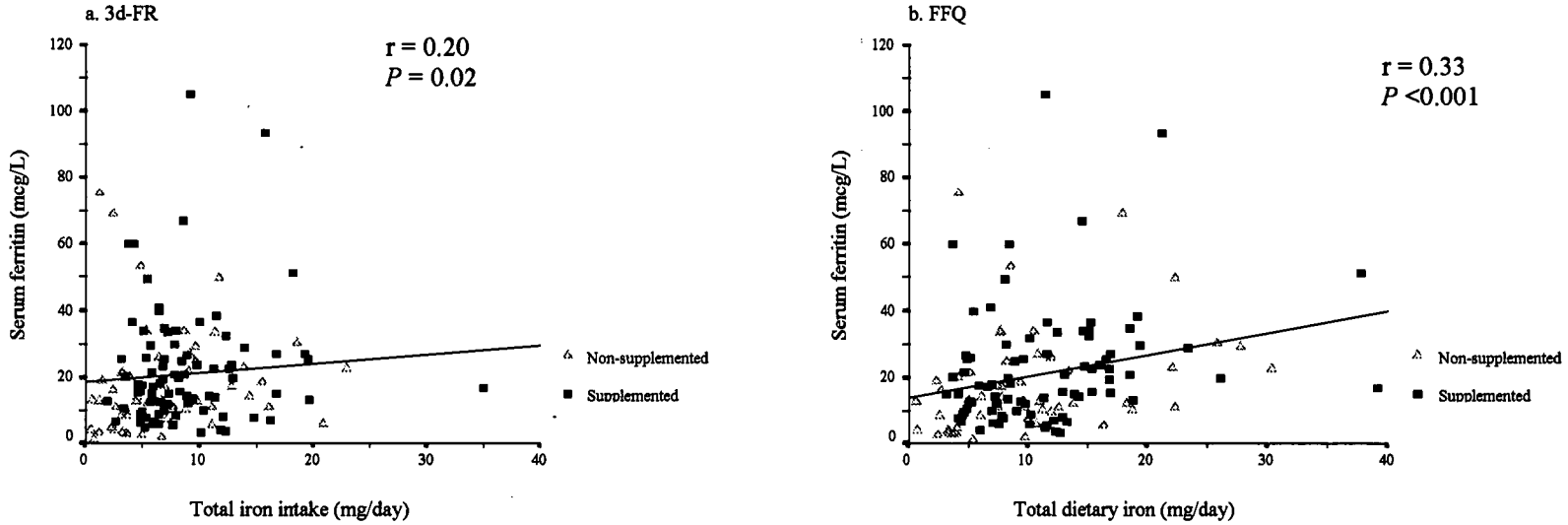


Figure 4.11. Scatterplots of hemoglobin (g/L) versus intakes of total iron (mg/day) and heme iron (mg/day) as estimated from a. 3-day food record (3d-FR), n=139 and b. Food Frequency Questionnaire (FFQ), n=140.

[1]Supplemented group includes infants fed an iron-fortified formula for one mth prior to the study and/or with a history of having been fed an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin supplement for ≥1 mth.

The relation between total iron intake and serum ferritin was significant, with a higher correlation coefficient when determined by the FFQ, r=0.328, $P<0.001$, than by the 3d-FR, r=0.192, $P=0.021$, **Figure 4.12**. Excluding infants who took iron supplements did not change the significant relations between total iron intake and serum ferritin, 3d-FR r=0.20, $P=0.022$; FFQ r=0.32, $P<0.001$. The intake of heme iron determined by the FFQ, but not the 3d-FR was significantly related to serum ferritin, r=0.18, $P=0.033$, and r=0.1, $P>0.05$, respectively, **Figure 4.12**. Excluding the one infant with a heme iron intake of 3.1 mg/day determined by the 3d-FR did not change the statistical interpretation of the results, r=0.08, $P>0.05$. Excluding infants who took iron supplements also had no effect on the statistical relation between heme iron determined by the 3d-FR and serum ferritin, r=0.06, $P=0.515$, but the relation between the heme iron intake determined by the FFQ and serum ferritin was no longer significant, r=0.16, $P=0.071$. Excluding the 16 infants who had a serum ferritin concentration >35 μg/L did not change the significant relations between total iron and serum ferritin determined by the 3d-FR, r=0.28, $P=0.002$ or FFQ, r=0.35, $P<0.001$.

Total iron



Heme iron

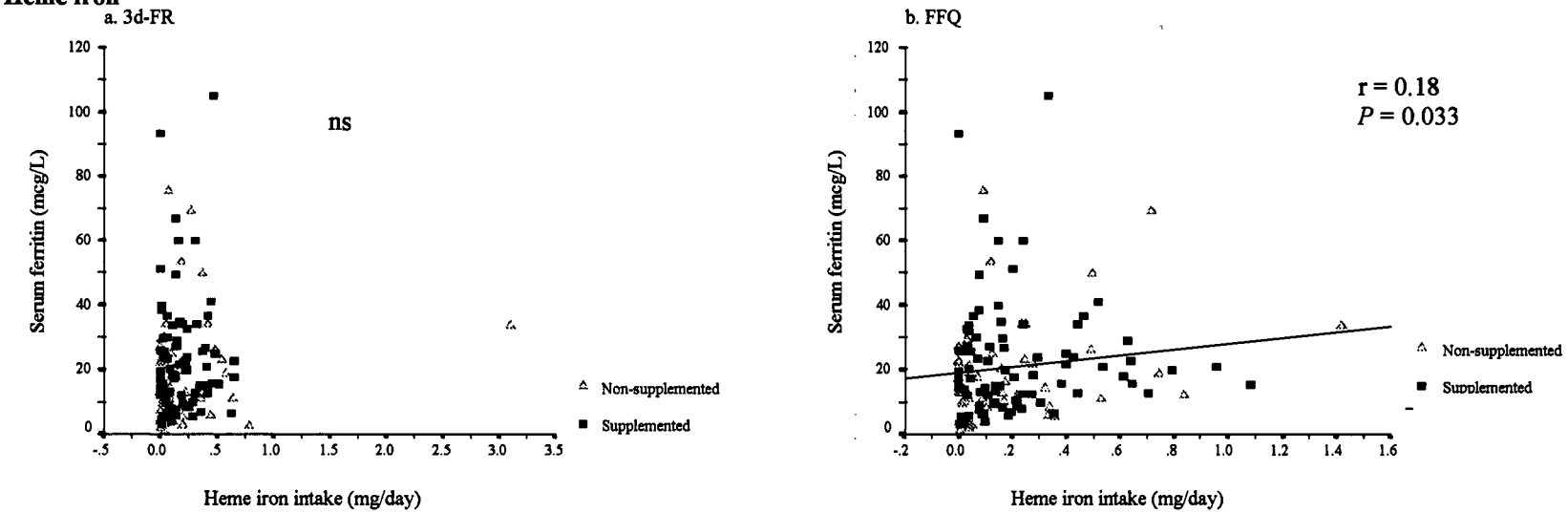
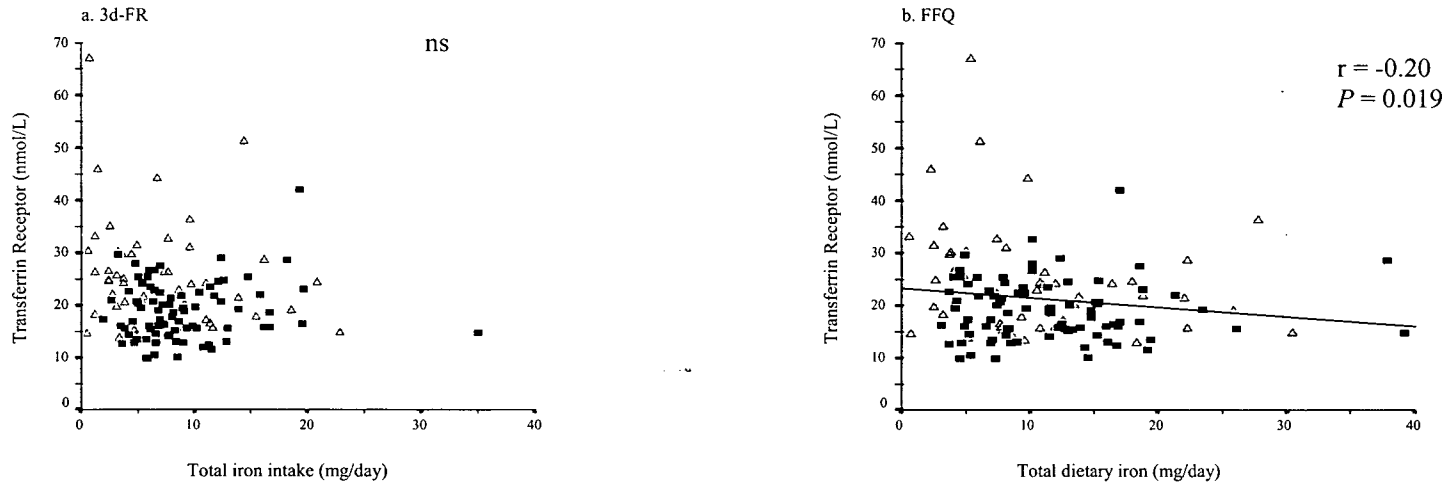


Figure 4.12. Scatterplots of serum ferritin (μg/L) versus intakes of total iron (mg/day) and heme iron (mg/day) as estimated from a. 3-day food record (3d-FR), n=138 and b. Food Frequency Questionnaire (FFQ), n=140.

[1]Supplemented group includes infants fed an iron-fortified formula for one mth prior to the study and/or with a history of having been fed an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin supplement for ≥1 mth.

A statistically significant inverse relation was found between the sTfR and the total iron intake determined by the FFQ, r=-0.198, *P*=0.019, but not when determined by the 3d-FR (**Figure 4.13**). The correlation coefficient between the total iron intake determined by the FFQ and sTfR was higher when infants who took iron supplements were excluded, r=-0.236, *P*=0.007. The intake of heme iron determined by the FFQ was also significantly inversely related to the sTfR, r=-0.256, *P*=0.002, but not when determined by the 3d-FR, r=-0.114, *P*>0.05 (**Figure 4.13**). Excluding the one infant with a heme iron intake of 3.1 mg/day determined by the 3d-FR did not change the statistical interpretation of the results, r=-0.109, *P*>0.05. Excluding the infants who took iron supplements also had no effect on the statistical relations between heme iron intake and sTfR, FFQ r=-0.269, *P*=0.002; 3d-FR r=-0.113, *P*>0.05.

Total iron



Heme iron

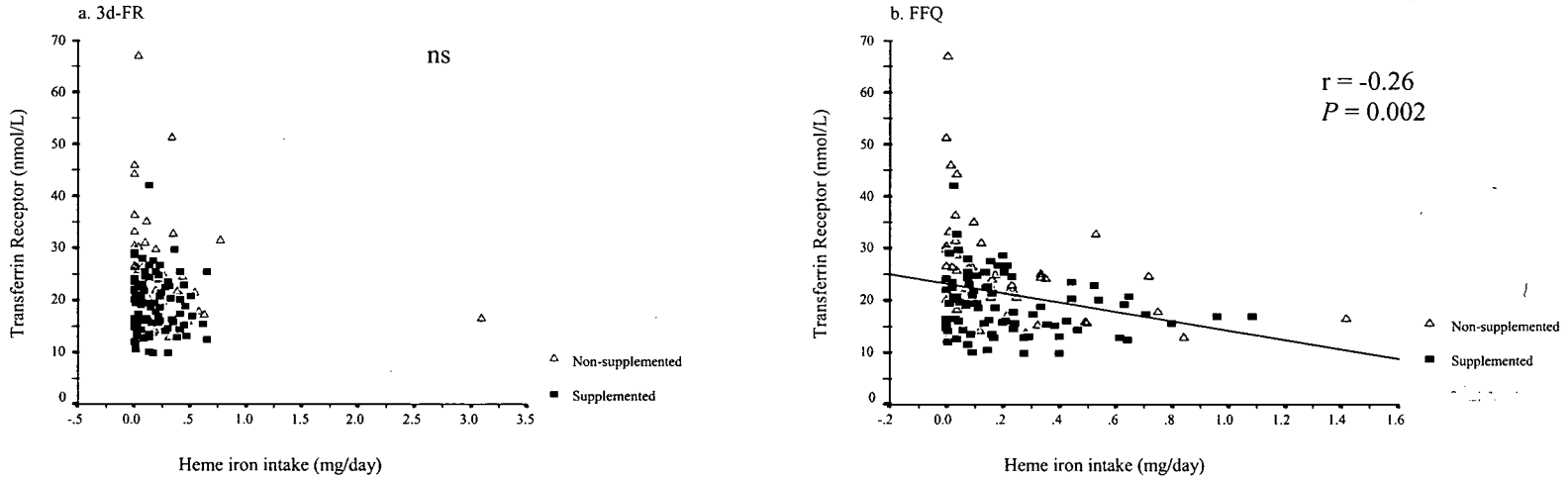


Figure 4.13. Scatterplots of sTfR (nmol/L) versus intakes of total iron (mg/day) and heme iron (mg/day) as estimated from a. 3-day food record (3d-FR), n=138 and b. Food Frequency Questionnaire (FFQ), n=140.

[1]Supplemented group includes infants fed an iron-fortified formula for one mth prior to the study and/or with a history of having been fed an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin supplement for ≥1 mth.

The inverse relation between sTfR:ferritin ratio and total iron intake showed a higher correlation coefficient when determined by the FFQ, r=-0.33, $P<0.001$ than by the 3d-FR, r=-0.19, $P=0.028$ (**Figure 4.14**). Excluding infants who took iron supplements had no apparent effect on the significant inverse relations between total iron intake and sTfR:ferritin ratio, 3d-FR r=-0.19, $P=0.031$; FFQ r=-0.34, $P<0.001$. The sTfR:ferritin was significantly inversely related, r=-0.27, $P=0.001$, to the intake of heme iron determined by the FFQ, but when determined by the 3d-FR, r=-0.13, $P>0.05$ (**Figure 4.14**). Excluding the one infant with a heme iron intake of 3.1 mg/day as determined by the 3d-FR did not change the interpretation of the results, r=-0.11, $P>0.05$. Excluding the infants who took iron supplements also had no effect on the significant relations between heme iron intake and sTfR:ferritin ratio, 3d-FR r=-0.10, $P>0.05$; FFQ r=-0.26, $P=0.003$. Excluding n=16 infants who had a serum ferritin concentration >35 μg/L did not change the significant inverse relations between sTfR:ferritin ratio and total iron as assessed by the 3d-FR, r=-0.27, $P=0.003$; FFQ, r=-0.35, $P<0.001$.

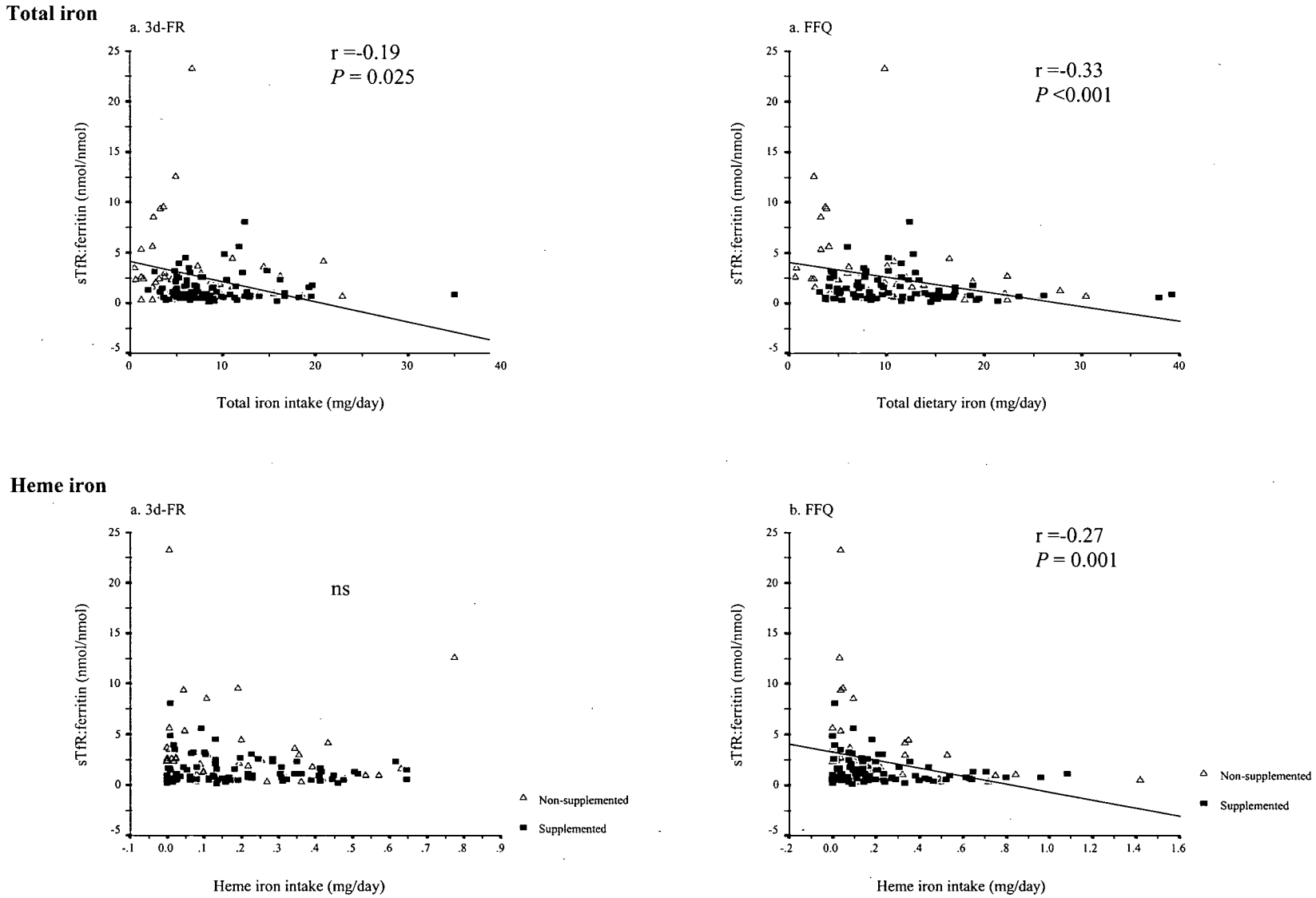


Figure 4.14. Scatterplots of sTfR:ferritin versus intakes of total iron (mg/day) and heme iron (mg/day) as estimated from a. 3-day food record (3d-FR), n=138 and b. Food Frequency Questionnaire (FFQ), n=140.

[1]Supplemented group includes infants fed an iron-fortified formula for one mth prior to the study and/or with a history of having been fed an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin supplement for ≥1 mth.

The ability of the 3d-FR and FFQ to classify the infants, when grouped by quartiles of total iron intake to quartiles of sTfR, serum ferritin and sTfR:ferritin ratio is shown in Table 4.27. Infants were categorized as closely classified if they were misclassified by one quartile and as misclassified if they were misclassified by 2 or more quartiles. Consistent with the results presented in Figures 4.11-4.14, classification of total iron intake by the FFQ and serum ferritin, resulted in approximately 70% of the infants being either correctly or closely classified. Removing infants who had received iron supplements had little effect on the proportion of infants being either correctly or closely classified.

Table 4.27. Classification of infants by quartiles of total iron intake determined from a 3d-FR and FFQ compared with classification by quartiles of sTfR, serum ferritin and sTfR: ferritin.

Variable	3d-FR			FFQ		
	Correctly classified	Closely classified[1]	Mis-Classified[2]	Correctly classified	Closely classified[1]	Mis-Classified[2]
Excluding infants given iron supplements						
Serum ferritin	40	54	38	39	54	38
	(30)	*(41)*	*(29)*	*(29)*	*(41)*	*(29)*
sTfR	28	52	54	26	53	54
	(21)	*(39)*	*(40)*	*(19)*	*(40)*	*(41)*
sTfR:ferritin	33	43	56	25	48	60
	(25)	*(33)*	*(42)*	*(19)*	*(36)*	*(45)*
Including infants given iron supplements						
Serum ferritin	41	56	40	42	56	40
	(30)	*(41)*	*(29)*	*(20)*	*(40)*	*(29)*
sTfR	29	53	56	28	55	56
	(21)	*(38)*	*(41)*	*(30)*	*(40)*	*(40)*
sTfR:ferritin	37	43	58	27	48	64
	(27)	*(31)*	*(42)*	*(19)*	*(35)*	*(46)*

3d-FR, 3-day food record, n=132 excluding infants given supplements, n=138 including infants given supplements; FFQ, food frequency questionnaire, n=133 excluding infants given iron supplements, n=139 including infants given iron supplements, with supplements defined as iron drops or a multivitamin/mineral supplement with iron at the time of the study (n=6).

[1]Infants misclassified by one quartile.

[2]Infants misclassified by 2 or more quartiles.

4.7. Development of a Screening Tool to Predict Infants at Risk for Iron Deficiency Anemia and Low Iron Stores.

4.7.1 Multivariate Predictors of Iron Deficiency Anemia and Low Iron Stores among Study Participants.

Multivariate logistic regression was used to determine potential predictors of poor iron status, i.e. either IDA or low iron stores (**Table 4.28**). The odds ratio of having poor iron status in infants not given either an iron-fortified infant formula or iron supplement was 4.79 (CI 1.95-11.78) times that of infants given either an iron-fortified infant formula or iron supplement, and was statistically significant ($P<0.05$). The odds ratio of having poor iron status if cows' milk was introduced prior to 9 mths of age was 12.95 (CI 1.24-135.03) times that if cows' milk was introduced after 9 mths of age, and was also statistically significant ($P<0.05$). The odds ratio of having either IDA or low iron stores in infants fed ≥800 g/day cows' milk was 7.63 (CI 2.12-27.50), and for infants fed <30 g meat/day was 3.77 (CI 1.35-10.50) compared with infants fed <800 g/day cows' milk or >30 g meat/day, respectively, and was statistically significant. The odds ratio of having either IDA or low iron stores in 8-12 mth old infants was 2.41 times that of 13-26 mth old infants, but was not of statistical significance. The grouping of infants with both IDA and low iron stores together, however, does not consider predictors of low iron stores without IDA. This was addressed through multivariate logistic regression analysis as shown in **Table 4.29**. The odds ratio of having low iron stores without IDA in infants 13-26 mths of age was 3.14 (CI 1.13-8.70) times that of infants 8-12 mths of age, and was statistically significant ($P<0.05$). The odds ratio of having low iron stores without anemia in infants not given either an iron-fortified formula or iron supplement was 3.09 (CI 1.18-8.09), in infants fed ≥800 g/day cows' milk was 9.38 (CI 2.75-31.99) and in infants fed <30 g meat/day was 3.36 (CI 1.17-9.69) compared with infants given an iron-fortified formula or iron supplement, <800 g/day cows' milk, or ≥30 g meat/day, respectively, $P<0.001$. The odds ratio of having low iron stores in infants fed <20 g soy products/day was 3.27 and was not different from that of infants fed ≥20 g soy products/day.

Table 4.28. Logistic regression analysis of low iron stores without or with iron deficiency anemia, with infant age and with feeding practices.

Variable	Odds ratio	95% confidence interval	Coefficient	*P* value
Infant age, 8-12 mths vs. 13-26 mths	2.41	0.91 - 6.34	0.88	0.07
Feeding practices				
Not iron supplemented vs. supplemented[1]	4.79	1.95 - 11.78	1.57	<0.001
Cows' milk introduced vs. not introduced <9 mths of age	12.95	1.24 - 135.03	2.56	<0.05
Cows' milk intake ≥800 vs. <800 g/day	7.63	2.12 - 27.50	2.03	<0.005
Meat intake <30 vs. ≥30 g/day[2]	3.77	1.35 - 10.50	1.33	<0.05

Infants were grouped as low iron stores including those with iron deficiency anemia, n=45, ferritin ≤12 μg/L, or normal iron status, n=89, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L; 4 infants with a low hemoglobin but ferritin >12 μg/L were not included in analysis.

[1]Not iron supplemented included infants not fed an iron-fortified formula for one mth prior to the study and/or an iron-fortified formula for ≥3 mths, or given iron drops or a multivitamin/mineral supplement for ≥1 mth.

[2]Includes all meats, poultry and fish.

Table 4.29. Logistic regression analysis of low iron stores with infant age and with feeding practices.

Variable	Odds ratio	95% confidence interval	Coefficient	*P* value
Infant age, 13-26 mths vs. 8-12 mths	3.14	1.13 - 8.70	1.14	<0.05
Feeding practices				
Not iron supplemented vs. supplemented[1]	3.09	1.18 - 8.09	1.13	<0.05
Cows' milk intake ≥800 vs. <800 mL/day	9.38	2.75 - 31.99	2.24	<0.0005
Meat intake <30 vs. >30 g/day[2]	3.36	1.17 - 9.66	1.21	<0.05
Soy-based product intake <20 g/day[3]	3.27	0.63 - 17.10	1.19	0.16

Infants were grouped as low iron stores without anemia, n=36, ferritin ≤12 μg/L and Hgb ≥110g/L, or normal iron status, n=89, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L; 4 infants with ferritin >12 μg/L and 9 infants with iron deficiency anemia were not included in analysis.
[1]Not iron supplemented included infants not fed an iron fortified formula for one mth prior to the study and/or an iron-fortified formula for ≥3 mths, or given iron drops or a multivitamin/mineral supplement for ≥1 mth
[2]Includes all meats, poultry and fish.
[3]Includes all soy-based products with the exception of soy-based infant formulas.

4.7.2 Classification and Regression Tree (CART) Analyses of Predictors of Risk for Iron Deficiency Anemia and Low Iron Stores among Study Participants.

The data collected in this study was used in posthoc exploratory analyses to test the utility of the results of the multivariate logistic regression analysis in **Table 4.28** as a model for predicting an infant's risk for poor iron status, i.e. IDA or low iron stores. This regression model, y=-3.26 + 0.88 (1) + 1.57(2) + 2.56(3) + 2.03(4) + 1.32 (5), where y=risk of poor iron status, included 5 variables: 1, 0 if infant age=8-12 mths or 1 if infant age=13-26 mths; 2, 0 if the infant was given an iron-fortified infant formula or iron supplement or 1 if the infant was not given an iron-fortified infant formula or iron supplement; 3, 0 if the infant was not fed cows' milk prior to 9 mths of age or 1 if the infant was fed cows' milk prior to 9 mths of age; 4, 0 if the infant was fed <800 g cows' milk or milk products/day or 1 if the infant was fed ≥800 g cows' milk or milk products/day; and 5, 0 if the infant was fed ≥30 g MPF/day or 1 if the infant was fed <30 g MPF/day. By assigning each of the 5 variables in the final multivariate logistic regression model a 0 or 1, depending on whether the infant did or did not have the risk factor, each infant's score for their risk of IDA was calculated. A predictive value was then calculated from the equation 1/[1 + exp(-score)] for each infant. The sensitivity, specificity, and positive (PPV) and negative (NPV) predictive values for cut-off levels of predictive values ranging from 0.05-0.95 were calculated by comparison of the infant's categorisation of iron status based on their calculated predictive value with their actual iron status based on the hematological and biochemical criteria, and are shown in **Table 4.30 and Figure 4.15**. A cut-off value of 0.2 was found to have the highest true positive fraction (i.e. sensitivity) of 87% and the lowest false positive fraction (i.e. 1-specificity) of 51% (**Table 4.30, Figure 4.15**). CART analyses were then used to develop a decision tree-type screening tool that might be useful to predict an infant's iron status (**Figures 4.16 and 4.17**). The raw tree produced by the routine that had 5 decision choices gave a misclassification rate of 33/134 (25%) (**Figure 4.16**). When the tree was pruned back to 2 decision choices the misclassification rate rose by 1% to 35/135 (26%) (**Figure 4.17**).

Table 4.30. Sensitivity, specificity, and positive (PPV) and negative (NPV) predictive values of specific cut-off levels of predictive values of dietary predictors of risk compared with the diagnosis of iron deficiency anemia or low iron stores.[1]

Cut-off level	Sensitivity %	Specificity %	PPV %	NPV %
≥0.05	100	4.5	34.6	100
≥0.10	91.1	18.0	36.0	80
≥0.20	86.7	49.4	46.4	88
≥0.30	75.6	66.3	53.1	84.3
≥0.40	68.9	75.3	58.5	82.7
≥0.50	46.7	91.0	72.4	77.1
≥0.60	46.7	92.1	75	77.4
≥0.70	33.3	98.9	93.7	74.6
≥0.80	17.8	100	100	70.6
≥0.90	11.1	100	100	69.0
≥0.95	0	100	100	66.4

Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L, n=9; Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L, n=38.

[1]Scores for each infant were calculated using the regression model, y=-3.26 + 0.88 (1) + 1.57(2) + 2.56(3) + 2.03(4) + 1.32 (5), where y=risk of poor iron status, and included 5 variables: 1, 0 if infant age=8-12 mths or 1 if infant age=13-26 mths; 2, 0 if the infant was given an iron-fortified infant formula or iron supplement or 1 if the infant was not given an iron-fortified infant formula or iron supplement; 3, 0 if the infant was not fed cows' milk prior to 9 mths of age or 1 if the infant was fed cows' milk prior to 9 mths of age; 4, 0 if the infant was fed <800 g cows' milk or milk products/day or 1 if the infant was fed ≥800 g cows' milk or milk products/day; and 5, 0 if the infant was fed ≥30 g MPF/day or 1 if the infant was fed <30 g MPF/day. By assigning each of the 5 variables in the final multivariate logistic regression model a 0 or 1, depending on whether the infant did or did not have the risk factor, each infant's score for their risk of poor iron status was calculated. Predictive values were then calculated from the equation 1/[1 + exp(-score)] for each infant. The sensitivity, specificity, and positive (PPV) and negative (NPV) predictive values of each infant's predicted iron status were calculated for cut-off values ranging from 0.05-0.95 for the calculated predictive values compared with each infant's actual iron status based on the hematological and biochemical criteria.

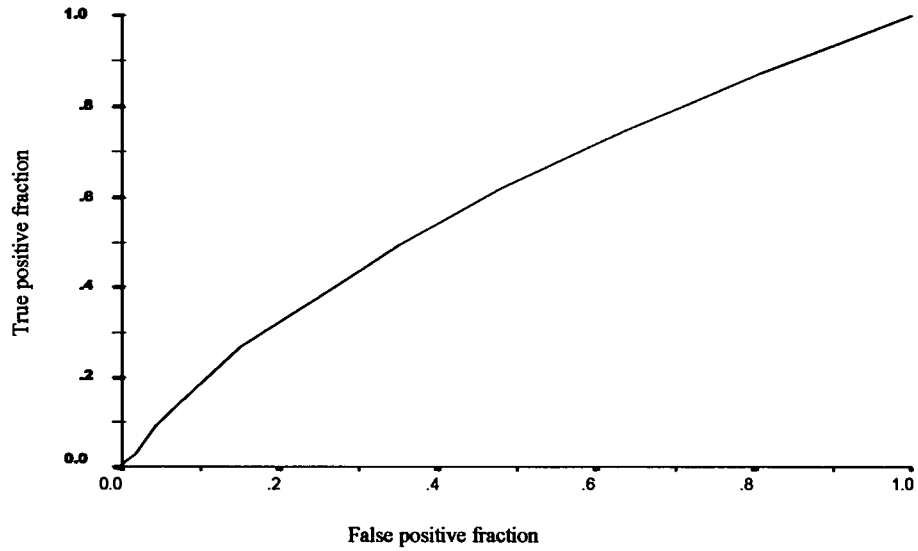


Figure 4.15. Receiver Operating Characteristic (ROC) Curve for dietary predictors to detect infants with iron deficiency anemia or low iron stores.

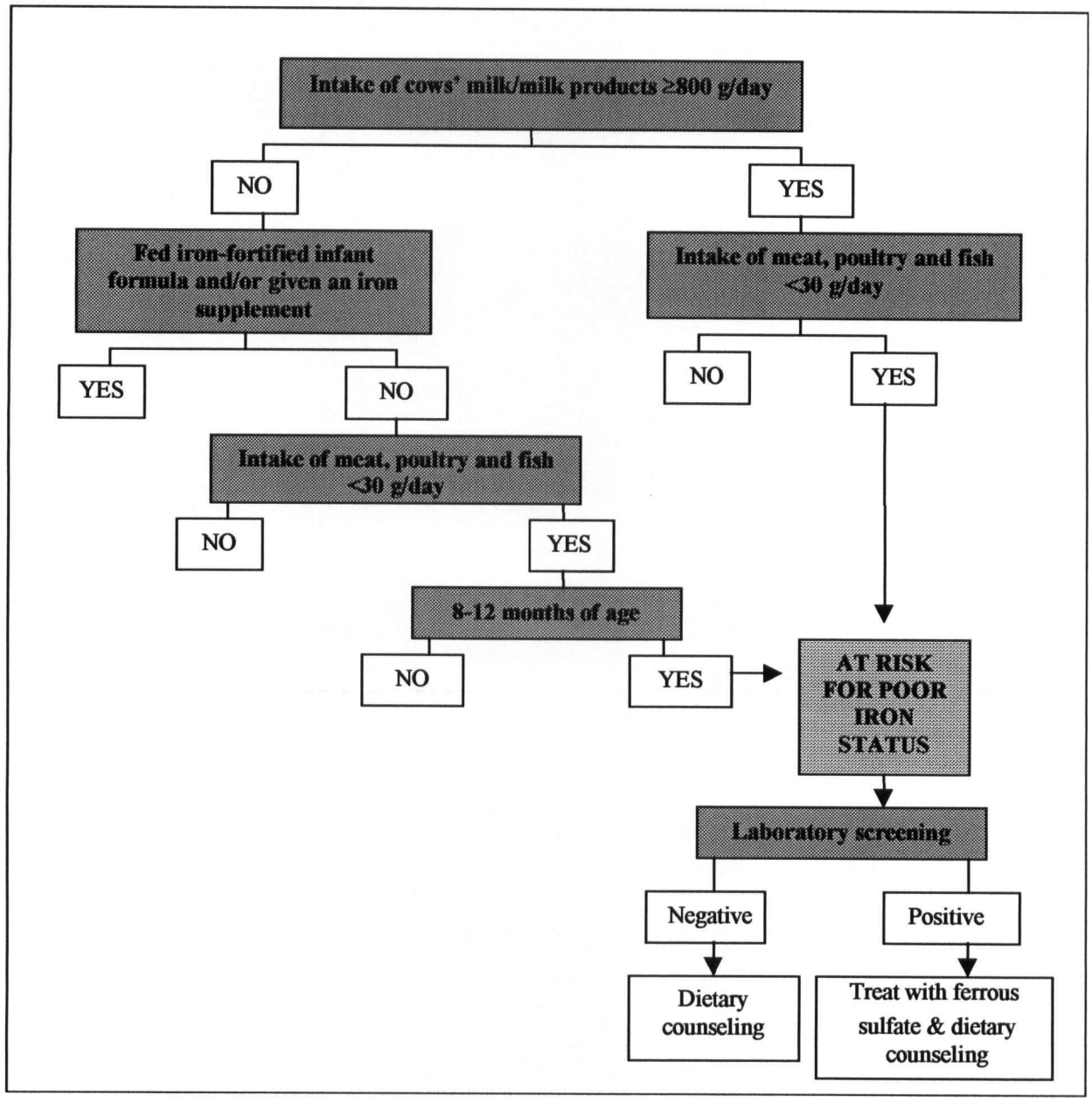


Figure 4.16. Classification and Regression Tree (CART) analysis of dietary predictors to detect infants with poor iron status.

Infants, n=135 were grouped as poor iron status, including all infants with ferritin ≤12 μg/L and as normal iron status, including all infants with Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L; 4 infants with a low hemoglobin but ferritin >12 μg/L were not included in analysis. Not iron supplemented group includes infants not fed an iron-fortified formula for one mth prior to the study and/or with a history of having been fed an iron-fortified formula for ≥3 mths, or an iron supplement including iron drops or a multivitamin/mineral supplement for ≥1 mth. MPF includes all meats, poultry and fish.

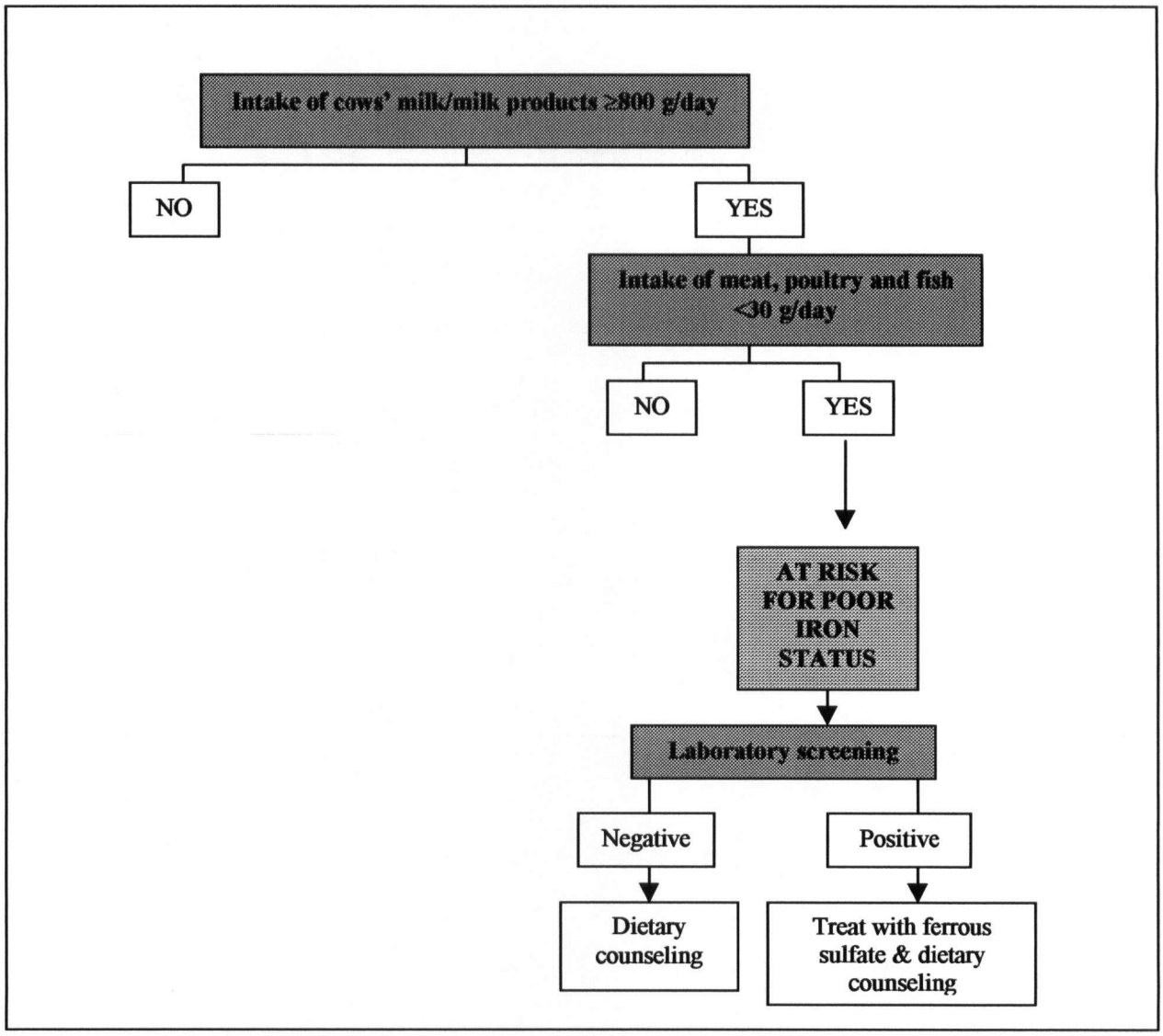


Figure 4.17. Simplified Classification and Regression Tree (CART) analysis of dietary predictors to detect infants with poor iron status.

Infants, n=135 were grouped as poor iron status, including all infants with ferritin ≤12 μg/L and as normal iron status, including all infants with Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$; 4 infants with a low hemoglobin but ferritin >12 μg/L were not included in analysis. MPF includes all meats, poultry and fish.

4.8. Comparison of Dietary Parameters as Determined by the 3-day Food Record and Food Frequency Questionnaire.

The median intakes of energy, iron and other dietary factors that influence iron absorption determined by the 3d-FR and FFQ, together with the intakes per 100 kcal are shown in **Table 4.31.** The median intakes of energy, iron (total, heme and non-heme), vitamin C, calcium and dietary fibre determined by the FFQ and 3d-FR were highly correlated (r=0.35 - 0.75, P<0.001). With the exception of calcium, however, the median intakes of energy, iron (total, heme and non-heme), vitamin C and dietary fibre determined by the FFQ were significantly different than those determined by the 3d-FR (**Table 4.31**). The median intakes of food from the food groups that provide the major sources of iron and dietary factors influencing iron absorption determined by the 3d-FR and FFQ as total g/day and g/100 kcal are shown in **Table 4.32.** The median intakes of food from the food groups that provide major sources of iron and dietary factors influencing iron absorption determined by the FFQ and 3d-FR were also highly correlated (r=0.28 - 0.99, P<0.001) with no significant differences in the median daily intakes of MPF, regular formula, iron-fortified infant cereal, and soy-based products determined by the FFQ and by the 3d-FR.

Table 4.31. Comparison of the intakes of energy, total iron, heme iron, non-heme iron, vitamin C, calcium, and dietary fibre from non-milk foods determined by the FFQ and 3d-FR analyses in infants 8-26 mths of age.

Nutrient	Absolute daily intake		r	*P* value	Daily intake/100 kcal		r	*P* value	t	*P*-value
	FFQ	3d-FR			FFQ	3d-FR				
Energy (kcal)	1119 (303-3178)	929 (357-1851)	0.60	<0.001					-6.86	<0.001
Total Iron (mg)	9.6 (0.6-39.2)	7.1 (0.5-35.0)	0.64	<0.001	0.9 (0.4-9.5)	0.9 (0.3-6.0)	0.77	<0.001	20.54	<0.001
Heme Iron (mg)	0.11 (0-1.4)	0.13 (0-3.1)	0.72	<0.001	0.02 (0-0.1)	0.02 (0-0.2)	0.61	<0.001	3.12	<0.001
Non-heme Iron (mg)	8.1 (0.6-39.2)	6.9 (0.6-35.0)	0.35	<0.001	0.7 (0.1-6.5)	0.9 (0.3-6.0)	0.84	<0.001	-9.86	0.002
Vitamin C (mg)	74 (15-261)	77.5 (15-349)	0.64	<0.001	8 (1-27)	11.4 (0-40)	0.55	<0.001	-4.72	<0.001
Calcium (mg)	861 (152-2437)	691 (179-1513)	0.75	<0.001	40 (10-28)	36 (5-195)	0.75	<0.001	-1.21	0.23
Dietary fibre (g)	6.0 (0.4-27.3)	4.9 (0.3-19.5)	0.68	<0.001	0.8 (0.2-2.8)	0.9 (0.1-3.1)	0.66	<0.001	-17.54	<0.001

Results shown are median (range), n=142 infants; FFQ, food frequency questionnaire; 3d-FR, 3-day food record.
Spearman's rho (2-tailed) test was used to test associations between individual nutrient intakes determined by the FFQ and those determined by the 3d-FR. Paired Students t-test was used to test if the transformed absolute mean nutrient intakes determined by the FFQ were different from those determined by the 3d-FR.

Table 4.32. Comparison of intakes of food from the food groups that provide major sources of iron and dietary factors influencing iron absorption determined by the FFQ and 3d-FR analyses in infants 8-26 mths of age.

Food group	Daily absolute intake (g/day)		r	*P* value	Daily intake (g)/100 kcal		r	*P* value	t	*P* value
	FFQ	3d-FR			FFQ	3d-FR				
Meat, fish and poultry (MFP)	15 (0-229)	20 (0-358)	0.71	<0.001	17 (0-177)	20 (0-200)	0.66	<0.001	-0.27	0.79
Mixed dishes with MFP	41 (0-1127)	0 (0-177)	0.28	<0.001	44 (0-1193)	0 (0-278)	0.17	<0.05	-6.31	<0.001
Iron-fortified infant formula	0 (0-1094)	0 (0-931)	0.91	<0.001	0 (0-1555)	0 (0-1134)	0.92	<0.001	-3.16	0.02
Regular formula	0 (0-633)	0 (0-669)	0.82	<0.001	0 (0-697)	0 (0-736)	0.82	<0.001	0.59	0.56
Breast milk	0 (0-861)	0 (0-1020)	0.99	<0.001	0 (0-1293)	0 (0-1322)	0.99	<0.001	3.19	0.002
Iron-fortified infant cereal	0 (0-67)	0 (0-79)	0.88	<0.001	0 (0-83)	0 (0-163)	0.89	<0.001	1.24	0.22
Other fortified cereals	9 (0-189)	1 (0-199)	0.69	<0.001	9 (0-191)	1 (0-187)	0.68	<0.001	-4.70	<0.001
Fruit and fruit juice	170 (0-606)	162 (0-725)	0.70	<0.001	185 (0-819)	163 (0-662)	0.61	<0.001	-1.96	0.05
Milk and milk products	227 (0-1509)	191 (0-1903)	0.92	<0.001	245 (0-1987)	196 (0-1064)	0.92	<0.001	-4.89	<0.001
Soy-based products	0 (0-475)	1 (0-199)	0.80	<0.001	0 (0-623)	0 (0-1055)	0.63	<0.001	1.11	0.27

Results shown are median (range), n=142 infants; FFQ, food frequency questionnaire; 3d-FR, 3-day food record.
Spearman's rho (2-tailed) test was used to test associations between individual intakes of foods determined by the FFQ and those determined by the 3d-FR. Paired Students t-test was used to test if the transformed absolute mean nutrient intakes determined by the FFQ were different from those determined by the 3d-FR.

4.9. Clinical Utility of the Soluble Transferrin Receptor for Detecting Iron Deficiency Anemia and Low Iron Stores Among Infants 8-26 Mths of Age.

Analyses were undertaken to determine the distribution of sTfR concentrations and sTfR:ferritin ratio, and the utility of the sTfR as a measure for detecting IDA and low iron stores in the infants who participated in this study. The infants with IDA had a higher sTfR ($P<0.05$ and $P<0.0001$) and sTfR:ferritin ratio ($P<0.05$ and $P<0.0001$) than infants with low iron stores or normal iron status, respectively (**Table 4.33; Appendix Q, Figure 5.15**). sTfR:ferritin ratio but not sTfR concentration was also significantly higher among infants with low iron stores than among those with normal iron status ($P<0.0001$).

The means ± standard deviations (SD), together with the medians and ranges for sTfR concentration and sTfR:ferritin ratio for the 94 infants with normal iron status, for the whole group of infants, and for the infants grouped by gender, age and race are given in **Table 4.34**. The mean ± SD (median, range) sTfR concentration and sTfR:ferritin ratio among the infants with normal iron status were 19.8 ± 7.4 (18.8, 9.7-51.1) nmol/L and 0.9 ± 0.6 (0.8, 0.1-3.6), respectively. The distribution of sTfR concentrations and sTfR:ferritin ratios, shown in **Figure 4.18**, are skewed to the right with values for 3 and 4 infants, respectively above the 95% confidence interval. There was no significant correlation between infant age and either sTfR concentration or sTfR:ferritin ratio (**Table 4.34**). A gender-related difference in sTfR, with males having a significantly higher sTfR concentration than females, however, was found for the group of infants with normal iron status ($P<0.05$). Infants from Caucasian ancestries with normal iron status also had significantly higher values for sTfR ($P<0.005$) and sTfR:ferritin ($P<0.05$) (21.5 ± 7.6 nmol/L and 1.0± 0.5, respectively) than infants from Chinese ancestries (17.2 ± 4.9 nmol/L and 0.8 ± 0.4, respectively) (**Table 4.34**). Significant inverse associations were found between sTfR and ferritin ($r=-0.32$, $P<0.001$), sTfR and Hgb ($r=-0.27$, $P<0.001$) (**Figure 4.19**) and the sTfR:ferritin ratio and Hgb ($r=-0.28$, $P=0.001$) (**Figure 4.20**).

The sTfR concentration and sTfR:ferritin ratios for the 9 infants who met the criteria for IDA are shown in **Table 4.35**. All the infants with IDA had a sTfR concentration ≥24 nmol/L, with the exception of one infant who had a value of 21.7 nmol/L, and all had a sTfR:ferritin ratio ≥2. The sensitivity, specificity, positive (PPV) and negative (NPV) predictive values of specific cut-off values of the sTfR compared to diagnosis of IDA based on the standard

measures of Hgb and ferritin are shown in **Table 4.36**. Receiver operating characteristic curves showing the performance of sTfR for the diagnosis of IDA and low iron stores are illustrated in **Appendix Q, Figure 5.16**. A sTfR cut-off of ≥24 nmol/L had a sensitivity and specificity of 89% and 73%, respectively, for the diagnosis of IDA **(Table 4.36)**. However, 37 of the 136 infants without IDA also had sTfR values ≥24 nmol/L, resulting in a positive predictive value of only 18% in this group of infants **(Table 4.36)**. Of the 37 infants without IDA with sTfR values ≥24 nmol/L, 16 had low iron stores and 21 had normal iron status. A sTfR cut-off of ≥24 nmol/L had a sensitivity and specificity of 51% and 79%, respectively, for the diagnosis of low iron stores **(Table 4.36)**. Lowering the sTfR cut-off to ≥20 nmol/L increased the sensitivity to 100%, but decreased the specificity to 51% and the PPV to only 12% for this group of infants for detecting IDA. Lowering the sTfR cut-off to ≥20 nmol/L increased sensitivity to 70% but decreased the specificity to 56% for detecting low iron stores **(Table 4.36)**.

Table 4.33. Soluble transferrin receptor (sTfR) and sTfR:ferritin ratio among infants aged 8-26 mths with normal iron status, low iron stores and iron deficiency anemia.

Index	Iron deficiency anemia (n=9)	Low iron stores (n=38)	Normal iron status (n=94)
sTfR (nmol/L)	34.1 ± 14.0[a] *30.1 (21.7 – 67.1)*	22.1 ± 5.3[b] *21.9 (12.7 – 32.7)*	19.8 ± 7.4[b] *18.8 (9.7 – 51.1)*
sTfR:ferritin	13.6 ± 21.2[a] *4.4 (2.1 – 67.2)*	3.6 ± 2.3[b] *3.0 (1.1 – 12.5)*	0.9 ± 0.6[c] *0.8 (0.1 – 3.6)*

Values shown are mean ± SD, and in italics, median (range).
Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L; low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L; normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$/L.
Values in the same row with different superscripts are significantly different, $P<0.05$.

Table 4.34. Soluble transferrin receptor (sTfR) and sTfR:ferritin ratio in infants aged 8-26 mths with normal iron status.

Group	n	sTfR (nmol/L)[1]	sTfR:ferritin[1]
Age (mths)			
8-26	94	19.8 ± 7.4 *18.8 (9.7-51.1)*	0.9 ± 0.6 *(0.8 (0.1-3.6)*
8-12	40	21.7 ± 9.4 *19.0 (11.4-51.1)*	1.1 ± 0.7 *9.0 (0.2-3.6)*
13-17	19	17.9 ± 5.1 *17.6 (9.7-27.4)*	0.7 ± 0.3 *0.6 (0.3-1.8)*
18-26	35	18.7 ± 5.3 *18.2 (9.8-30.9)*	0.9 ± 0.5 *0.9 (0.1-1.8)*
Gender			
Males	53	21.2 ± 7.6[a] *19.4 (11.4-51.1)*	0.9 ± 0.6 *0.8 (0.2-3.6)*
Females	41	18.0 ± 6.9 *15.9 (9.7-45.9)*	0.9 ± 0.5 *0.8 (0.1-2.4)*
Race			
Caucasian	47	21.5 ± 7.6[b] *20.1 (9.8-45.9)*	1.0 ± 0.5[b] *0.9 (0.2-1.8)*
Chinese	38	17.2 ± 4.9 *16.4 (9.7-29.6)*	0.8 ± 0.4 *0.7 (0.1-1.8)*
Other	7	23.4 ± 13.2 *18.8 (13.4-51.1)*	1.0 ± 1.1 *0.6 (0.3-3.6)*

Results shown are mean ± SD, and in italics, median (range); Independent sample t-test found values denoted by superscripts significantly different from values for females by [a], t=2.464, df=91, $P<0.05$; One-way ANOVA and Bonferroni post hoc test for multiple comparisons found values denoted by superscripts significantly different from values for Chinese infants, for sTfR, by [b], F=4.943, df=2, $P<0.05$; for sTfR:ferritin, by [c], F=2.972, df=2, $P=0.053$.
[1]For the purpose of classifying infants in this study a sTfR of <24 nmol/L and sTfR:ferritin <2, respectively, was considered normal.

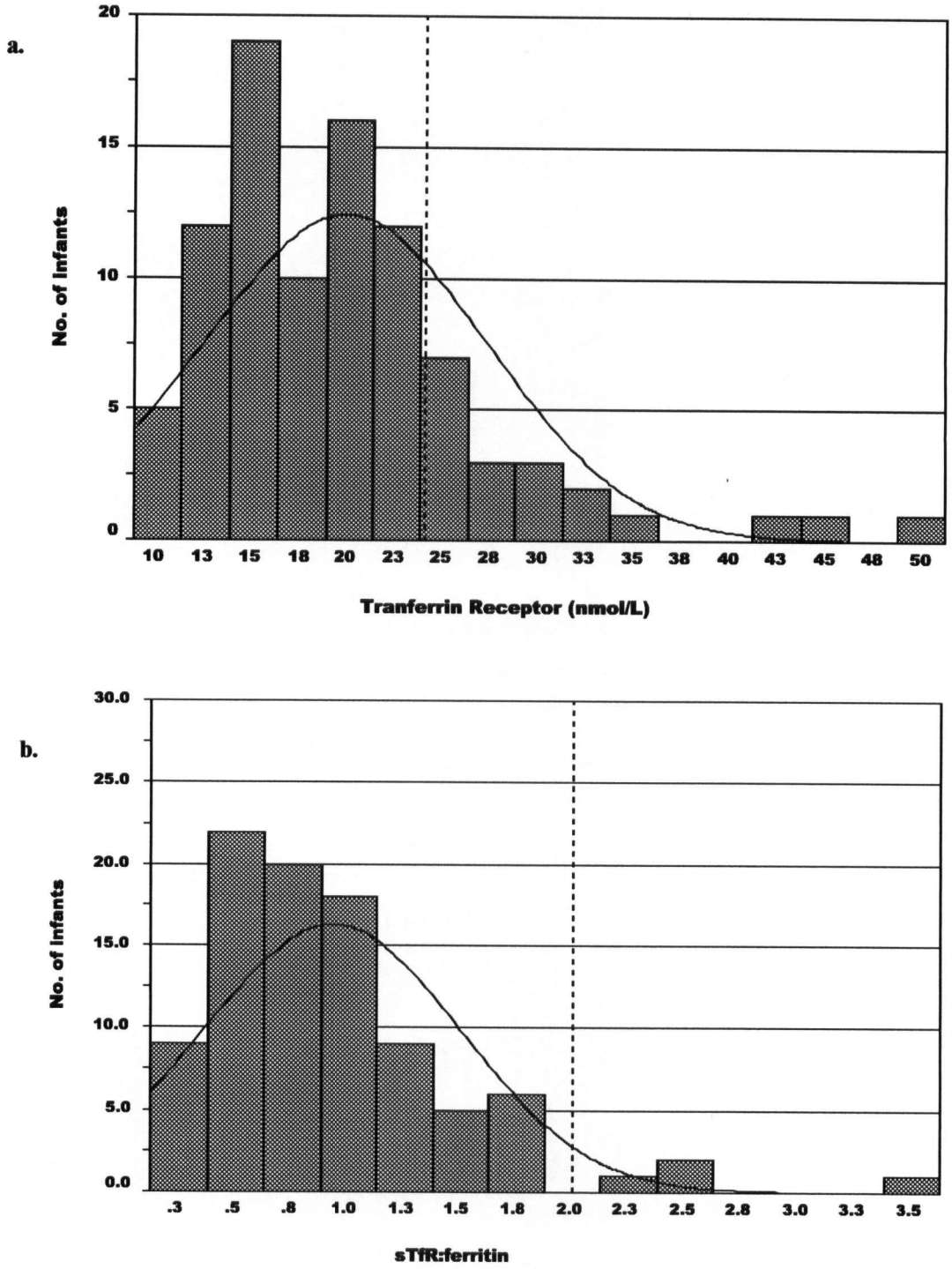


Figure 4.18. Histogram and fitted Gaussian distribution curves of a. sTfR and b. sTfR:ferritin ratios in infants aged 8-26 mths with normal iron status, n=94.

Normal iron status defined as Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 X10^9/L. The bars represent observed values, the curve shows the expected values for a Gaussian distribution; mean ± SD, for sTfR 19.8 ± 7.4; for sTfR:ferritin 0.9 ± 0.6. For the purpose of classifying infants, a sTfR of <24 nmol/L and sTfR:ferritin <2, respectively, was considered normal and is shown by the dotted line.

Table 4.35. Soluble transferrin receptor (sTfR) and sTfR:ferritin ratio in infants with iron deficiency anemia.

Subject	Hgb (g/L)	Serum ferritin (μg/L)	sTfR (nmol/L)	sTfR:ferritin
1	92	10.3	21.7	2.1
2	94	1.0	67.1	67.1
3	94	13.1	30.2	2.3
4	95	4.1	35.1	8.5
5	96	1.9	44.1	23.2
6	104	10.3	26.3	2.5
7	105	3.2	30.1	9.4
8	106	10.8	28.5	2.6
9	108	5.4	24.0	4.4

Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L.
Infant number 4 had co-existing iron deficiency anemia and beta-thalassemia trait.

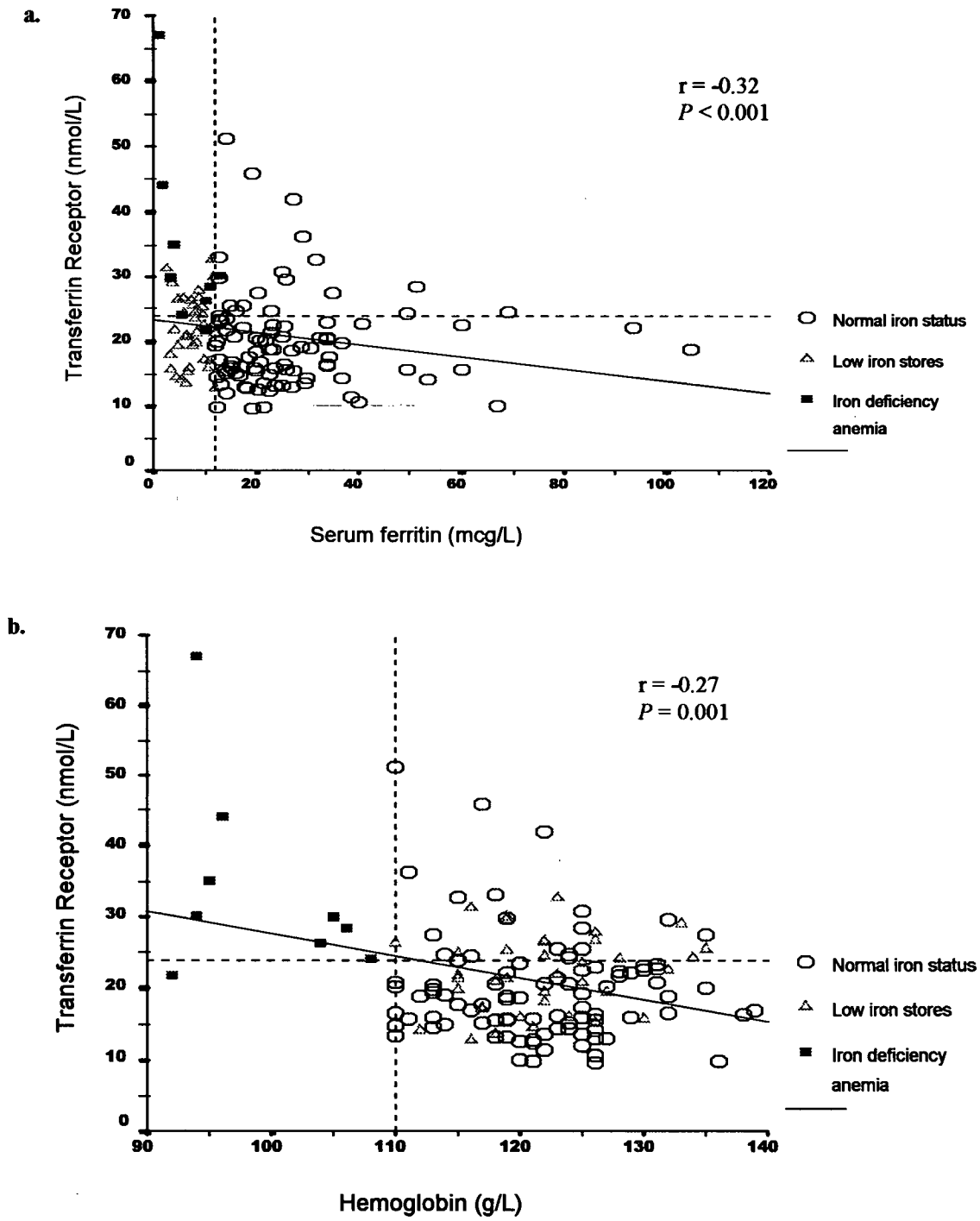


Figure 4.19. Scatterplots of relations between sTfR concentration and a. ferritin and b. hemoglobin in infants 8-26 mths of age, n=140.
❁, Iron deficiency anemia; ✎, Low iron stores; ✐, Normal iron status; 4 infants classified as low hemoglobin (not included). The data points to the left of the vertical dashed lines represent infants with ferritin and Hgb values <12 μg/L and <110 g/L, respectively. The data points above the horizontal dashed line represent infants with sTfR values ≥24 nmol/L.

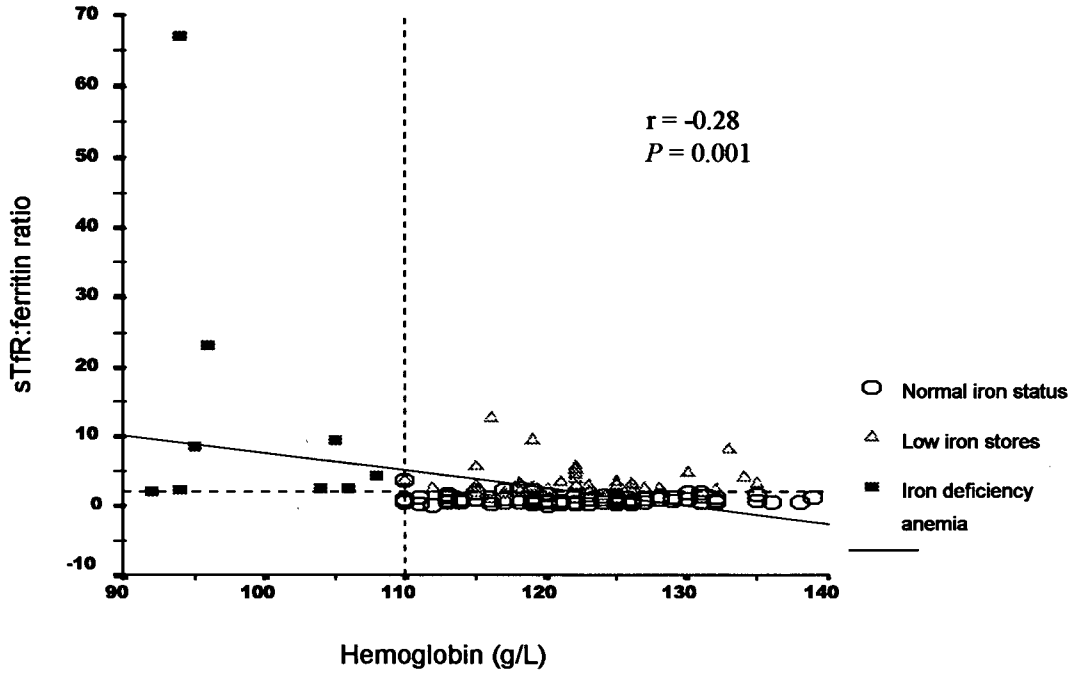


Figure 4.20. Scatterplot of the relation between sTfR:ferritin ratio and hemoglobin in infants 8-26 mths of age, n=140.
❁, Iron deficiency anemia; ✎, Low iron stores; ✌, Normal iron status; 4 infants classified as low hemoglobin (not included). The data points to the left of the vertical dashed line represent infants with Hgb values <110 g/L. The data points above the horizontal dashed line represent infants with sTfR:ferritin ratios ≥2.

Table 4.36. Sensitivity, specificity, and positive (PPV) and negative (NPV) predictive values of specific cut-off values of the soluble transferrin receptor (sTfR) compared with diagnosis of iron deficiency anemia defined on the basis of Hgb and serum ferritin, and low iron stores defined on the basis of serum ferritin.

sTfR (nmol/L) cut-off	Sensitivity %	Specificity %	PPV %	NPV %
Iron deficiency anemia[1]				
≥16	100	32	9	100
≥20	100	51	12	100
≥24	89	73	18	99
≥28	67	89	29	98
≥32	33	95	30	95
Low iron stores[2]				
≥16	83	37	39	82
≥20	70	56	43	80
≥24	51	79	53	77
≥28	23	90	52	71
≥32	8	94	40	68

[1]Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L, n=9.
[2]Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L, n=38.

4.10 Summary of Findings

4.10.1 Study Participants

Consistent with the study objectives and the methods of recruitment, the study population consisted predominantly of infants from Caucasian and Chinese ancestries (89%), with family food practices generally reflecting their ethnic background. Most of the infants were from 2-adult families with parents who had attained higher education, although a wide range of family income levels was represented. The only incentive that was offered to parents to encourage participation was assessment of their infant's diet and iron status. It is probable that, because of the method of recruitment and the requirements for parental time, recording of diet and blood tests, with no financial incentives, the parents who participated were highly motivated with respect to their infant's diet and health.

4.10.2 Summary of Results with Regard to Hypotheses

Hypothesis 1: *There is no difference in the prevalence of iron deficiency anemia and low iron stores between infants 8-12 or 13-26 mths of age in Vancouver of Caucasian compared with Chinese ancestry.*

This study demonstrates statistically significant differences in the prevalence of IDA and low iron stores among infants 8-12 and 13-26 mths of age of Caucasian compared with Chinese ancestry. Thus, hypothesis 1 is rejected. The prevalence of IDA was significantly higher among the Caucasian (9%) compared with the Chinese infants (2%). Fifteen percent of the Caucasian infants 8-12 mths of age were classified as iron deficient anemic compared with only 6% of Chinese infants. None of the Chinese infants 13-17 or 18-26 mths of age had IDA. One Caucasian infant aged 13 mths and one aged 22 mths had IDA. The prevalence of low iron stores was also statistically significantly higher among the Caucasian (30%) compared with the Chinese infants (19%). At 8-12 and 13-17 mths of age, 15% and 50% of Caucasian compared with only 0% and 25% of the Chinese infants, respectively had low iron stores. At 18-26 mths of age, however, the prevalence of low iron stores was about 30% among both the Caucasian and Chinese infants.

Hypothesis 2: *Dietary assessment using a Socio-Cultural and Infant Feeding Questionnaire will find no difference in the feeding histories (i.e. the duration of breast-feeding, age of introduction of cows' milk, feeding with iron-fortified infant formula, or use of iron supplements, and age of introduction or duration of feeding of iron-fortified infant cereal or meats) among infants with normal iron status and poor iron status at 8-12 or 13-26 mths of age.*

This study found a statistically significant association between iron status in infants 8-12 mths of age and the duration of breast-feeding ($P<0.05$), whether or not the infant had received supplemental iron from either iron-fortified formula or vitamin/mineral supplements ($P<0.001$), and the age of introduction of cows' milk ($P<0.005$). The odds ratio of having IDA or low iron stores in infants not given either an iron-fortified infant formula or iron supplements was 4.79 (CI 1.95-11.78), and for infants introduced to cows' milk prior to 9 mths of age was 12.95 (CI 1.24-135.03) and was significantly higher than for infants given either an iron-fortified infant formula or iron supplement or not introduced to cows' milk prior to 9 mths of age, respectively. Therefore, the hypothesis that there is no association between iron status and infant feeding history was rejected for infants 8-12 mths of age. This study, however, found no association between iron status and feeding history for infants aged 13-26 mths. Further, neither the age of introduction nor the duration of feeding of iron-fortified infant cereals or meats, poultry or fish (MPF) differed among infants aged 8-12 or 13-26 mths with different iron status.

Hypothesis 3: *Dietary assessment using a food frequency questionnaire (FFQ) will find no difference in the intakes of MPF, mixed dishes with MPF, iron-fortified infant formula or iron-fortified infant cereal, cows' milk and milk products, soy-based products or regular infant formula among infants with normal iron status and poor iron status at 8-12 or 13-26 mths of age.*

The median intake of MPF was significantly lower ($P<0.05$) among infants of both 8-12 and 13-26 mths of age with poor iron status than among those with normal iron status. The intake of MPF was also a significant predictor of risk of IDA and low iron stores in multivariate analyses; the infants who had an intake <30 g MPF/day had a 3.77 (CI 1.35-10.50) times greater risk of IDA and low iron stores than infants with an intake of ≥30 g MPF/day. Infants 8-12 mths of age with poor iron status had a significantly lower median intake of iron-fortified formula and higher intakes of human milk and cows' milk and milk products than infants with normal iron status. The intake of cows' milk and milk products was also a statistically significant predictor of risk of IDA and low iron stores in multivariate analyses; thus the infants with an intake of ≥800 g cows' milk and milk products/day had a

7.63 (CI 2.12-27.50) times greater risk of IDA and low iron stores than those with an intake of <800 g cows' milk and milk products/day. Infants 13-26 mths of age with normal iron status had higher intakes of other cereals, i.e. cereals other than iron-fortified infant cereals, and soy-based products than infants with poor iron status in the univariate analysis, but the intakes of neither of these food groups were significant predictors of risk for IDA and low iron stores in multivariate analyses. Based on these results it is concluded that the intakes of several food groups determined by the FFQ differed among infants with poor iron status and normal iron status. Consequently, hypothesis 3 was rejected. Of note, however, the intakes of iron-fortified infant cereal, low iron infant formula or mixed dishes with MPF were not significantly different between infants with poor iron status compared with normal iron status either at 8-12 or 13-26 mths of age.

Hypothesis 4: *Dietary assessment using a 3d-FR will find no difference in the intakes of iron (total, heme or non-heme), energy, vitamin C, calcium, or fibre from non-milk food sources among infants with poor iron status and infants with normal iron status.*

This study found no differences in the median intakes of energy, dietary iron (total, heme and non-heme), vitamin C, calcium or dietary fibre from non-milk foods determined by the 3d-FR between infants with poor iron status and infants with normal iron status. This suggests that hypothesis 4 should be accepted. However, the proportion of infants with a total iron intake <77% of the RNI was significantly higher for infants with poor iron status than with normal iron status. Moreover, when infants with serum ferritin >10-<16 μg/L were excluded, the heme iron intake was statistically significantly lower ($P<0.05$) and the calcium intake showed a trend toward being higher ($P=0.09$) in infants with serum ferritin ≤10 μg/L than infants with serum ferritin ≥16 μg/L.

Hypothesis 5: *Dietary assessment using a Socio-Cultural and Infant Feeding Questionnaire will find no difference in the feeding histories (i.e. the duration of breast-feeding, age of introduction of cows' milk, feeding with iron-fortified infant formula, or use of iron supplements, and age of introduction or duration of feeding of iron-fortified infant cereal or meats) between infants of Caucasian and Chinese ancestry of 8-12 or 13-26 mths of age.*

This study found no differences in the proportions of Chinese compared with Caucasian infants 8-12 mths of age who had been breast-fed >6 mths, given supplemental iron from an iron-fortified formula or iron supplement, introduced to cows' milk before 9 mths of age, or fed iron-fortified infant cereals or meats for durations ≤2 and ≤1

mths, respectively. A significantly greater proportion of the Caucasian than the Chinese infants 8-12 mths of age, however, had not been introduced MPF by 9 mths of age. No significant differences in feeding histories were found between the 13-26 mth old infants of Caucasian compared with Chinese ancestry. Therefore, with the exception of the age of introduction of MPF for infants 8-12 mths of age, the hypothesis of no difference in feeding histories between Caucasian and Chinese infants is accepted.

Hypothesis 6: *Dietary assessment using a FFQ will find no difference in the intakes of MPF, mixed dishes with MPF, iron-fortified infant formula, iron-fortified infant cereal, cows' milk and milk products, soy-based products or regular infant formula between infants of Caucasian and Chinese ancestry at 8-12 or 13-26 mths of age.*

This study demonstrated differences in the intakes of several food groups that provide major sources of iron and other factors that influence iron absorption between infants of Caucasian and Chinese ancestry. Caucasian infants aged 8-12 mths had significantly lower median intakes of MPF, mixed dishes with MPF and iron-fortified infant formula, and higher intakes of human milk and 'other cereals' than Chinese infants. Caucasian infants 13-26 mths of age had significantly lower median intakes of mixed dishes with MPF, iron-fortified infant formula, but higher intakes of human milk, other cereals and fruits and fruit juices than 13-26 mth old Chinese infants. Thus, the intake of several food groups determined by the 2-week FFQ differed between Caucasian and Chinese infants and consequently hypothesis 6 is rejected. The intakes of regular formula, iron-fortified infant cereal, cows' milk and milk products and soy-based products, however, were not significantly different between Caucasian and Chinese infants at either ages 8-12 or 13-26 mths, and the intake of MPF did not differ between Caucasian and Chinese infants ages 13-26 mths.

Hypothesis 7: *Dietary assessment using a 3d-FR will find no difference in the intakes of iron (total, heme or non-heme), energy, vitamin C, calcium, or fibre from non-milk foods between infants of Caucasian and Chinese ancestry at 8-12 or 13-26 mths of age.*

The median total iron intake from non-milk foods was significantly lower among the Chinese than the Caucasian infants. Although 30% of the Chinese and 19% of the Caucasian infants had total iron intakes <77% of the age-specific RNI, this difference was not of statistical significance, $P>0.05$. However, the Caucasian infants had a significantly lower intake of heme iron from non-milk foods than the Chinese infants. Moreover, the Chinese

infants at both 8-12 and 13-26 mths of age had lower intakes of dietary fibre, and those 13-26 mths of age had significantly lower intakes of energy, non-heme iron, vitamin C, and calcium from non-milk foods than the Caucasian infants, even after adjusting for total energy intake. The intake of dietary fibre was also significantly higher in the Caucasian than the Chinese infants of 8-12 mths of age. Thus, after adjusting for energy, several statistically significant differences were found in the median intakes of iron (total, heme and non-heme), energy, vitamin C, calcium and dietary fibre from non-milk foods between infants of Caucasian versus Chinese ancestry at both ages 8-12 and 13-26 mths. Thus, hypothesis 7 is rejected.

Hypothesis 8: *Dietary assessment using a FFQ will find no relation between the intakes of total or heme iron and the biochemical indices of iron status, Hgb, serum ferritin, sTfR and sTfR:ferritin among infants of 8-26 mths of age.*

This study found statistically significant relations between serum ferritin, sTfR and sTfR:ferritin and the dietary intakes of total ($r = 0.33$, $P<0.001$, $r = -0.20$, $P<0.05$, $r = -0.33$, $P<0.001$) and heme ($r = 0.18$, $P<0.05$, $r = -0.26$, $P<0.005$, $r = -0.27$, $P=0.001$) iron determined by the FFQ, providing evidence of criterion validity. Thus, hypothesis 8 is rejected as the FFQ developed here provided a valid assessment of total and heme iron intakes compared with biochemical indices of iron status.

4.10.3 Relative Validity of the FFQ compared with the 3d-FR

This study demonstrated statistically significant relations between the intakes of total and heme iron determined by the FFQ compared with those determined by the 3d-FR. With the exception of mixed dishes with MPF, the FFQ determined median intakes of food from the food groups that provide the major sources of iron and factors that influence iron absorption were highly correlated with those determined by the 3d-FR ($R^2= 0.37$-0.98, $P<0.001$). With the exception of calcium, the median intakes of energy, iron (total, heme and non-heme), vitamin C and dietary fibre determined by the FFQ were significantly different than those determined by the 3d-FR. With the exception of MPF, regular formula, iron-fortified infant cereal, and soy-based products, the FFQ determined median intakes of food from the food groups that provide major sources of iron and factors that influence iron absorption were significantly different than those determined by the 3d-FR. Thus, the FFQ developed here provided a valid assessment of the dietary sources and intakes of iron and inhibitors and enhancers of iron absorption as compared with those determined by a 3d-FR, evidence of relative validity.

4.10.4 Multivariate Predictors of Poor Iron Status

This study identified 4 key dietary patterns that are robust predictors of poor iron status among Caucasian and Chinese infants of 8-26 mths of age in Vancouver. These dietary patterns have the potential to be used as a short dietary screening tool to identify infants at risk for IDA. An intake of ≥800 g cows' milk and milk products/day and <30 g/day of MPF, or among infants not given ≥800 g cows' milk and milk products/day, a history of no iron-fortified infant formula or iron supplement and an intake of<30 g of MPF/day in an 8-12 mth old infant were found to be the best predictors of poor iron status, with a misclassification rate of 25%.

4.10.5 Clinical Utility of the sTfR

This study found no significant correlation between infant age and sTfR concentration or sTfR:ferritin ratio. A gender-related difference in sTfR, however, was found for infants with normal iron status, with males having a significantly higher sTfR concentration than females. Infants from Caucasian ancestries with normal iron status also had significantly higher values for sTfR and sTfR:ferritin than infants from Chinese ancestries. An inverse association was found between sTfR and ferritin, sTfR and Hgb and sTfR:ferritin and Hgb. This study, suggests that sTfR is a sensitive indicator of IDA, but not low iron stores. The specificity of sTfR was poor, however, for both IDA and low iron stores.

CHAPTER 5. DISCUSSION

A total of 148 infants participated in this study which was designed to 1) investigate the prevalence of iron deficiency anemia (IDA) and low iron stores among infants 8-26 mths of age from Caucasian and Chinese ancestries in Vancouver, 2) examine the potential value of dietary assessment instruments for classifying infants with poor iron status (i.e. low iron stores or IDA) and normal iron status, and 3) validate a food frequency questionnaire (FFQ) for measuring iron intakes in infancy by comparison with a 3-day food record (3d-FR) and biochemical indices of iron status. A secondary aim was to explore the distribution of sTfR concentration and sTfR:ferritin ratio and the utility of sTfR as a biochemical measure for detecting IDA and low iron stores in infants aged 8-26 mths. The results are consistent with previous work (Lwanga, 1996; Innis et al., 1997) which found that Caucasian infants at about 9 mths of age appear to be at a higher risk for IDA and low iron stores than Chinese infants. This research provides the first data on the iron status of Caucasian and Chinese infants to 2 years of age in Vancouver. The findings suggest that low iron stores, but not IDA is prevalent in the 2nd year of life among both Caucasian and Chinese infants. This study provides new data to show that 4 key dietary patterns predicted poor iron status in this group of infants: 1) a history of no iron-fortified infant formula or iron supplement, 2) a history of cows' milk introduction prior to 9 mths of age, 3) an average intake of ≥800 g/day cows' milk and milk products within the previous 2 weeks, and 4) an average intake of <30 g/day of MPF within the previous 2 weeks. This chapter discusses the problem of IDA and low iron stores and dietary predictors of risk among Caucasian and Chinese infants in Vancouver. The implications of these findings for strategies for primary and secondary prevention of IDA are then discussed in relation to the current practices and available literature in the area of IDA prevention. This discussion focuses on the application of the dietary patterns associated with poor iron status to strategies for prevention and on the use of dietary versus biochemical indices of iron status for identifying infants at risk for IDA.

5.1 Iron Status of Caucasian and Chinese Infants Aged 8-26 Mths in Vancouver.

5.1.1 Prevalence of Iron Deficiency Anemia and Low Iron Stores Among Caucasian and Chinese Infants Aged 8-26 Mths in Vancouver.

This study found that the prevalence of IDA was higher at 8-12 mths than at 13-26 mths of age in both Caucasian and Chinese infants in Vancouver, and that the risk of poor iron status appears to be higher among the Caucasian than the Chinese infants at 8-26 mths of age. Fifteen percent of Caucasian and 6% of Chinese infants were found to have IDA at 8-12 mths of age, while only 4% of Caucasian and no Chinese infants were found to have IDA at 13-26 mths of age. The only other study providing comparative data on the iron status of Caucasian and Chinese infants was conducted by Innis et al. (1997) in 1993 in Vancouver. The infants studied by Innis et al. (1997) were predominantly from 2-parent families, with parents who had completed some post-secondary education, but tended to be from higher income families than the infants in our study. The work by Innis et al. (1997) included a large number of infants from Caucasian (n=245) and Chinese (n=81) ancestries, but considered infants only at 9 mths of age. The finding of 8% IDA and 25% low iron stores among Caucasian, and 4% IDA and 12% low iron stores among Chinese infants at 9 mths of age by Innis et al. (1997) raised important questions about the risk of IDA among infants from Caucasian and Chinese ancestries in Vancouver in the 2nd year of life. The number of infants within each age category in the present study is small, and the 9% of potentially eligible infants identified from the birth lists who participated in this study may not be representative of those who did not participate. Based on the literature (Froom et al., 1999; Chou et al., 1997), however, non-participants tend to be at higher risk for poorer health outcomes. Thus, it is reasonable to anticipate that these estimates of poor iron status found here are conservative. Importantly, however, the results provide new cross-sectional data on the iron status of Caucasian and Chinese infants in Vancouver from the first to 2nd year of life, as well as the dietary risk factors associated with poor iron status among these infants.

Our findings show that Caucasian infants appear to be at a higher risk for IDA in the first (15%) than the 2nd (4%) year of life. This is consistent with studies in the U.S. (Sargent et al., 1996; Looker et al., 1997) and Europe (Hercberg et al., 1987) that have reported a decline in the prevalence of iron deficiency from the first to the 2nd year of life. In contrast, Chan-Yip & Gray-Donald (1987) reported a prevalence of 11% IDA at 6-12 mths and 16.5% at 19-36 mths among Chinese infants in Montreal, suggesting a possible increase rather than decrease in the prevalence

of IDA with increasing age. No other published information appears to be available on the prevalence of IDA among Chinese infants in Canada. Differences in the criteria used to define IDA in this study (i.e. Hgb <110 g/L with a ferritin ≤12 μg/L) and in the study by Chan-Yip & Gray-Donald (i.e. MCV ≤70 fL with ferritin ≤12 μg/L) might account for the differences in results, but are unlikely to account for the different trends in IDA with age. When the criteria of Chan-Yip & Gray-Donald (1987) were used to classify iron status in our study, 6% of the Chinese infants (n=1 at each of 8, 15 and 26 mths of age) met the criteria for IDA. Thus, the prevalence of IDA among the Chinese infants in this study and the study by Innis et al. (1997) in Vancouver is about half that reported by Chan-Yip & Gray-Donald (14%) for 6-36 mth old Chinese infants in Montreal. Possibly, secular changes in infant feeding practices in the last 10-15 years, such as rates of feeding with cows' milk, low iron and iron-fortified infant formulas and breast-feeding (CPS Nutrition Committee, 1979; CPS et al., 1998), or cultural differences in the study populations might explain the difference in the prevalence of IDA between the Chinese infants in this study and the infants in Montreal. Information on feeding practices was not routinely recorded by Chan-Yip & Gray-Donald (1987), but retrospective reporting at the time of diagnosis of IDA revealed that many of the infants had been fed excessive quantities of whole cows' milk and that only 18% had been breast-fed for at least 4 mths. In contrast, none of the Chinese infants aged 8-12 mths, and only 5/31 of those aged 13-26 mths in our study were fed ≥800 mL cows' milk/day and 64% were breast-fed for at least 4 mths. Similar changes in infant feeding practices over the past 20-30 years have occurred in the U.S. (Yip et al., 1987a&b; Miller at al., 1985; Vazquez-Seoane et al., 1985) to those reported in Canada (Health and Welfare Canada, 1993; Health and Welfare Canada, 1991; MacNally et al., 1985; Tanaka et al., 1987; Williams et al., 1996) and have been associated with an overall decline in the prevalence of IDA in infancy (Looker et al., 1997; Dallman, 1990; Yip et al., 1987a&b). Further, although not specifically mentioned, Chan-Yip & Gray-Donald (1987) reported that most of the infants in their study were from families of first generation immigrants from China and Southeast Asia. About 40% of the Chinese infants in our study were from families of first generation immigrants from China and Southeast Asia, 44% from families of first generation immigrants from Hong Kong, and 6% from families who had lived in Canada all their lives (**Appendix Q, Table 5.4**). It is known that infant feeding practices change with acculturation (Rassin et al., 1993) and vary considerably both within and across ethnic backgrounds (Rassin et al., 1984; Martinez & Kreiger, 1985; Minister of Public Works and Government Services Canada, 1997). Thus, differences in socio-cultural background could explain the apparent low prevalence of IDA found among Chinese infants in Vancouver. It is possible that other groups of Chinese infants with different socio-cultural

backgrounds, such as those from lower SES backgrounds, living in other parts of North America, or who have recently immigrated to Canada would be at a higher risk for IDA than the infants studied here.

In contrast to the prevalence of IDA, the prevalence of low iron stores was much higher in the 2nd than the first year of life in both the Chinese and Caucasian infants in this study. None of the Chinese infants aged 8-12 mths, but 25-28% of those aged 13-26 mths had low iron stores. Fifteen percent of the Caucasian infants 8-12 mths of age and 30-50% of those 13-26 mths of age had low iron stores. A longitudinal study of upper middle class, French Canadian infants in Montreal by Brault-Debuc et al. (1983) found a prevalence of 29% low iron stores (defined as ferritin ≤10 μg/L) at 18 mths of age, but only 8% at 24 mths. In contrast, our study found 31% low iron stores among infants at 22-26 mths of age, (15% at 18-20 mths of age). The lower cut-off value of a serum ferritin of ≤10 μg/L used by Brault-Debuc et al. (1983) is one possible explanation for the lower prevalence of low iron stores in the infants. However, using a serum ferritin ≤10 μg/L rather than ≤12 μg/L as the criteria for low iron stores, 21% of the 22-26 mth old infants in our study met the criteria for low iron stores, a prevalence still higher than the 8% reported by Brault-Debuc et al. (1983). The parents in the study by Brault-Debuc et al. (1983) kept food records for their infants once every 3 mths from 3 to 18 mths, then again at 24 mths of age. Whether the practice of keeping repeat food records influenced the parents' infant feeding practices and thus led to the decrease in low iron stores in the 2nd year is not known.

The finding that 29% of infants aged 8-26 mths in our study had low iron stores agrees closely with recent work by Zlotkin et al. (1996) who found that about 30% of infants 8-15 mths of age from 4 major Canadian urban centres had low iron stores. Innis et al. (1997) found a prevalence of low iron stores of 29% among Caucasian infants and 12% among Chinese aged 9 mths, higher than the 15% and 0% found here for 8-12 mth old Caucasian and Chinese infants, respectively. Possibly, the lower prevalence of low iron stores in the 8-12 mth old infants in our study is explained by inadequate power due to the lower number of infants compared with the 245 Caucasian and 81 Chinese infants studied by Innis et al. (1997).

The use of ferritin as a measure of low iron stores has several important limitations that need to be considered with respect to the interpretation of our findings. As an acute phase reactant, ferritin may be elevated 3 to 5-fold in infants with infection (Cook et al., 1993; Lipschitz et al., 1974), a condition common in infancy. The parents of infants in this study were asked if their infant had a current or recent infection, and for those that had, blood work was not completed until the infant had been apparently free of infection for at least 2 weeks. It is possible, however, that the ferritin values of some infants were elevated due to undetected mild infection. Four infants had a Hgb of 102-109 g/L,

and a ferritin >12 μg/L. Serum ferritin may have been falsely elevated by infection, remained elevated from the time of infection, or the low Hgb may have been a physiologically low normal value in some or all of these infants. Ferritin is also increased in individuals with iron overload and genetic hemochromotosis, although these conditions are rare in infancy (Gordeuk et al., 1994). Serum ferritin has also been shown to increase during starvation, and in brief periods of fasting (Worwood, 1980), however, fasting is not likely to have complicated the results for infants in this study. Despite the limitations in the sensitivity of serum ferritin as a measure of adequate iron stores, a serum ferritin value ≤12 μg/L is a highly specific indicator of low iron stores (Ali et al., 1978). Given the possibility that some of the infants may have had falsely elevated serum ferritin values, the 29% prevalence of low iron stores found in this study may have been an underestimate.

The higher prevalence of poor iron status found here among the Caucasian compared with the Chinese infants may be explained by the differences found in the feeding histories, and the food and nutrient intakes of the Caucasian and the Chinese infants. Based on their feeding histories, all of the Chinese infants aged 8-12 mths had been introduced to MPF by 9 mths of age, while 88% of the Caucasian infants had. Possibly, the greater number of Chinese infants 8-12 mths of age fed sources of heme iron decreased the risk of poor iron status among this group. No other differences were apparent between the feeding histories of the Chinese and Caucasian infants at 8-12 mths of age, and no differences in the feeding histories were apparent between the groups of 13-26 mth old infants. The absence of any differences in the feeding histories between the Caucasian and Chinese infants at 13-26 mths of age may reflect the limitations of retrospective questionnaires for assessing the iron status of older infants, as discussed further in **Section 5.2.1.2**. As might be anticipated from the later introduction of MPF, the Caucasian infants aged 8-12 mths had lower intakes of MPF and mixed dishes with MPF and, therefore, a lower intake of heme iron than the Chinese infants. The 13-26 mth old Caucasian infants also had a lower intake of mixed dishes with MPF than the Chinese infants. Despite the lower intake of heme iron, the intake of total iron from non-milk foods was higher in the Caucasian than in the Chinese infants at both 8-12 and 13-26 mths of age. The 2-week FFQ showed that the higher intake of total iron in the Caucasian infants was explained by higher intakes of other cereals (i.e. iron-fortified cereals other than infant cereals) and bread, pasta and rice. Milk represented 55% compared with 67% of the total food intake of the Caucasian and Chinese infants, respectively. The total non-milk food intake of the Caucasian and Chinese infants aged 8-12 mths was 1050 and 1101 g/day, respectively and was not statistically different. However, the 8-12 mth old Caucasian infants received about 98% of their total iron intake from non-milk foods, compared with only 32% for the Chinese infants.

The lower intakes of iron from milk sources among the Caucasian than the Chinese infants at both 8-12 and 13-26 mths can be explained by higher intakes of human milk and lower intakes of iron-fortified infant formula among the Caucasian than the Chinese infants. As might be expected from the higher intakes of iron from non-milk foods, including fruits and vegetables, and other cereals, the Caucasian infants aged 8-12 mths had higher intakes of non-heme iron, vitamin C and dietary fibre than the Chinese infants. The Caucasian infants aged 8-12 mths also had higher intakes of calcium, a primary inhibitor of both heme and non-heme iron absorption, from non-fluid milk sources than the Chinese infants. Consistent with the higher intake of total iron from non-milk foods, the Caucasian infants 13-26 mths of age had higher intakes of energy and, even after adjusting for energy intake, higher intakes of non-heme iron, vitamin C, calcium and dietary fibre than the Chinese infants. Different food consumption patterns between the Caucasian and Chinese infants in this study may, therefore, explain the higher prevalence of poor iron status among the Caucasian compared with the Chinese infants.

No other published data appear to be available comparing the dietary intakes or sources of iron (total, heme and non-heme), energy, vitamin C, calcium and fibre among Caucasian and Chinese infants. The only other study providing comparative data on the iron status of Caucasian and Chinese infants in relation to possible dietary risk factors was the study by Innis et al. (1997), which found a higher prevalence of IDA among Caucasian (8%) than Chinese (4%) infants at 9 mths of age. Consistent with our findings, the higher prevalence of IDA found by Innis et al. (1997) among Caucasian compared with Chinese infants was associated with a higher rate of breast-feeding among Caucasian mothers and the predominant use of iron-fortified formula by Chinese mothers. It is not clear how many Chinese infants were fed an iron-fortified formula in the study by Innis et al. (1997), which was conducted in 1993, but only about 16% were breast-fed >6 mths compared with 35% in this study. Sixty-five percent of the Chinese infants in this study were fed an iron-fortified formula or given an iron supplement. There were no differences between the proportions of Caucasian and Chinese infants in this study who had been breast-fed >6 mths or who had received supplemental iron. Since the patterns of primary milk feeding differed between the infants in this study and that by Innis et al. (1997), it is possible that the patterns of solid food feeding, and the significance of the iron intake from solid foods to iron balance also differed. In contrast to our findings, however, Innis et al. (1997) found no differences in the age of introduction of solid foods between the infants with iron deficiency and those with normal iron status. Data on the durations or quantities of solid foods fed, however, was not collected for the infants studied by Innis et al. (1997).

Only 2 other studies, one by Chan-Yip & Gray-Donald (1987) in Montreal and one by Leung et al. (1988) in Hong Kong have reported information on the feeding practices of Chinese infants in relation to their iron status. As discussed previously, important differences between the feeding practices of the infants in our study and those studied by Chan-Yip & Gray-Donald (1987) may have accounted for the lower prevalence of IDA and low iron stores found for the infants in our study. Although Chan-Yip & Gray-Donald (1987) did not determine the age of introduction of solid foods among Chinese infants in Montreal, they speculated that many infants had been fed traditional Chinese beikost, which is known to have a low iron bioavailability (Dallman & Siimes, 1979a; Hallberg et al., 1977; Hsia & Yeung, 1976). In contrast, about 75-80% of the Chinese infants in our study had been fed an iron-fortified infant cereal by 6 mths of age, or fed meats by 9 mths of age.

Consistent with our findings, Leung et al. (1988) found a low prevalence of IDA among Chinese infants in Hong Kong, despite solid food feeding practices that might be expected to place infants at risk for IDA. Twenty percent of the Chinese infants studied by Leung et al. (1988) had not been fed meats or fish by 9 mths of age, and 71% had not been fed an iron-fortified infant cereal by 6 mths of age. In contrast, only 21% of the Chinese infants in our study had not been fed an iron-fortified infant cereal by 6 mths of age. Further, by 8 mths of age, iron-fortified infant cereals were replaced by traditional rice-based foods (congee) among the Chinese infants in Hong Kong who had been fed iron-fortified infant cereals. In contrast, 32 of the 45 Chinese infants in our study who had been fed iron-fortified infant cereal were still being fed an iron-fortified infant cereal at 8 mths of age. Of importance, 72% of the infants in Hong Kong were still being fed an iron-fortified infant formula at 18 mths of age, and none had been given cows' milk prior to 15 mths. Thus, the prolonged feeding of iron-fortified infant formula rather than low iron milk probably protected these infants from IDA, irrespective of their solid food feeding practices.

5.1.2 Implications of the High Prevalence of Iron Deficiency Anemia and Low Iron Stores at 8-12 Mths of Age and Low Iron Stores at 13-26 Mths of Age for Infant Health and Development.

The lower prevalence of IDA among infants aged 13-26 mths than among those aged 8-12 mths suggests that IDA may be corrected as the variety and amount of solid food increases throughout the latter part of infancy and early childhood. Despite this possibility, the finding of 12% IDA at 8-12 mths of age indicates that the prevalence of IDA among infants in the latter half of the first year of life in Vancouver has not improved since 1993 (Innis et al., 1997), and thus continues to be a significant problem. Moreover, the 9% of potentially eligible infants in this study

were likely from families who were more highly motivated with respect to their infant's diet and health. Thus, based on U.S. data (Gupta et al., 1999; Kwaitkowski et al., 1999), it is likely that the problem of IDA and low iron stores was underestimated in terms of both prevalence and severity. Substantial evidence exists to show that IDA in infancy is associated with poor developmental outcomes, including impaired immunity (Murray et al., 1975a&b, 1978; Galan et al., 1992; Thibault et al, 1993), growth (Auckett et al., 1986; Briend et al., 1990; Chwang et al., 1988; Latham et al., 1990), mental and motor development (Lozoff et al., 1982, 1987, 1996; Walter et al., 1983, 1989; Grindulis et al., 1986), and educational performance later in life (Lozoff et al., 1991; Palti et al., 1985; Watkins & Pollitt, 1990; Hurtado et al., 1999). Considering that 12% (and possibly up to 20%) of 8-12 mth old infants may be at risk for impaired infant health and development due to IDA, and the potential burden that this may place on our medical, social and education systems, it is clear that further improvement in strategies for the prevention of IDA in the latter half of the first year of life among infants in Vancouver is important.

The finding of 15% IDA among Caucasian infants and 26% IDA among those breast-fed >6 mths suggests that there are limitations to the effectiveness of current strategies in Canada aimed at the prevention of IDA. Evaluation of current strategies used to prevent IDA within in the context of Green's & Kreuter's (1991) PRECEDE model, i.e. Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation, might be useful to determine the factors that should be targeted in future initiatives to prevent IDA. The primary strategies currently used to prevent IDA in infancy encompass all 3 categories of factors that influence the feeding practices that determine an infant's risk of IDA. Predisposing factors such as parents' knowledge, attitudes and beliefs about infant nutrition are targeted through infant feeding guidelines and education so that parents are able make informed decisions about infant feeding. Current prevention strategies also include enabling factors, such as the availability of iron-fortified products, and reinforcing factors, such as the education of health professionals to encourage and support appropriate infant feeding. Other predisposing, reinforcing, and enabling factors, however, that might be important for groups of infants at risk of IDA are clearly being missed in IDA prevention initiatives. For example, current strategies may be failing to address other key enabling factors among certain subgroups of the population such as the inaccessibility of these iron-fortified infant products due to price, lack of parents' infant feeding skills and language or other barriers that prevent access to health care or health information. Evidence that Caucasian infants in Vancouver are being breast-fed for longer durations and introduced to iron-fortified cereals by 4-6 mths of age (Williams et al., 1996; present study) suggests that the messages aimed at parents and health professionals on the

infant feeding practices recommended to prevent IDA are being followed. This raises the possibility that the primary strategy used to prevent IDA among infants being breast-fed, namely the recommendation to introduce of iron-fortified infant cereal at 4-6 mths for age (CPS Nutrition Committee, 1991; CPS et al., 1998), may not be adequate to prevent IDA among breast-fed infants.

The reasons for the higher prevalence of low iron stores in the 2nd than in the first year of life in our study are not clear. It may be reasonable to expect that iron stores would increase in the 2nd year as the diet is becoming more varied, meat intakes are increasing and the rates of erythropoiesis and growth are slowing. The group of 13-17 mth old infants with low iron stores may be comprised of one or more of 3 possible groups: 1) infants who had IDA prior to 12 mths of age and in whom this was "corrected", although the iron stores remained depleted, 2) infants in whom iron stores had become depleted after the first year, and 3) infants in whom low iron stores remained unchanged from the first year. Unfortunately, a cross-sectional study design as used here cannot address whether or not the infants with low iron stores were in the process of building up their stores following recovery from IDA, were depleting their stores, or were maintaining low iron balance. Ethical issues prevent longitudinal evaluation of the natural course of IDA in infancy.

The physiological significance and thus, the implications of the high prevalence of low iron stores among Caucasian and Chinese infants in the 2nd year of life in our study are also not clear. Evidence to date on whether or not low iron stores in the absence of anemia during infancy affects cognitive or motor development has indicated that iron depletion alone is not sufficient to significantly alter developmental status (Injradinata & Pollitt, 1994; Lozoff et al., 1987). However, alterations in behavior were demonstrated by Bruner et al. (1996) in adolescent girls with iron deficiency without anemia. It is possible that global tests of mental and motor function, such as the Bayley Scales of Infant Development used in studies with infants are not sensitive enough to detect subtle differences in functioning that may occur in infants with iron deficiency without frank anemia. Other more narrowly defined assessment instruments and tests, such as those assessing visual recognition and attention, that are externally valid and reliable for detecting changes in physiological or behavioral function are needed to assess the effects of suboptimal levels of tissue iron on specific aspects of infant cognitive and motor functioning (Pollitt, 2000; Wainwright, 1996). It is also possible that the iron deficiency without anemia may have detrimental consequences in some infants, such as those living in disadvantaged social or economic circumstances but not in others who may be resilient to the effects of the iron deficiency due to protective environmental factors (Horowitz 1989; McLoyd, 1998;

Miller, 1998). Currently, data do not exist to show conclusively whether or not low iron stores alone has a negative impact on infant development. Thus, until the time that this evidence is available, it is prudent to aim to prevent, not only frank IDA, but poor iron status.

The finding of a low prevalence of IDA among infants 13-26 mths of age is reassuring in that the prevalence of IDA appears to decrease in the 2nd year of life. Nonetheless, 4% Caucasian infants were found to have IDA in the 2nd year of life. Lozoff et al. (1991) found that infants with IDA at 12-23 mths of age tested lower than age matched controls with normal iron status on tests of mental and motor development, and upon retesting at 5 years of age they continued to score lower on developmental tests. The work of Lozoff et al. (1991) suggests that IDA even in the 2nd year of life may have consequences detrimental to infant development. Further, infants with low iron stores are clearly at risk for IDA if the dietary supply of iron continues to be inadequate to meet the physiological need for iron. Studies in the U.S. have indicated that the total iron intake decreases from the first to the 2nd year of life (Zeigler & Foman, 1996). The findings here and in the U.S. (Sargent et al., 1996), however, show that the risk of IDA appears to decrease from the first to the 2nd year of life. Possibly the lower prevalence of IDA despite lower iron intakes is explained by higher intakes of heme iron, along with lower endogenous iron requirements in the 2nd year of life. Although the available data suggest that low iron stores may not be a concern in infants without anemia with adequate intakes of total or heme iron, these low iron stores may place some infants at particular risk for IDA. Although not represented by infants in this study, infants at risk for IDA due to low iron stores may include, for example, infants whose family follows a vegetarian diet, fussy eaters, infants with a dislike of meats or consuming inadequate amounts of solid foods while being primarily breast-fed or fed a low iron milk, or infants from disadvantages SES backgrounds. Observational evidence by Kwiatkowski et al. (1999) that severe anemia (Hgb <60 g/L) due to nutritional reasons (i.e. diets that included >1 L of milk or did not include meat or iron-fortified cereal) presents as a common problem between one and 3 years of age suggests that some groups of infants may be at risk for IDA due to low iron stores. Infants from disadvantaged SES backgrounds may be at risk for feeding practices that are inconsistent with current recommendations (Schwartz & Evers, 1998; Moffatt et al., 1994). These infants may also be more susceptible to poor developmental outcomes due to IDA (McLoyd, 1998; Miller, 1998) due to an interactive risk imposed by the nutritional insult and environmental deprivation (Horowitz, 1989). Thus, it is also possible that infants in disadvantaged social and environmental circumstances may be more vulnerable to potential physiological or behavioral consequences of low iron stores, whereas infants in advantaged

circumstances may be resilient to nutritional insults. Therefore, the finding that, in addition to the 12% of infants with IDA at 8-12 mths of age, about 29% of infants of 8-26 mths of age had low iron stores provides further justification for recommendations to improve strategies for primary prevention to decrease the risk of poor iron status, and for secondary prevention to identify infants at risk for IDA in the latter half of the first year of life.

The high prevalence of poor iron status found in our study is of further concern because the evidence provided by all of the studies to date (Lozoff et al., 1996; Grindulis et al., 1986; Walter et al., 1989; Lozoff et al., 1989; Walter et al., 1983), with the exception of one (Idjradinata & Pollitt, 1993), indicates that the impact of IDA on development may be irreversible. Strategies for identification of infants at risk of developing IDA are, therefore, important. Ideally, considering the possible irreversibility of developmental delays due to IDA, infants should be identified prior to development of the anemia. Identification of infants with low iron stores, or iron deficiency erythropoiesis (IDE) prior to the onset of anemia would have the potential to prevent the known consequences of IDA on infant health and development.

Finally, although not evident from this study, there is considerable evidence that IDA may also be a marker for other underlying often co-existing risk conditions and factors (i.e. poor SES, other nutrient deficiencies, overall poor diet) (Moffatt et al., 1994; Lozoff et al., 1996; Pollitt, 2000). For the infants in this study, addressing the underlying root causes of the feeding patterns that place infants at risk for poor iron status would require further research into the reasons, for example, that Caucasian mothers delay introduction and feed lower quantities of meats, or feed higher quantities of cows' milk and milk products. Possibly, these risk patterns represent a disjuncture between the current public discourse around healthy eating, and lay interpretation and extrapolation of guidelines for healthy eating aimed at adults to infants. For example, the recommendation to choose leaner and smaller portions of meats (Health and Welfare Canada, 1992) is often misinterpreted by the public to mean that meat is bad, an interpretation that if extrapolated to infant feeding might place an infant at risk for IDA.

5.2 Strategies for Identification of Infants at Risk for Iron Deficiency Anemia.

5.2.1 Use of Dietary Assessment Instruments to Assess Iron Status in Infancy.

5.2.1.1 Value of the Food Frequency Questionnaire for Assessing the Intake of Iron and Other Factors Influencing Iron Absorption.

A key finding was that the FFQ developed in this study provided a valid assessment of the intake of iron as compared with a 3d-FR and with biochemical indices of iron status among Caucasian and Chinese infants of 8-26 mths of age. The intakes of total and heme iron determined by the FFQ were related to the biochemical indices of iron status, thus providing criterion (i.e. biochemical) validation of the FFQ measures of iron intake. Statistically significant, but weak correlations were found between serum ferritin, sTfR and sTfR:ferritin and the intakes of total ($r=0.33$, $P<0.001$, $r=-0.20$, $P<0.05$, $r=-0.33$, $P<0.001$, respectively) and heme ($r=0.18$, $P<0.05$, $r=-0.26$, $P<0.005$, $r=-0.27$, $P=0.001$, respectively) iron as determined by the FFQ. The relation between total iron and serum ferritin increased when infants who had been given iron supplements were excluded from the analyses. Although including supplement users should increase the range of both iron intake and the ferritin values, thereby potentially improving the correlation between the two (Willett, 1998), the proportion of non-heme iron absorption decreases as intake increases. Further absorption from a single large dose of iron would be expected to be less than from iron consumed intermittently in smaller amounts throughout the day. Thus, when infants who had received large amounts of supplemental iron were excluded from the analysis, a higher r value for the relation between dietary iron intake and the ferritin values would be expected.

To the best of our knowledge, this is the first study to report a relation between the intake of iron as determined by a FFQ designed to assess iron nutrition, and biochemical markers of iron status in an infant population. Biochemical and hematological indices of iron status are not likely to be influenced by recent changes in iron intake, such as that reflected by the time periods covered by the 3d-FR and 2-week FFQ used in this study. The iron intake determined by the 3d-FR and 2-week FFQ can only serve as a proxy of an infant's long-term iron intake. However, the congruence of the relations found in our study between the biochemical indices of iron status and measures of dietary iron intake, and the relations reported between serum ferritin and the intakes of total, heme iron and meat and fish assessed by dietary records by others for infants (Salas et al., 1990; Soustre et al., 1986), older children (Salas et al.,

1990; Gibson et al., 1988) and by FFQ for adults (Ascherio et al., 1994; Fleming et al., 1998) suggests that our FFQ provided a valid assessment of iron intake for the infants in our study.

The associations found in our study between the biochemical indices of iron status and the FFQ intake of dietary iron were lower than those previously reported for preschool children (Gibson et al., 1988) and adults (Ascherio et al., 1994; Fleming et al., 1998). The range of iron intakes among the infants in our study was wide and thus should be adequate to determine if a relation existed between iron intake and the biochemical indices of iron status. The weaker relation between the iron intake measured by the FFQ and the biochemical indices of iron status in our study than in studies of older groups (Gibson et al., 1988; Ascherio et al., 1994; Flemming et al., 1998) might be explained by a greater potential for the greater importance of other determinants of iron balance on iron status in infancy. For example, the lower intakes of meat and higher proportions of non-heme to heme iron in infants' diets than in the diets of older children or adults might result in a greater effect of inhibitors and enhancers of iron absorption on iron balance (Cook et al., 1991a). A high proportion of the total iron intake was from non-heme food sources, both for the infants studied here (97-98%) and in the preschool children studied by Gibson et al. (1988) (94-95%). The mean intakes of non-heme iron were 7.4 ± 5.2 mg/day for female and 8.4 ± 5.0 mg/day for male infants in this study, and were 9.1 ± 2.0 mg/day for girls and 10.7 ± 3.2 mg/day for boys studied by Gibson et al. (1988). Dietary components such as calcium, which decrease the absorption of non-heme iron, might be higher in the diet of infants than in older children and adults. Whether possible differences in the intake of non-heme and heme iron have a greater influence on iron status in 8-26 mth olds than in older children and in adults is not clear, but could reasonably contribute to differences between this study with infants and other studies with older populations (Gibson et al., 1988; Ascherio et al., 1994; Fleming et al., 1998). Other factors common to infants, such as the variability in the infant's iron endowment at birth (Preziosi et al., 1997) and growth rate (Siimes & Salmenperä, 1989; Sherriff et al., 1999; Emond et al., 1995; Dewey et al., 1998; Michaelson et al., 1995), the consumption of cows' milk and associated influence of occult blood loss on iron balance during early infancy (Woodruff et al., 1972; Foman et al., 1981; Lönnerdal, 1990), and higher rates of infection may also contribute to the weaker relations between dietary and biochemical variables found in this study than found in other studies with older populations.

Although there are limitations associated with using biochemical indices of iron status as a proxy for validating dietary assessment instruments, the consistency of the relations between total and heme iron and the biochemical indices of iron status used in this study provides reassurance that the FFQ provides a valid assessment

of iron intake for the infants in our study. Further, despite the potential for falsely elevated ferritin values due to infection, the consistency of the inverse relations between total iron intake as assessed by the FFQ and the sTfR and sTfR:ferritin ratio, and the positive relationship between total iron and serum ferritin adds weight to the conclusion that the FFQ provides a valid assessment of the iron status of infants. No other published data appear to be available on the relationship between sTfR and dietary iron intakes. Nonetheless, since serum ferritin is a major determinant of the sTfR concentration (Virtenan et al., 1999), the finding of a relation between sTfR and total iron intake is not unexpected.

In contrast to the biochemical indices of iron status, no associations were found between Hgb and the intake of iron determined either by the 3d-FR or the FFQ. The absence of an association between the intake of total iron and Hgb is consistent with other studies (Hercberg et al., 1987; Gibson et al., 1988), and is not surprising because Hgb concentrations plateau once the level of transport iron in the body is adequate. In contrast to total iron, however, statistically significant, but weak correlations were found between Hgb and the intake of heme iron determined by the FFQ ($r=0.26$, $P=0.002$) and the 3d-FR ($r=0.21$, $P=0.01$). Exclusion of the infants who had been given iron supplements ($n=6$) from the analyses increased the r value for the relation between heme iron intake, as determined by both the FFQ ($r=0.28$, $P=0.001$) and 3d-FR ($r=0.23$, $P=0.009$) and Hgb. This is reasonably explained because supplemental iron increases total iron, but not heme iron intake, and would increase iron status. The significant positive relation between heme iron and Hgb, however, was unexpected because as noted, Hgb concentrations plateau once the level of transport iron in the body is adequate. Possibly, a significant number of infants in this study had suboptimal levels of body transport iron and consequently, Hgb concentrations below the physiological potential for infants. In support of this explanation, at least 35% of the infants in this study had IDA, low iron stores, or a low Hgb with a ferritin >12 μg/L. The absence of a similar relationship between total iron and Hgb may be explained by a higher variability in the impact of total iron than heme iron on iron balance due to the influence of inhibitors and enhancers of iron absorption.

Our findings also show the relative validity of the FFQ for estimating intakes of energy, iron and other dietary factors known to promote or inhibit food iron absorption when compared with a 3d-FR. A dietary record is the best available gold standard to assess the relative validity of a FFQ (Willett, 1998; Jacques et al., 1993). Significant correlations were found between the intakes of energy ($r=0.60$, $P<0.001$), total iron ($r=0.64$, $P<0.001$), heme iron ($r=0.72$, $P<0.001$), non-heme iron ($r=0.35$, $P<0.001$), vitamin C ($r=0.64$, $P<0.001$), calcium ($r=0.75$,

$P<0.001$) and dietary fibre (r=0.68, $P<0.001$), and the intakes of food from the food groups that provide the major sources of iron and inhibitors and enhancers of iron absorption (r=0.28-0.99, $P<0.001$) determined by the FFQ and the 3d-FR. The significant, but weak correlation found between the intakes of mixed dishes with MPF determined by the FFQ and 3d-FR may be explained by the grouping of mixed dishes with MPF as composite dishes on the FFQ, but analysis as their respective ingredients on the 3d-FR.

To the best of our knowledge, this is the first report of a FFQ developed and used to estimate the intakes of iron and other dietary factors that influence iron absorption in infants. A FFQ, known as the 'Willet FFQ', has been validated for estimation of iron intakes in adults (Willet et al., 1987). The correlation between the intakes of nutrients and foods from the major food groups determined by the FFQ and 3d-FR was higher in this study with infants than in Willett's work with adults. This may be explained by differences both in the populations and in the time periods covered by the dietary assessments. Less intra-individual variation would be expected in the dietary intakes and food consumption patterns of infants than adults (Black et al., 1983). Reasonably, lower intra-individual variation in dietary intakes might contribute to higher correlations between estimates of iron intake using a FFQ and 3d-FR approach. The overlapping time periods of the 3d-FR and the FFQ used in this study is necessary for studies with infants where the diet characteristically undergoes enormous changes in short periods of time. This, however, may have contributed to the higher correlations between the intakes of nutrients and amounts of food from the major food groups determined by the FFQ and 3d-FR. Since the 2 weeks covered by the FFQ included the 3 days of dietary recording, it might be expected that the correlations would be higher than for dietary assessment done at discrete times. Further, the possibility that recording their infant's intake influenced the ability of the parents to recall their infant's intake during the FFQ interview is a further important consideration.

While there were generally good correlations between the nutrient and food intakes estimated by the 3d-FR and FFQ, the estimates of the absolute intakes of nutrients and foods from the major food groups differed markedly. The median daily total energy and iron intakes estimated from the FFQ were higher than those estimated by the 3d-FR (1119 vs. 929 kcal and 9.6 vs. 7.1 mg, respectively, $P<0.001$). Several factors might explain these differences. It is possible that the large number of food items (n=191) on the FFQ may have resulted in an overestimation of actual intakes. FFQs with a larger number of food items have been found to overestimate (Livingstone et al., 1990 & 1992), whereas FFQs with a smaller number of food items tend to underestimate (Yarnell et al., 1983) nutrient intakes. Kaskoun et al. (1994) found that the "Willet" FFQ, which was used to measure usual intake over the

previous year in children 4-7 years of age, significantly over-estimated energy intakes compared with total energy expenditure estimated by the doubly-labeled water method. The FFQ designed for this study measured intakes over the previous 2 weeks; thus, it is possible that the greater number of days covered by the FFQ than the 3-day FR may explain the higher estimates of intake achieved from the FFQ. Considering that key food sources of iron, such as meats, are consumed infrequently by infants and young children (Gibson et al., 1988; Ernst et al., 1990), however, the intake data estimated by the FFQ may be closer to the true usual intake, i.e. certain foods consumed over the 2 weeks covered by the FFQ may not have been eaten in the 3 days covered by the food record. On the other hand, the 3d-FR may be subject to underestimation of usual intakes due to possible underreporting, as a result of social desirability bias. The recording of food eaten during a 3d-FR can also result in a change in usual dietary patterns, which may result in either an under- or overestimation of usual intakes.

Information on dietary intakes in infants and young children is limited, probably in part due to a lack of dietary assessment instruments designed specifically for this age. In addition to the face and content validity of the FFQ, the results showed both relative validity of the FFQ compared with a 3d-FR and criterion validity compared with biochemical parameters of iron status. Importantly, this suggests that our FFQ can serve as a valuable research instrument for assessing the intakes of energy, iron and factors influencing iron absorption in 8-26 mth old Caucasian and Chinese infants, and fill a gap that currently exists in dietary assessment methodology. The low respondent burden, ease of administration and low cost of the FFQ suggest it is a more attractive, practical method than the 3d-FR for the determination of usual iron intakes. The different energy and iron intakes determined by the FFQ and 3d-FR, however, should be taken into consideration in studies assessing iron intakes in infancy. Future work is needed to determine the degree of under- or over-estimation of absolute food and nutrient intakes before the FFQ can be used as a quantitative measure of the intakes of energy, iron or other dietary factors influencing iron absorption in infancy. Further studies are also needed to address issues of reliability and predictive validity of the FFQ. The relative and criterion validity of this FFQ should be assessed for groups of infants from other SES or socio-economic or ethnic backgrounds, before it can be used with other populations that might be at risk for IDA, such as infants from vegetarian, First Nations or disadvantaged family backgrounds.

5.2.1.2 Value of Assessment of Feeding History and Current Dietary Intake for Classifying Infants by Iron Status.

A primary aim of this study was to explore the value of a retrospective assessment of infant feeding history, using the Socio-Cultural and Infant Feeding Questionnaire, and the concurrent assessment of dietary intake using a 3d-FR and FFQ for classifying infants according to iron status. The purpose of this exploratory analysis was to identify potential variables that could be included on a dietary assessment tool to identify infants at risk for IDA. The retrospective assessment of feeding history included: 1) duration of breast-feeding, 2) age(s) of introduction and types (low iron or iron-fortified) of infant formula, cows' milk or other milks fed from birth to the time of the study, and the amounts fed at the time of the study, 3) ages of introduction and durations of feeding of solid foods including iron-fortified infant cereals and MPF. The concurrent assessment of diet included: 1) the intakes of energy, iron (total, heme and non-heme), vitamin C, calcium and dietary fibre from complementary foods, (i.e. non-milk foods) as assessed by a 3d-FR, and 2) the intakes of foods from food groups representing major sources of iron and dietary factors influencing iron absorption as assessed by a FFQ. Univariate analysis of the results revealed several differences between the feeding histories of infants with iron deficiency and normal iron status at 8-12 mths of age, in the variables representing current diet at both 8-12 and 13-26 mths of age, but no differences in the feeding histories of infants 13-26 mths of age, or in the intakes of nutrients from complementary foods at either 8-12 or 13-26 mths of age. The independent positive predictors of poor iron status that emerged from the multivariate analyses were 1) a history of no iron-fortified infant formula or iron supplements, 2) a history of cows' milk introduction prior to 9 mths of age, 3) an average intake of ≥800 g/day cows' milk and milk products in the previous 2 weeks, and 4) an average intake of <30 g/day of MPF in the previous 2 weeks.

Several reasons may explain why the infant's iron status is related to the assessment of the feeding history at 8-12 mths, but not at 13-26 mths of age, and the assessment of the current total dietary intake at both 8-12 and 13-26 mths of age. Human milk and/or infant formula is now usually the major contributor to the total iron intake of infants of 12 mths of age or younger, whereas other foods become progressively more important for infants older than one year of age (Ernst et al., 1990). The relevance of the history of feeding practices to the infant's current iron status may be problematic because the intake of foods and supplements that influence iron status may be rapidly changing. For example, the Hgb concentration can increase 10 g/L in about one month in infants given iron supplements (AAP, 1998). Meat is an enhancer of nonheme iron absorption in infants (Engelmann et al., 1998) and

infants starting to eat larger amounts of heme iron may experience rapid increases in iron stores and/or Hgb (Engelmann et al., 1997). Thus, it can be anticipated that the iron status of infants >12 mths may not reflect their early feeding history, but rather reflect the intake of recent weeks. It is also possible that the recall bias inherent in retrospective questionnaires, such as the Infant Feeding and Socio-Cultural Questionnaire explains the lack of association between feeding history and iron status in infants aged 13-26 mths, but not in those aged 8-12 mths, because of the longer duration of the recall for the older infants. Persson & Carlgen (1984) and Rios et al. (1994) found that a decrease in the reliability of information obtained on breast-feeding duration and the age of introduction of solid foods occurred as the time between the actual feeding practices and the mother's recall increased. Finally, the retrospective assessment of infant feeding was not able to account for other aspects of the diet that may have been important determinants of iron status, for example, the quantities of complementary foods, heme and non-heme iron, and composition of the diet as a whole. Our results show a relation between diet and iron status when assessed using measures of current or recent intake, but no relation when assessed retrospectively in older infants. Importantly, this illustrates the importance of assessment of the infant's current intake in studies examining predictors of poor iron status in infants older than one year of age.

There are also several possible explanations for the lack of differences in the 3d-FR assessment of nutrient intakes from complementary foods between infants with poor iron status and normal iron status, despite differences in the FFQ assessment of food group intakes of the major food sources of iron and dietary factors influencing iron absorption. The lack of association between the 3d-FR intake of calcium and iron status, despite an association between the history of age of introduction and FFQ intake of cows' milk might be explained by the inclusion of only solid foods, and thus exclusion of all fluid cows' milk from the analysis. Similarly, the exclusion of iron-fortified infant formulas from the analysis might explain the lack of an association between 3d-FR assessment of dietary iron and iron status, despite an association between the intake of food groups that are the main contributors of iron, (i.e. iron-fortified infant formula, mixed dishes with MPF, and other cereals) and iron status. When all foods were included in the analysis, 34% of infants with poor iron status had total iron intakes <77% RNI, a prevalence more than 2-fold that of infants with normal iron status. This supports the explanation that the inclusion of only non-milk foods in the 3d-FR analysis resulted in the lack of significant differences in the iron intakes of infants with iron deficiency and normal iron status. The 3d-FR also may not have adequately reflected the intake of dietary iron with respect to long-term iron status, contributing to the lack of a significant difference in iron intakes of infants with poor iron status and

normal iron status. Biochemical indices of iron status are not influenced by recent changes in iron intake, that would be recorded in the 3d-FR, but rather longer-term food consumption patterns.

Several other factors may have confounded or biased the relations between iron status and the dietary variables in this study. It is possible that some of the infants with low iron stores may have been classified as normal iron status if their serum ferritin was falsely elevated, for example due to infection, and their Hgb was normal. It is also possible that some of the infants with low iron stores may have had IDA at younger ages and at the time of the study were consuming adequate amounts of iron and thus were in the process of increasing their stores, but still had ferritins of ≤12 μg/L. Cooper & Zlotkin (1996) have reported a wide intra-individual variability (about 24%) for serum ferritin analysis of capillary blood. It is also possible that variability in serum ferritin may have resulted in misclassification of some infants with serum ferritin concentrations in the range of about 11-15 μg/L. The biases due to the misclassification of infants would have resulted in an underestimation of the relations between iron status and diet. Exclusion of infants with serum ferritin >10-<16 μg/L in the statistical analysis, however, did not change the relations found here between iron status and diet. Finally, iron balance in infancy is multifactorial, and other factors that were not measured in this study but that may have been important determinants of an infant's iron status, such as the iron endowment at birth (Preziosi et al., 1997), the amount of blood transferred from the placenta before clamping the umbilical cord (Oski, 1989) and maternal iron status (Preziosi et al., 1997), may have confounded the findings. However, misclassification of an infant's iron status, recent changes in dietary intakes that would not be reflected by iron status, or the influence of other unknown determinants of iron balance and small numbers of infants would have resulted in weaker associations between the dietary variables and iron status. Thus, the strength of the relations found in our study between poor iron status and the dietary variables are probably a conservative estimate. It follows that the dietary predictors of risk for poor iron status reported here were probably robust.

Despite the limitations associated with the use of the recall of infant feeding history as a means of assessing risk for iron deficiency, this study found differences in several of the variables used to define feeding history between infants with normal and poor iron status at 8-12 mths of age. Associations were found between iron status and a history of breast-feeding >6 mths, not having been given an iron fortified infant formula or iron supplement, and the introduction of cows' milk prior to 9 mths of age, but not the ages of introduction or durations of feeding of iron-fortified infant cereals or MPF.

The findings here show that a history of either having been breast-fed >6 mths and having received no supplemental iron are key factors to consider in identifying infants at risk for IDA. The congruence of these findings with numerous other studies suggests that these dietary factors may be quite robust predictors of poor iron status. A history of breast-feeding >6 mths has been associated with an increased risk of IDA (Siimes et al., 1984; Innis et al., 1997; Calvo et al., 1992; Pizarro et al., 1991; Walter et al., 1993; Duncan et al., 1985; Lönnerdal et al., 1994; Saarinen, 1978; Haschke et al., 1993; Kim et al., 1996), while a history of feeding with iron-fortified infant formula has been associated with a decreased risk of IDA and low iron stores (Pizarro et al., 1991; Moffatt et al., 1994; Irigoyen et al., 1990; Miller et al., 1985) among infants of 8-12 mths of age. This study found that 26% of the infants 8-12 mths of age who had been exclusively breast-fed >6 mths had IDA compared with only 3% of those who had been exclusively breast-fed for ≤6 mths. In this study, however, breast-feeding >6 mths was not a significant predictor of poor iron status in a multivariate logistic regression model that controlled for infant age and other infant feeding practices. A history of not having been given either an iron-fortified infant formula or an iron supplement, on the other hand, was a significant predictor of IDA and low iron stores in the multivariate logistic regression model. This is not surprising because breast-feeding >6 mths was not related to low iron stores at any age, or to IDA at 13-26 mths of age in the univariate analysis, while a history of not having been given either an iron-fortified infant formula or an iron supplement was related to both IDA and low iron stores at 8-12 mths of age. Thus, a history of not having been given either an iron-fortified infant formula or an iron supplement is a stronger and more consistent variable than a history of breast-feeding >6 mths with regards to predicting poor iron status.

In contrast our finding that breast-feeding >6 mths was associated with IDA among infants of 8-12 mths of age, Greene-Finestone et al. (1991) reported that infants who were breast-fed for longer durations had a lower prevalence of IDA compared with infants breast-fed for shorter durations. The prevalence of IDA was 11% among infants breast-fed >6 mths, similar to the 15% reported for all infants breast-fed >6 mths in our study. In contrast to the low prevalence (3%) found in this study among infants breast-fed ≤6 mths, Greene-Finestone et al. (1991) found that 14% of infants breast-fed <6 mths and 19% of those never breast-fed had IDA. Differences between the findings of Greene-Finestone et al. (1991) and our study might be explained by the use of low iron formula, which was more common for infant feeding in the 1980's compared with current infant feeding practices. Although the types of infant formulas used by mothers in Ottawa-Carlton in 1984 are not reported by Greene-Finestone et al. (1989 & 1991), it wasn't until 1991 that the CPS Nutrition Committee recommended that iron-fortified formulas be given to

infants not breast-fed or to infants weaned from breast-feeding before 9 mths of age. Thus, it is likely that more infants who were not breast-fed in 1984 were fed low iron formulas than infants in more recent cross-sectional studies (present study, Innis et al., 1997; Pizarro et al., 1991; Kim et al., 1996).

No differences were found in the proportion of infants who had not been fed iron-fortified infant cereals or MPF by the recommended ages of 6 mths for cereals (CPS et al., 1998), and 9 mths for meats (B.C. Ministry of Health, 1995) between the group of infants with normal and poor iron status. Similarly, other studies (Pizarro et al., 1991; Calvo et al., 1992; Innis et al., 1997) have not been able to explain the high prevalence of IDA among infants exclusively breast-fed >6 mths by the failure to introduce iron-containing complementary foods by the recommended ages of introduction. The importance of solid foods in the diet of the exclusively breast-fed infant is supported, however, by evidence that infants who had been breast-fed to 7.5 or 9 mths of age and given solid foods had more favorable biochemical parameters of iron status, such as serum ferritin and total iron binding capacity (TIBC), although not Hgb, when compared with infants who had been breast-fed to 7.5 or 9 mths and not given solid foods (Siimes & Salmenperä, 1989). The reason that the importance of age appropriate introduction of iron-containing complementary foods was not shown by these former studies might be that other important variables, such as the quantities or durations of feeding of solid foods were not taken into account.

The findings of a study by Dewey et al. (1998) also provides important insight into the possible reasons for the lack of association in this study between the history of the age of introduction of complementary foods and iron status. Using a randomized intervention design, Dewey et al. (1998) found that infants who were exclusively breast-fed to 4 mths of age, but introduced to iron-fortified complementary foods starting at 4 mths had higher Hgb, Hct and ferritin values at 6 mths of age than infants exclusively breast-fed to 6 mths of age without the introduction of complementary foods. Although the infants exclusively breast-fed to 6 mths had an iron intake of only 0.2 mg/day, compared with 4.0 mg/day among those who had been fed solid foods starting at 4 mths, the difference in Hgb at 6 mths of age was only 4%. Further, 25% of the infants who had received solids starting at 4-6 mths had low Hgb values (<103 g/L) at 6 mths of age, and no differences were present in the iron status between the 2 groups of infants at 12 mths of age (Dewey et al., 1998). This suggests that differences in the age of introduction of complementary foods between 4 and 6 mths may have only small, short-term effects on the iron status of exclusively breast-fed infants that may be no longer apparent by 12 mths of age. A possible note of caution is warranted because the Honduran infants studied by Dewey et al. (1998) had lower birth weights than the infants in this study in Vancouver,

i.e. 20% of the Honduran infants had a birth weight <2500 g and 50% had a birth weight 2500-3000 g. It would be expected, however, that the lower birth weights and thus lower iron endowment at birth among the infants studied by Dewey et al. (1998) would place them at higher risk for poor iron status, possibly making differences in the age of introduction of solid foods more important to iron balance than would be expected in our study.

In contrast to our findings, Requejo et al. (1999) recently reported that preschool children in Madrid, Spain with IDA were introduced to meats later (9.3 ± 1.2 mths) than those who did not have anemia (7.4 ± 2.0 mths). Although there was also a trend for infants with iron deficiency without anemia to be introduced to meats later, the difference was not significant. It is possible that a similar association between age of introduction of complementary foods and iron status may not have been found in our study due to the small number of infants with IDA (7 at 8-12 and 2 at 13-26 mths of age).

Although statistically significant associations between iron status and the feeding of either iron-fortified infant cereals or meats for short durations (≤2 and ≤1 mth, respectively) were not found in our study, 71% of the infants aged 8-12 mths with IDA had been fed meats for ≤1 mth, compared with only 22% of those with low iron stores and 49% of those with normal iron status. Consistent with this trend, Czajka-Narins et al. (1978) found that 4-24 mth old infants with IDA had consumed commercial strained foods for shorter durations than infants with either iron depletion or normal iron status, although data on the duration of feeding of solid foods was not provided, and the median age of introduction was earlier than recommended for both groups (3.3 ± 0.4 mths and 2.2 ± 0.3 mths, respectively). In contrast to the findings here, an association between iron status and the duration of feeding with iron-fortified infant cereals has been found in other studies (Lehmann et al., 1992; Greene-Finestone et al., 1991). Lehmann et al. (1992) reported that infants aged 10-14 mths who had been fed iron-fortified cereal for <6 mths were more likely to develop IDA than infants fed iron-fortified infant cereal for ≥6 mths (Odds Ratio, 3.15; CI, 1.25-7.96). Similarly, Greene-Finestone et al. (1991) reported a 2-fold increase in IDA among infants aged 6-36 mths fed infant cereals for <3 mths, although there were too few infants to test this association statistically. It is not clear why a similar association between the duration of feeding iron-fortified cereal and iron status was not found in this study, but the reason may be due to the small number of infants either being fed cereal later than the recommended ages or for short durations and the small number of infants with IDA. Nonetheless, retrospective assessment of the age of introduction and duration of feeding MPF or infant cereals do not appear to be important for predicting poor iron status among Caucasian and Chinese infants.

This study found that a history of being fed cows' milk prior to 9 mths of age was strongly associated with poor iron status among infants aged 8-12 mths in the univariate and in the multivariate analyses that controlled for infant age and other dietary factors. The odds ratio of having poor iron status in infants who had been fed cows' milk prior to 9 mths of age was about 13-fold (CI 1.2-135.0) that of infants who had not been fed cows' milk prior to 9 mths of age. The wide confidence interval was a result of the small number of infants in our study who had been fed cows' milk prior to 9 mths of age; nonetheless, there was a very strong tendency for these infants to have poor iron status. The association between the early introduction of cows' milk and poor iron status is consistent with numerous other observational studies that have found evidence of an increased risk of poor iron status among infants fed cows' milk before 6-8 mths of age (Mills, 1990; Lehmann et al., 1992; Sadowitz & Oski, 1990; Tunnessen & Oski, 1987; Morton, 1988). Other confounding factors that might have accounted for the differences in iron status, such as birth weight and the ages of introduction or quantities of complementary food fed were not taken into consideration by these observational designs. Nonetheless, the findings are remarkably similar to evidence from controlled trials (Foman et al., 1981; Fuchs et al., 1993a). Further, the finding that the early introduction of cows' milk is an important predictor of poor iron status is highly plausible. Unmodified cows' milk contains about 0.5 mg iron/L, similar to low iron formula, but it is high in protein, calcium and phosphorus, known inhibitors of iron absorption, and is low in vitamin C, a known enhancer of iron absorption. Moreover, feeding unmodified cows' milk has also been shown to cause occult GI blood loss (Woodruff et al., 1972; Foman et al., 1981; Lönnerdal, 1990; Zeigler et al., 1990), thus increasing the daily iron requirement. Studies suggest that occult GI blood loss, possibly due to a sensitivity to the cows' milk protein, accounts for the iron deficiency found in infants younger than about $4^{1/2}$ mths who have been fed cows' milk (Foman et al., 1981; Zeigler et al., 1990). In older infants other factors associated with early introduction of cows' milk, i.e. low intake of iron and enhancers of iron absorption and the inhibiting effect of cows' milk on the absorption of both heme and non-heme iron from complementary foods (Hallberg et al., 1992a&b, Hallberg et al., 1991; Fuchs et al., 1993a) appear to be important to the etiology of poor iron status. Four independent national studies in the U.S. (Ernst et al., 1990; Martinez et al., 1985; Martinez & Ryan, 1985; Raper et al., 1984), and other cross-sectional studies (Penrod et al., 1990) have found that infants fed whole cows' milk in the 2nd half of the first year of life have median iron intakes below the Recommended Daily Allowance (RDA). However, Fuch et al. (1993b) demonstrated that infants fed cows' milk had iron intakes of at least 2/3 of the RDA, a level considered to be associated with a low risk of deficiency. Thus, despite an apparent adequate consumption of iron

(including at least 9 Tbsp of iron-fortified infant cereal/day) and vitamin C, infants fed cows' milk in the study by Fuch et al. (1993b) had a higher incidence of low iron stores by 12 mths of age than infants fed formula (29% vs. 0-4%). These studies suggest that infants fed cows' milk are dependant on iron-fortified infant cereal as their primary source of iron, but that these infants are at risk of iron deficiency, despite an adequate intake of iron because the inhibitors of iron absorption in cows' milk (i.e. calcium and phosphorus) may lower the absorption of cereal iron. Recent evidence, however, suggests that high calcium intakes do not have a negative impact on the RBC iron incorporation in children of 3-5 years of age (Ames et al., 1999). Although similar data are not available for infants, the study by Ames et al. (1999) suggests that iron balance may not be compromised due to a high intake of cows' milk if the intake of meat is adequate. Breast-fed infants, however, may be more sensitive to the introduction of cows' milk than formula-fed infants, even when given whole cows' milk after 6 mths of age. Importantly, Zeigler et al. (1990) demonstrated that in breast-fed infants, occult blood loss might contribute to an increased risk of IDA even when the cows' milk is introduced as late as about $5^{1/2}$ and 8 mths of age.

This study also demonstrated significant associations between iron status and the intakes of both calcium and foods containing calcium, a key inhibitor of both heme and non-heme iron absorption. Consistent with the finding that more infants of 8-12 mths of age with poor iron status had been introduced to cows' milk early than infants with normal iron status, the median intake of cows' milk and milk products was also higher for the group of infants of 8-12 mths of age with poor iron status (70 g/day) than for the group with normal iron status (22 g/day). The intake of cows' milk and milk products remained a significant predictor of poor iron status in the multivariate analysis, even after controlling for age and the other dietary factors. Infants fed ≥800 g/day cows' milk and milk products were 7.6 (CI 2.1-27.5) times more likely than infants fed <800 g/day to have poor iron status. The small number of infants being fed ≥800 g/day cows' milk and milk products resulted in a confidence interval that was wide. Nonetheless, there was a strong tendency for infants with excessive intakes of cows' milk and milk products to have either IDA or low iron stores. It is also reassuring that consistent with this, when infants with serum ferritin >10-<16 μg/L were excluded from the analysis, the difference in calcium intakes from non-milk foods between infants with normal and poor iron status approached significance (P=0.08).

Consistent with our findings, other studies have also shown a negative association between the quantity of cows' milk consumed and low iron stores (Sadowitz & Oski, 1983; Mills, 1990; Salas et al., 1990; Michaelson et al., 1995; Kwiatkowski et al., 1999; Bramhagen & Axelsson, 1999). Although Michaelson et al. (1995) found a negative

association between the intake of cows' milk and serum ferritin with multivariate analysis of data collected for infants of 6-9 mths of age, this was not significant for infants of 10-12 mths of age. The lack of an association between the intake of cows' milk and serum ferritin among the older infants studied by Michaelson et al. (1995) may be due to the possibility that the repeated monthly 24-hour food records and the presence of infection had the potential to have a greater influence on iron status with increasing age. The infants studied by Michaelson et al. (1995) had a relatively high iron status with the 5-95th percentile of serum ferritin values of 17-78 μg/L and only 5% with Hgb <105 g/L. Thus, there may have been too few infants with poor iron status to show a relation between the intake of cows' milk and iron deficiency.

The congruency of the relations found in our study between poor iron status and several variables that were used to address the consumption of cows' milk (i.e. the introduction of cows' milk prior to 9 mths of age, the intake of calcium, even from non-milk foods, and the consumption of ≥800 g/day of cows' milk and milk products) suggests that questions regarding the intake of cows' milk may be a robust predictor of poor iron status in infancy. This study provides further evidence to show that the assessment of both the age of introduction and the quantity of cows' milk fed are important for identifying infants at risk for iron deficiency. The finding of an increased risk of poor iron status among infants fed cows' milk earlier than the recommended age of 9 mths or in large quantities is highly plausible, and although clearly multifactorial, the etiology appears to depend on the infants age, the type of primary milk feeding at the time the cows' milk is introduced, and the infant's intake of meat.

Consistent relations were also found in our study between iron status and both the 3d-FR assessment of the intake of total iron from all sources and the 2-week FFQ assessment of the intake of the major dietary sources of iron. Both the quantity of human milk and iron-fortified infant formula consumed during the 2-week FFQ were associated with poor iron status at 8-12 mths of age. Eighty one percent of the infants with poor iron status had been breast-fed during the 2 weeks over which the food intake was recorded in the FFQ. The estimated median intake of human milk for infants with poor iron status was about 303 g/day. Although 44% of the infants with normal iron status had also been breast-fed during this time, the median intake of the group was 0 g/day. In contrast, only one infant aged 8-12 mths with poor iron status had consumed iron-fortified infant formula, with an average intake of only 26 g/day. However, 75% of the infants with normal iron status had consumed iron-fortified infant formula with a median intake of 464 g/day. The consistency of the associations between the FFQ assessment of the intakes of human milk and iron-fortified infant formula with the feeding history assessment that breast-feeding >6 mths and not receiving

some form of supplemental iron were associated with poor iron status at 8-12 mths of age provides reassurance that these are important predictors of risk for infants 8-12 mths of age. In the multivariate analysis, however, neither the quantities of breast milk nor iron-fortified infant formula were significant predictors of poor iron status. This is not surprising because, as discussed previously, while the quantities of the primary milk feedings may be important predictors of risk for infants at 8-12 mths of age, these would not be expected to be a major determinant of iron status for older infants.

A significant difference was also found here in the intake of MPF, the main source of heme iron, between infants with normal and poor iron status at both 8-12 and 13-26 mths of age. Although there were no differences in the proportion of infants who had consumed MPF when grouped by iron status, the median intakes of infants with poor iron status (0 and 20 g/day at ages 8-12 and 13-26 mths, respectively) were lower than the intakes of infants with normal iron status (8 and 34 g/day at ages 8-12 and 13-26 mths, respectively). Further, infants aged 13-26 mths with poor iron status had significantly lower intakes of heme iron than infants with normal iron status when the analysis excluded infants with serum ferritin >10-<16 μg/L. The quantity of MPF in the infant's diet remained a significant predictor of risk of poor iron status in the multivariate analysis, even after controlling for age and other dietary variables. The odds ratio of having poor iron status among infants fed <30 g MPF/day was 3.8 (CI 1.3-10.5) times that of infants fed ≥30 g MPF/day. No differences, however, were found in the intakes of mixed dishes with MPF between infants grouped by iron status at either ages 8-12 or 13-26 mths. The lack of association between the intake of mixed dishes with MPF and iron status might be explained by the heterogeneous nature of this food group, (i.e. mixed dishes with MPF consists of a range of dishes with variable amounts of heme and non-heme iron, as well as enhancers and inhibitors of iron absorption), and the use of an average 30% MPF content in these dishes in analysis of data from the FFQ.

Similar to our findings, negative relations between the risk of poor iron status and the quantities of both MPF and heme iron consumed in the weaning period have been found in numerous other observational studies (Hercberg et al., 1987; Michaelson et al., 1995; Mira et al., 1996; Salas et al., 1990; Kwaitkowski et al., 1999). Importantly, and consistent with these findings, an intervention trial by Engelmann et al. (1997) recently demonstrated that a meat intake of 27 g/day resulted in the maintenance of Hgb concentration, while an intake of only 10 g/day resulted in a decrease in Hgb concentration in 8 mth old partially breast-fed infants. The protective effect of meat consumption in the weaning period to iron balance could reasonably result from the high bioavailability of the heme iron itself or from the increased

bioavailability of the non-heme iron in meals that contain meat. Foman et al. (1989) demonstrated that the addition of beef to a wet-pack strained vegetable and beef product that was fortified with ferrous sulfate (4.0 mg iron/100 g) did not improve the bioavailability of the non-heme iron in the product. Engelmann et al. (1998), however, demonstrated that 25% of solids by weight as meat added to a vegetable puree increased the non-heme iron absorption from 10 to 15%. This suggests that a greater quantity of meat is required to have an effect on the bioavailability of the non-heme iron than that in the product studied by Foman et al. (1989), which provided only about 5% of solids from meat. Our results provide support for these latter studies that there is a threshold level at which the consumption of meat does not appear to protect the infant from developing IDA.

While this study found that the intake of 'other cereals' (i.e. iron-fortified cereals other than infant cereals) was negatively associated with poor iron status for infants aged 13-26 mths, no difference was found in the intake of iron-fortified infant cereals between infants grouped by iron status at either ages 8-12 or 13-26 mths. In contrast, Walter et al. (1993) demonstrated that the intake of iron-fortified infant cereal was significantly related to iron status in a controlled trial. Infants were fed iron-fortified cereal from 4 to 15 mths of age and by 8 mths of age had achieved mean intakes of 25 g/day among those breast-fed, and 30 g/day among those formula-fed (Walter et al., 1993). The lack of an association between the intake of iron-fortified infant cereal and iron status in our study might be explained by the wide variation in the age of starting, duration of feeding, and the quantity of cereals fed within the groups of infants with normal and poor iron status.

The 2-week FFQ assessment of the intake of soy-based products was also negatively associated with poor iron status in the infants 13-26 mths of age. The infants with normal iron status had a higher intake of soy products (2 g/day) than those with iron deficiency (0 g/day), but the difference was not significant once infant age and other infant feeding practices were controlled for. The finding that infants with poor versus normal iron status had a lower intake of soy products is in contrast to the inverse relation that was expected. The absorption of iron from soy products can be extremely low (Derman, 1987; Macfarlane et al., 1990), and soy inhibits the absorption of non-heme iron (Cook et al., 1981; Hallberg & Rossander, 1982). However, the median intakes of soy products was very low among both Caucasian and Chinese infants, only 0 and 2 g/day for infants with poor and normal iron status, respectively. At intakes this low, it is unlikely that soy products would have any effect on non-heme iron absorption. Further, Macfarlane et al. (1990) have provided evidence that the bioavailability of iron from a variety of traditional oriental soy products is quite variable and that modification of soy by certain food-processing technologies, such as

fermentation can dramatically improve iron bioavailability. The soy products consumed by the infants in this study were mainly unfermented products, such as tofu. Macfarlane et al. (1990) also found that the iron absorption from different types of tofu vary considerably, with silken tofu having a higher absorption than regular tofu. Unfortunately, details of the specific types of tofu consumed by infants were not collected in our study.

This study found no association between iron status and the 3d-FR assessment of vitamin C intake, a key enhancer of iron absorption. The only other study to examine the relation between the intake of vitamin C from non-milk foods in infancy and iron status also found no association between serum ferritin and the intake of ascorbic acid (Salas et al., 1990). This is consistent with recent data by Reddy et al. (2000) that showed that the positive influence of ascorbic acid on iron absorption was less pronounced than the negative influence of animal tissue, phytic acid and calcium, when tested alone in the context of a complex meal. Our findings suggest that assessment of the intake of inhibitors of iron absorption or foods representing inhibitors of iron absorption may be more useful than the assessment of the intake of enhancers of iron absorption for identifying infants at risk of poor iron status.

The consistency of the dietary predictors of poor iron status that emerged in our study with the published literature, and the congruency of the relations between diet and iron status by the 3 different types of dietary assessment instruments used here suggests that these dietary patterns may be robust predictors of poor iron status in Caucasian and Chinese infants. The association between these dietary patterns and poor iron status is not surprising, although they do indicate the independent effects of both early introduction and excessive intakes of cows' milk on the occurrence of IDA and low iron stores, and the disadvantage of not being given supplemental iron or adequate quantities of MPF on iron status. This study provides the first data on the independent positive dietary predictors of poor iron status among Caucasian and Chinese infants of 8-26 mths of age, and importantly, this information can be used in primary prevention initiatives as will be discussed in **Section 5.3**, and to develop a screening tool to identify infants at risk for IDA, as will be discussed in **Section 5.2.3**.

5.2.2 Use of sTfR to Assess Iron Status in Infancy.

Previous studies with adults (Skikne et al., 1990; Heubers et al., 1990; Kohgo et al., 1987; Ferguson et al., 1992), pregnant women (Carriaga et al., 1991) and children (Punnonen et al., 1994) have shown that levels of sTfR and sTfR:ferritin ratios are highly sensitive to IDA. Consistent with this, the results of our study show that infants with IDA had higher sTfR concentrations and sTfR:ferritin ratios than infants with low iron stores or normal iron

status. All the infants with IDA had sTfR concentrations ≥24 nmol/L, with the exception of one infant who had a sTfR of 21.7 nmol/L, and all had a sTfR:ferritin ≥2. Thirty-seven of the 136 infants without IDA also had sTfR values ≥24 nmol/L. The specificity of a sTfR ≥24 nmol/L for IDA was 73%, but the positive predictive value (PPV) was only 18%. Of the 37 infants with sTfR values ≥24 nmol/L without IDA, 16 infants had low iron stores. The reason for the elevated sTfR in 21 infants without IDA is not known. It is possible that these infants also had low iron stores, but that their serum ferritin values were falsely elevated due to previous or concurrent infections. Among the 21 infants without IDA and low iron stores, the Hgb concentrations ranged from 100 g/L to 135 g/L, 4 infants had a Hgb ≤110 g/L, 8 with 111-120 g/L, and 9 had Hgb 121-135 g/L. It is unlikely that the elevated sTfR in these infants was due to other causes of anemia that increased erythropoiesis, such as megaloblastic anemia, thalassemias, sickle cell anemia, or autoimmune hemolytic anemia, as anemias of increased erythropoiesis should be rare in this group of 145 infants. One infant from Chinese ancestry, however, did have beta-thalassemia trait with coexisting IDA.

Although sTfR is a sensitive marker of IDA in infancy, and may offer a number of advantages over measures currently used to assess iron status, if used alone, however, the low specificity would result in a substantial number of infants with false positive tests. For both screening and diagnostic purposes, sTfR is currently more difficult to analyse and a more costly test than Hgb, and its relatively low sensitivity and particularly low specificity to IDA limits its use for screening and diagnostic purposes. Unlike serum ferritin, however, sTfR can distinguish individuals with IDE from those with only depleted iron stores, and individuals with low iron stores, with an elevated ferritin due to infection. sTfR also offers an advantage over Hgb for screening infants at risk for IDA because it can detect individuals with early IDE, prior to the onset of anemia (Baynes et al., 1994; Skikne et al., 1990), making it a potentially valuable test for detecting infants at risk for IDA. Thus, despite its limitations, sTfR offers a number of advantages for the assessment of iron status for screening, diagnostic and research purposes if used in conjunction with currently used biochemical and hematological measures of iron status, i.e. Hgb and serum ferritin. For diagnostic purposes, sTfR can be used in place of ferritin, along with Hgb to confirm a diagnosis of anemia due to iron deficiency, and for research purposes, used along with ferritin and Hgb, offers the ability to classify infants along the continuum of iron balance from normal iron status to IDA. The utility of sTfR for diagnostic and screening purposes, however, is dependent on the availability of less costly assays, and the establishment of reference standards, and would have to be reassessed based on these.

The sTfR:ferritin ratios, but not sTfR concentrations were significantly higher among the infants with low iron stores than among the infants with normal iron status. When compared with a ferritin ≤12 μg/L as a measure of low iron stores, a sTfR cut-off of ≥24 nmol/L had a sensitivity and specificity of 51% and 79%, respectively. Lowering the sTfR cut-off to ≥20 nmol/L increased the sensitivity to 70%, but decreased the specificity to 56%. The main reason for the disagreement between the serum ferritin and sTfR values is explained by the results for 14 of the 144 infants who had a ferritin ≤12 μg/L and a sTfR <24 nmol/L (**Figure 4.32**). Serum ferritin reflects iron stores and sTfR reflects the degree of erythropoiesis (Baynes, 1996; Skikne et al., 1990). Thus, these infants may have had low iron stores, but not to the extent that erythropoiesis was impaired. However, 5 of the 14 infants with ferritin ≤12 μg/L and a sTfR <24 nmol/L had an extremely low ferritin (i.e. ≤5 μg/L). It would be expected that the sTfR level would be elevated in these infants. The data from this study do not provide information on the relation between sTfR:ferritin and iron depletion because no external measure of iron stores other than serum ferritin was obtained. The gold standard for evaluation of the clinical utility of sTfR concentration for the diagnosis of low iron stores would be the amount of stainable iron in a bone marrow aspiration; however, this clearly could not be done for ethical reasons.

Our finding that a substantial number of infants with elevated sTfRs had normal ferritin values supports previous evidence that the sensitivity of ferritin for identification of iron deficiency is poor when used alone (Hulthén et al, 1998). Measurement of C-reactive protein would have been useful to differentiate infants with iron deficiency and coexisting infection from infants with infection, but with normal iron stores.

One of the limitations of the use of sTfR for screening, diagnostic and research purposes is the lack of a normal reference range for infants aged 8-26 mths. Differences in sTfR values were found between the male and female, and the Chinese and Caucasian infants in our study. Consistent with our findings, the only other published data on the distribution of sTfR concentrations across different ages in infancy found no age-related change for infants 9-15 mths of age (Yeung & Zlotkin, 1997). Males with normal iron status in this study, however, had a higher sTfR value than females. A higher sTfR concentration in males than females was also found for 4-6 mth old infants, although not for 7-12 or 13-24 mth old infants by Choi et al. (1999). In contrast to our findings, Yeung & Zlotkin (1997) and Virtanen et al. (1999) also found no difference in sTfR concentrations between male and female infants. Male infants have higher rates of weight gain compared with female infants (Hamill et al., 1979), and male infants are at a higher risk of IDA and low iron stores than female infants (Innis et al., 1997; Emond et al., 1996; Wharf et

al., 1997). Further, ferritin concentrations have been shown to be inversely related to weight gain in infancy when birth weight is controlled for (Michaelsen et al., 1995; Emond et al., 1996; Dewey et al., 1998; Lawson et al., 1998). This provides a reasonable explanation for the higher sTfR levels found in the male than in the female infants. Further work is needed to clarify why gender related differences were found in this study, but not in the studies of Yeung & Zlotkin (1997) and Virtanen et al. (1999) or in the study by Choi et al. (1999) for infants >6 mths of age.

The finding that the Caucasian infants with normal iron status had higher sTfR (21.5 ± 7.6 nmol/L) and sTfR:ferritin ratios (1.0 ± 0.5) than the Chinese infants (17.2 ± 4.9 nmol/L and 0.8 ± 0.4, respectively) suggests that race-specific reference standards should be considerd for sTfR. Race-related differences in Hgb concentrations, with a higher Hgb in black than white infants with normal iron status as young as one year of age were reported in the NHANES I study (Garn et al., 1981). Similarly, in the group of infants with normal iron status in this study, Chinese infants were found to have a significantly ($P<0.001$) higher Hgb (124.8 ± 5.9 g/L) than Caucasian infants (119.9 ± 7.1 g/L). Differences in Hgb concentration have not been reported for Caucasian and Chinese infants with normal iron status in other studies. Data on the distribution of sTfR concentrations and sTfR:ferritin ratios among infants of different races have also not been published. Whether or not the difference in sTfR concentrations between infants from Caucasian and Chinese ancestries in this study involved genetic background alone, or, in addition to, differences in feeding practices, iron supplementation, or growth rates is not known. Lönnerdal et al. (1994) found that exclusively breast-fed infants had higher TfR levels than exclusively formula-fed infants. Further, infants fed formula with 7 mg/L iron had the lowest level of TfR compared with infants fed formula with lower concentrations of iron and human milk (Lönnerdal et al., 1994). The FFQ data in our study indicate that the Chinese infants were fed iron-fortified infant formula more frequently and in larger quantities than the Caucasian infants, providing a reasonable explanation for the differences in sTfR concentrations between the groups of Caucasian and Chinese infants with normal iron status.

Given the high rate of growth and erythropoietic activity in infants, it would be expected that the reference range for TfR and sTfR for infants would be higher than that for adults. The mean sTfR concentration of the infants with normal iron status in this study was 19.8 ± 7.4 nmol/L, and is remarkably similar to published mean ± SD sTfR of 19.6 ± 5.0 reported by Allen et al (1998) for healthy adults using the same analytic method as that used here. Yeung & Zlotkin (1997), Lönnerdal (1994) and Persson et al. (1998), however, have reported higher TfR concentrations for infants than those reported by Cooper & Zlotkin (1996) for adults. The work of Virtanen et al.

(1999) also found higher TfR levels in healthy infants than adults. At least 2 possible explanations are available for the discrepancy. Virtanen et al. (1999) suggested that the difference in TfR at different ages is the result of normal age-specific physiologic variation in iron stores and serum iron concentration, rather than the rate of erythropoiesis. In our study, infants with a serum ferritin ≤12 μg/L were not included in the analysis of the "normal" distribution of sTfR, thus excluding infants with low iron stores. The 36 infants in the study by Virtanen et al. (1999) had ferritin values that ranged from 9 to 62 μg/L, thus including some infants with low iron stores. Similarly, 52% of the infants studied by Yeung & Zlotkin (1996) had ferritin values <10 μg/L and 26% of those studied by Persson et al. (1998) had values <10 μg/L. Thus, the differences in levels of TfR between the infants and adults studied by Yeung & Zlotkin (1997) and Virtanen et al. (1999) might be the result of the inclusion of data for infants with low ferritin concentrations. As done in this study, Allen et al. (1998) excluded women with Hgb <120 g/L or ferritin values <10 μg/L and men with Hgb <140 g/L or ferritin values <20 μg/L from their calculations of a normal reference sTfR of 19.6 ± 5.0 nmol/L.

Another potentially important difference between the studies by Yeung & Zlotkin (1997), Virtanen et al. (1999) and Lönnerdal (1994) and our study is the method used to measure TfR concentrations. Until very recently, all of the available published data on TfR in infants have been based on manually performed enzyme immunoassays that use cellular TfR from placental tissue as a calibrator. Considerable variation is present in the mean TfR values reported for adults using TfR assays calibrated against the disulfide-linked dimer TfR from placenta, which may be explained by differences in the specificity and reactivity of the antibodies against the transferrin-sTfR complex compared to the placenta TfR. Whether or not the disulfide-linked dimer derived from placental tissue behaves in the same way as the 2 sTfR monomers in serum is not known (Allen et al., 1998). This study provides the first data for infants using one of the more recently developed commercially available diagnostic sTfR assays that are calibrated against plasma sTfR (not the cellular TfR isolated from human placental tissue), which is thought to improve accuracy of the assay results (Allen et al., 1998; Cook, 1999). Clearly further studies are needed to examine the clinical utility of sTfR in infancy and young children, to establish reference standards for sTfR for healthy infants. Moreover, there is a need for standardization of methodology for evaluation of sTfR.

5.2.3 Use of a Brief Dietary Assessment Tool versus Biochemical/Hematological Indices of Iron Status as a First Stage Screening Test to Identify Infants at Risk for Iron Deficiency Anemia.

The 12% prevalence of IDA at 8-12 mths of age and 29% prevalence of low iron stores at 8-26 mths of age found in this study suggest that current strategies for the primary prevention of IDA may not be reaching, and/or may not be effective in preventing the risk of IDA for particular subgroups of infants. Given the negative impact that IDA can have on infant growth, immunity, development and educational performance later in life, and the extent of the problem in Vancouver, these findings suggest that community-based screening according to the criteria described by Cadman et al. (1984) to identify "at-risk" infants prior to the development of IDA is a strategy that is also warranted. This study provides evidence that IDA and low iron stores are prevalent problems among Caucasian infants in Vancouver, and that a dietary screening tool meets some of the criteria for a community-based screening test (Cadman et al., 1984; Sackett, 1978 & 1994).

Two possible approaches to identify infants at risk for IDA are screening with available biochemical or hematological indices of iron status, and screening with dietary assessment. Our findings suggest that dietary assessment using a brief screening tool would be an appropriate and potentially effective first stage screening tool to identify infants with poor iron status, and may offer a number of advantages over first stage screening for IDA using blood testing.

Of importance, risk for IDA can be identified by factors such as ancestry and age. As a result, a dietary assessment tool offers the potential to be a more cost-effective first stage screening test for the early detection of IDA than using biochemical or hematological indices of iron status. Mass screening or screening of infants suspected to be at risk of IDA (i.e. case finding) using inexpensive biochemical or hematological screening tests, such as Hgb or Hct, followed with a more expensive but more definitive blood test for iron status to confirm the results has the disadvantage of not identifying infants until they become overtly anemic. For example, a first stage screening using a Hgb or Hct would have missed the 29% of infants found to have low iron stores in this study. In this respect, the sTfR might offer advantages over hematological and biochemical indices currently used to screen infants for IDA. sTfR offers the advantage of identifying infants with IDE prior to the onset of anemia, and is not influenced by infection. sTfR was highly sensitive to IDA and only 17 of the 94 infants with normal iron status had an elevated sTfR. Although these results suggest that sTfR may be of value as a first stage screening test, analysis of sTfR is currently expensive and not readily available. Further, normal reference ranges based on commercially

available assays have not been published. Of importance, since blood tests are invasive and unacceptable to parents of infants who otherwise appear healthy (Mills, 1990, James et al., 1997), sTfR is not an ideal first stage screening test for iron deficiency in infants. From a community-based screening point of view, a brief dietary screening tool is a simpler, less invasive and thus potentially more acceptable first stage screening test than blood testing, with the potential to be applied on a large scale (Sackett, 1994; Beaglehole et al., 1993).

The exploratory, posthoc Classification and Regression Tree (CART) analyses in this study suggest that a brief screening questionnaire based on 4 dietary risk patterns found here to be robustly associated with poor iron status may have potential as a valid screening test for identification of infants with poor iron status. The 4 dietary patterns that were significant predictors of IDA and low iron stores in the multivariate analysis were: 1) a history of no iron-fortified infant formula or iron supplements, 2) a history of cows' milk introduction prior to 9 mths of age, 3) an average intake of ≥800 g/day cows' milk and milk products within the previous 2 weeks, and 4) an average intake of <30 g/day of MPF within the previous 2 weeks. When combined in exploratory, posthoc analyses as a screening test, these 4 dietary patterns had a sensitivity of 87% and a specificity of 49%. The negative predictive value for poor iron status was 88% for the population studied, meaning that dietary screening failed to identify 6 of the 45 infants who had either IDA or low iron stores. Thus, the brief dietary screening tool presented here can be used to identify infants at risk for IDA according to the criteria for a community-based screening test (Sackett, 1994; Cadman et al., 1984). The limitations imposed by the posthoc analyses used to test the potential value of our proposed dietary screening tool, however, must be considered. Testing the utility of the tool with the same set of infants as that used to develop the tool is solely for exploratory purposes. The dietary screening tools that we are proposing clearly need to be field-tested with a different and larger group of infants before firm conclusions can be drawn about their predictability.

Only 2 previous studies (Boutry & Needlman, 1996; Bogen et al., 2000) have examined the utility of dietary screening tools for use with populations considered to be "high-risk" for IDA, and both have focused on low-income, black infants living in inner cities in the U.S. The 87% sensitivity of the 4 dietary screening questions tested here for predicting poor iron status was comparable with the sensitivity of 95% reported by Boutry & Needlman (1996), and 73% reported by Bogen et al. (2000). The specificity of 49% for our tool, however, was higher than the 15% and 29%, respectively found for the tools tested in these latter studies. The dietary screening questionnaires were used by Boutry & Needlman (1996) and Bogen et al. (2000) for identifying infants with overt microcytic anemia and IDA, respectively, and not for identifying risk of either low iron stores or IDA as done in our study. In contrast to the

retrospective assessment of feeding practices used by Boutry & Needlman (1996), the screening tools examined in our study and the study by Bogen et al. (2000) included questions concerning both the infant's feeding history and current dietary intake. Our findings show that assessment of current or recent intake, i.e. using the FFQ and 3d-FR, is important in predicting iron status in infants >12 mths of age, while retrospective assessment was of limited value with these infants. This suggests that screening questions concerning the current or recent diet might be more predictive of the risk of poor iron status than retrospective assessment of feeding history for infants >1 year of age.

Our findings suggest that dietary patterns can be used to identify infants at risk for IDA. This supports the recommendation by expert groups in Canada (Canadian Task Force for Periodic Health Examination, 1994) and the U.S. (Earl & Woteki, 1993; U.S. Department of Health and Human Services, 1998) that physicians should assess the diets of infants classified as "high-risk" for IDA at about 6-12 mths of age to determine the need to screen for IDA with a blood test. Infants defined as "high risk" by the Canadian Task Force for Periodic Health Examination (1994) include infants of low SES, Chinese or aboriginal ethnic origin, low birth weight (<2500 g), and infants fed only cows' milk during the first year of life, and are defined based on their higher prevalence of IDA and a greater likelihood of inability to consume iron-fortified products. Similarly, CPS et al. (1998) recommends that a blood test be done for infants of 6 to 8 mths of age on the basis of whether or not they are being fed consistent with current infant feeding recommendations aimed at the prevention of IDA. Despite these recommendations, the approach of dietary assessment as a first stage screening test to identify infants at risk for IDA is not documented to be the usual practice in Canada or the U.S. (Canadian Task Force for Periodic Health Examination, 1994; Boutry & Needlman, 1996; Bogen et al., 2000). Importantly, our findings suggest that Caucasian infants in Vancouver, particularly those who are breast-fed >6 mths, should also be classified as a high risk group, and be included in the recommendation for dietary screening for IDA. The finding that these questions relating to 4 dietary patterns have potential value as a brief first stage screening tool is important, because a tool that is quick, easy to administer, acceptable and predictive of an infant's risk for iron deficiency might be valuable for use by public health nurses, family doctors and pediatricians to identify infants 8-26 mths of age at risk for IDA. A brief dietary screening tool also offers the potential to be a cost-effective approach to identifying infants at risk for IDA, as the time for a health care practitioner to ask 2-4 questions about infant feeding implies relatively little cost to the health care system. Based on the results of a positive dietary screening test, more definitive diagnosis with biochemical and hematological parameters of iron status can be ordered and with a positive

test follow-up with iron supplementation can be initiated, while a negative test provides the opportunity for preventive infant feeding guidance.

5.3 Strategies for Primary Prevention of Iron Deficiency Anemia in Infancy: Are Current Guidelines for Infant Feeding Effective in Preventing Iron Deficiency Anemia in Chinese and Caucasian Infants?

This is the first study to provide cross-sectional data on the prevalence of IDA in infants aged 12 to 26 mths from Caucasian and Chinese ancestries in Vancouver. The high prevalence of IDA and low iron stores among Caucasian infants is particularly concerning considering evidence from national (Health and Welfare Canada, 1993; Health and Welfare Canada, 1991) and regional surveys (Tanaka et al., 1987, Williams et al., 1996, Kwavnick et al., 1999) that feeding practices among infants in Canada have increasingly become consistent with guidelines for infant feeding specifically aimed at prevention of IDA (CPS Nutrition Committee, 1991; CPS et al., 1998). This suggests that the infant feeding guidelines and/or approaches used to educate parents and health professionals may not be adequate for preventing IDA among particular groups of infants. Importantly, our findings can be used to target public health resources for the prevention of IDA to infants at the greatest risk, defined by age and ethnicity and feeding practices, and to design strategies for prevention that will be more effective than current strategies in preventing iron deficiency. Specifically, efforts to prevent IDA by the Vancouver Health Department should target Caucasian infants of 8-12 mths of age, particularly those breast-fed >6 mths, and infant feeding recommendations should place more emphasis on increasing the intake of meats or alternative sources of highly bioavailable iron during infancy.

The findings of this study emphasize the importance of current national and provincial recommendations that whole cows' milk should not be introduced until 9-12 mths of age, iron-fortified formula or supplemental iron should be provided to infants not breast-fed (CPS et al., 1998; B.C. Ministry of Health, 1995), and provincial guidelines that meats should be introduced by 6-9 mths of age (B.C. Ministry of Health, 1995). Recent data by Ames et al. (1999) and Yeung & Zlotkin (2000) suggest that the guidelines concerning the introduction of meats may be particularly important to infants being fed cows' milk.

Despite the increased risk of IDA in infants breast-fed for longer than 6 mths in both this and other studies (Innis et al., 1997; Calvo et al., 1992; Pizarro et al., 1991; Kim et al., 1996), exclusive breast-feeding offers many

advantages for infants, including a decreased risk of acute respiratory infections, diarrhea, otitis media, atopic skin disorders (Lopez-Alarcon et al., 1997; Dewey et al., 1995; Cohen et al., 1995), childhood asthma (Oddy et al., 1999) and obesity (Von Kries et al., 1999), and lower hospital admissions (Cunningham et al., 1991). In addition, in developed countries, breast-feeding protects against infant mortality (Victora et al., 1987). Numerous components of breast milk, such as growth factors and hormones, and benefits offered by the act of breast-feeding itself, cannot be matched by bottle-feeding with infant formula (deAndraca et al., 1998). Most authorities agree that the benefits of breast-feeding appear to increase with increasing duration (Wilson et al., 1998) and that exclusive breast-feeding for at least 4 mths contributes to the prevention of IDA as long as this is accompanied by later, age appropriate introduction of iron-containing complementary foods (CPS et al., 1998; CPS Nutrition Committee, 1991, AAP Committee on Nutrition, 1992). Current Canadian nutrition recommendations specifically aimed at the prevention of iron deficiency in infancy recommend that complementary foods containing iron, such as iron-fortified infant cereals be introduced at 4 to 6 mths of age and that iron-fortified foods continue to be offered beyond one year of age (CPS et al., 1998). It is generally agreed that complementary foods should not be introduced later than 6 mths of age because this places the infant at risk for IDA, and other nutrition related problems (Schmitz & McNeish, 1987; Satter, 1990). The iron stores of healthy term infants become depleted at 4-6 mths of age and the iron content of breast milk alone is inadequate to meet the needs for iron for growth and replacement of iron losses beyond this age. Thus, it seems reasonable that differences in the age of introduction of solid foods, in the durations of feeding, and in the quantities fed may explain why some infants who are breast-fed for longer durations develop IDA, while others do not. Our study has provided information on the history of the age of introduction, duration of feeding, and the sources and intakes of complementary foods fed to infants in relation to their iron status. Although 19 of the infants in this study (13%) had been introduced to an iron-fortified infant cereal later than 6 mths of age, and 44 (30%) had been introduced to meats later than 9 mths of age, neither of these factors explained the poor iron status. The absence of differences in the age of introduction or duration of feeding of solid foods between infants with normal and poor iron status, but presence of differences in the FFQ intakes of certain foods suggests that the quantity of complementary foods is an important predictor of risk for poor iron status. Thus, the findings of this research suggest that in addition to recommending the ages at which iron-containing complementary foods should be introduced, more emphasis should be put on guidelines to ensure adequate quantities of appropriate foods are fed. In particular, the results of our study suggest that the intakes of heme iron among the Caucasian infants who are fed

primarily with breast milk or other low iron milks may be inadequate. Other data are also available (Mira et al., 1996; Engelmann et al., 1998) to suggest that dietary sources of highly bioavailable heme iron may play an important role in improving iron nutrition in infancy. This study presents the first data to show that an inadequate intake of MPF (i.e. <10 g/day) is a particular problem among Caucasian infants placing them at risk for poor iron status. Of the 34 Caucasian infants 8-12 mths of age with FFQ reports, 28 (84%) had intakes of MPF <10 g/day, whereas only 37% of Chinese infants of 8-12 mths of age had meat intakes <10 g/day. These findings point to the importance of examining ways to encourage an adequate intake of meat during the weaning period in future strategies aimed at the prevention of iron deficiency, particularly among Caucasian infants who are at risk for the late introduction and subsequent low intakes of meats. Westcott et al. (1998) provided evidence that pureed beef, which was introduced to breast-fed infants at 5-7 mths of age as the first complementary food was accepted as well as iron-fortified infant cereal. Increasing meat intakes in infancy would also increase intakes of dietary zinc which has been also been found to be a common nutrient deficiency in late infancy (Michaelson et al., 1994; Walravens et al., 1992). However, in making recommendations for increasing meat intakes in infancy, it is also important to consider the possible negative nutritional consequences, such as increasing protein intakes beyond the infant's requirement. Engelmann et al. (1997) found, however, that total protein intakes were not different between infants fed high and low meat diets. This was because the infants fed the low meat diets were fed higher amounts of other high protein foods. Current national recommendations for the prevention of IDA (CPS et al., 1998; CPS Nutrition Committee, 1991), however, do not place particular importance on giving adequate amounts of meats. Further, there is no recommendation for the amount of heme iron that should be provided in infancy. Although there is no recommendation by CPS et al. (1998) for either the age of introduction, or quantity of meats that should be fed throughout the weaning period, the latest guidelines from B.C. Ministry of Health (1995) on infant feeding practices advise parents to start with one tsp (5 g) of meats, fish or poultry and to increase to 6 Tbsp (90 g/day from 6 to 9 mths of age and then to 8 Tbsp (120 g)/day from 9 to 12 mths of age. An intake of 6-8 Tbsp/day would provide 0.7-1.0 mg of heme iron. Assuming a bioavailability of 25%, infants being fed meats according to the provincial guidelines (B.C. Ministry of Health, 1995) would be getting approximately 0.18-0.25 mg or 26-36% of the total of the endogenous requirement for iron at this age (approximately 0.7 mg/day). Although the findings of Mira et al. (1996), suggest that a heme iron intake of <0.71 mg/day, (i.e. less than approximately 6 Tbsp or 90 g) is associated with a 3-fold increase in the risk of iron deficiency, our study provides support for the work by Engelmann et al. (1997) that showed that an intake of about 2-3 Tbsp or 30-45 g of meat/day would be adequate to decrease the risk of IDA and

low iron stores in infancy. For parents who choose not to give meats to their infants or populations who are unable to rely on meat due to cultural, religious or financial reasons, however, alternative strategies, for example, improving the bioavailability of non-heme iron should be investigated.

5.4 Study Limitations

While the results of this study revealed important relations between diet and IDA and low iron stores among Chinese and Caucasian infants in Vancouver, several limitations to the interpretation and generalizability of the findings must be considered. The subjects in this study were selected from birth lists without bias (i.e. without prior knowledge of the subject's iron status or family diet or SES). Participation in the study, however, was solely based on the parents' willingness to participate. Although the response rate of 23% was quite high, participants in this study may not constitute a representative sample of Vancouver infants. It is possible that those who could not be contacted and those who chose not to participate represented parents who were less interested in and/or less knowledgeable, able or skilled in how to provide a nutritious diet to their infants. This study, therefore, may not have included infants most likely to be at risk for IDA. This study did not involve infants from many groups known to be at high risk for IDA, such as premature infants, and infants from First Nations, South East Asian, and vegetarian family backgrounds. Clearly, parents who participated in the study may have been influenced by the general research subject, which was described in the informed consent. A self-selection bias is inherent in a cross-sectional design and, as a result the parents who participated are more likely to have had a particular interest in their infants' diet and overall health than the parents who did not participate. These biases, however, would probably have led to underestimation of the prevalence of feeding practices and dietary intakes associated with poor iron status. Since this study was limited to one geographic area, a major urban city, the generalizability to infants in other regions must also be cautious.

Although this study has provided important information on the iron status of infants 8-26 mths of age from Caucasian and Chinese ancestries in Vancouver, it does not provide information on the etiology of the high prevalence of low iron stores found among infants of 8-26 mths of age. Because of the cross-sectional design of this study, it is unclear whether the infants with low iron stores were in the process of depleting, maintaining or building up their iron stores. The finding that the prevalence of IDA was lower, but low iron stores was higher among infants 13-26 mths of age than 8-12 mths of age may suggest that the group of infants 13-26 mths of age with low iron stores included infants who had

previously had IDA and were in the process of building up their stores. A longitudinal design would be necessary to study the natural history of IDA and low iron stores. Repeat blood testing in apparently healthy infants, however, would not be ethical and any infants identified with IDA should be treated rather than followed to observe the natural history of the disease.

Several factors may have confounded and biased the relations between iron status and the dietary variables in this study. Differences in the infant's iron status due to other factors that were not measured in this study may have confounded the relationships found between the dietary variables and iron status. Examples of such factors include the maternal iron status, iron supplementation during pregnancy, the length of time between birth and cord clamping, illness with loss of food intake, growth velocity, and genetic predisposition to conditions of iron overload. It is possible that the relationships between the dietary variables examined in this study and iron status at 8-26 mths of age were confounded by these factors. The inability to control for these factors either in the study design or in the statistical analysis, however, would have resulted in an underestimation of the relations between the dietary variables and iron status. Although necessary to increase the power to examine differences in dietary variables between infants with poor and normal iron status, the grouping of infants with either iron deficiency anemia or low iron stores were grouped together as having poor iron status may have confounded the results. Among the infants with poor iron status, some of those with low iron stores may have had IDA at younger ages and at the time of the study may have been consuming adequate amounts of iron. Inclusion of infants who were in the process of increasing their stores by consuming adequate dietary iron, despite having ferritins were ≤ 12 μg/L, would have resulted in an underestimation of the relation between iron status and diet.

This study was not designed to identify the underlying determinants of particular feeding behaviors and food consumption patterns that the parents engage in, for example factors such as the parents' knowledge, skills, attitudes, beliefs and social and economic environments. This information is important to allow consideration of culturally appropriate, practical recommended that are acceptable to the parents' context in the design of strategies. This information is important, for example, in making a recommendation to increase the intake of heme iron in infancy for the prevention of IDA.

Limitations inherent in the dietary assessment instruments chosen and developed for this study must also be considered in the interpretation of the findings. As with other dietary studies, it is possible that the food and nutrient intake determinations, which were based on recording and estimation of nutrient intake, did not reflect the actual

intakes. Reliability and validity of the recorded food intake data is a concern because of the high respondent burden associated with food records and respondent fatigue. Training of both the participants and interviewers, in addition to the follow-up contact and review of the food records with the participants to clarify and probe for forgotten foods (Bolland et al., 1988) was done to increase the accuracy of the 3d-FR. Recording of the food intake, however, may have caused alterations in the types and quantities of foods fed to the infants on the recording days, and this would compromise the validity of the data to represent usual intakes. The parents chose the recording days, and may have altered their infant's intake to represent a perceived ideal. The FFQ did not measure specific details of intake, and thus the nutrient intakes derived from the FFQ can only be regarded as approximations. The fact that information on feeding practices and dietary intakes was collected from parents rather than from direct observation also introduces bias to the results. However, parents have been shown to be reliable reporters of their child's diet at home (Klesges et al., 1987), and both mothers and fathers have been shown to be reasonably accurate at recalling their child's dietary intake (Basch et al., 1990). Consensus recall in which the parents and child combine to give the recall has been shown to be more accurate than recall from either parent alone (Eck et al., 1989) particularly in preschool children (Rockett & Colditz, 1997) and those away from home for >4 hours a day (Baranowski et al., 1991). Considering the age of the participants in this study, however, consensus recall was not possible, and probably not necessary for this study, as the participants were all <26 mths of age The retrospective nature of the FFQ and infant feeding history questionnaire is also subject to a potential recall bias. It is not possible to determine whether the dietary assessment instruments used in this study over or underestimated the actual intakes. However, the parents were not aware of the iron status of their infant until all the dietary data had been collected, so any potential error would have not occurred systematically by iron status. Further, the overlap of the recording of the 3d-FR and the FFQ interview raises the possibility of a test-retest bias. The same food composition data was used to calculate nutrient intakes for both the FFQ and 3d-FR; thus any error associated with the nutrient database was the same for both instruments. Finally, although the FFQ proved to be a valid assessment of iron intake when compared with the 3d-FR and selected biochemical indices of iron status, this study did not include measures of intra- or inter-observer reliability, or repeatability of the FFQ.

Estimation of human milk intake by breast-fed infants is difficult, particularly in studies including a large number of free-living infants with assessments carried out over more than one day. The method used to estimate the intakes of human milk may have introduced error and this needs to be considered in the interpretation of the

findings. Test-weighing each infant after each breast-feeding would have been desirable to determine the quantities of human milk consumed. It was not practical to ask mothers to weigh their infant before and after every breast-feed during the 3 days that they recorded their infant's food intake. Clearly, test-weighing could not be considered in the data collection by the FFQ or feeding history. Thus, an assumption was made that 5 minutes of breast-feeding was equivalent to an intake of one fluid ounce of human milk to estimate the quantities of human milk consumed by breast-fed babies, as reported on the 3d-FR and FFQ. This estimate was derived from test-weighing 3 breast-fed infants according to the procedure described by Dewey et al. (1984), and by asking mothers in the pilot study how much formula or expressed milk their infant usually consumed during a 5 minute period of bottle-feeding. Clearly, both this method of estimate and the use of one average figure for all babies and all feeds of human milk intakes may have resulted in under-or over-estimation of human milk intakes. Human milk contains about 0.3-0.4 mg iron/L. Thus, even in an exclusively breast-fed infant, with the intake of 750 mL/day an iron content of 0.3 mg/L, human milk would at most contribute 0.2-0.3 mg iron/day to an infant's diet. Any errors associated with estimating the intake of breast milk is clearly of greater concern in infants who were being exclusively breast-fed, than in infants who were partially breast-feeding, or not breast-fed, and thus is of more relevance to younger infants. Longer breast-feeding was associated with increased risk of IDA, which based on the iron content of human milk and iron requirements, is to be expected. The consistency of the relations between iron status and the dietary variables determined by the feeding history and FFQ, with the 3d-FR suggests that the error associated with estimating the iron intake of breast milk was not significant. Indeed the iron content of human milk is 0.3 mg/L, thus an error of 5 minutes per breast-feed over 8 feeds per day would result in a potential error of at most ± 0.1 mg iron/day.

The hematological and biochemical indices used to measure the iron status of the infants in this study, also have several important limitations. Capillary blood samples, although easy to obtain, may be less reliable than venous blood for quantification of Hgb (Nathan & Oski 1993) and serum ferritin (Cooper & Zlotkin, 1996), but more reliable for sTfR (Cooper & Zlotkin, 1996). Capillary blood samples were used because finger prick, rather than venopuncture, is likely to be more acceptable to parents, is preferable outside of a physician's office or medical laboratory, and venous blood draws in infants with small veins may sometimes be difficult.

A total of 9 infants with 7/59 of ages 8-12 mths, and 2/86 of ages 13-26 mths were found to have IDA. This study lacked the power to determine potential relations between IDA and the dietary variables. The group of infants with IDA and low iron stores was combined to increase the power to determine possible relations between poor iron

status and the potential dietary predictors. However, the group of infants aged 13-26 mths with low iron stores may have consisted of a heterogeneous group of infants who may have been in the process of depleting, building up or maintaining their iron stores. These 3 groups of infants with low iron stores may have had quite different food consumption patterns and dietary intakes at the time of the study and different dietary histories, thus confounding the relations found between diet and iron status. Only 7/145 infants had been introduced to cows' milk prior to 9 mths of age. Six of these infants had either IDA or low iron stores. However, given the significant relation found between the age of introduction of cows' milk and iron deficiency, and the congruence of this finding with the available literature, early introduction of cows' milk should clearly be considered in future studies of the dietary predictors of risk for iron deficiency, particularly with other groups of infants who may have a higher prevalence of early introduction of cows' milk.

5.5 Conclusions and Implications for Measurement, Policy and Practice

5.5.1 *Risk of Poor Iron Status Among Caucasian and Chinese Infants in Vancouver:*

The finding of 15% IDA among Caucasian infants at 8-12 mths of age is consistent with previous work (Lwanga, 1996; Innis et al., 1997). Thus, our findings suggest that IDA is a significant public health problem among Caucasian infants in Vancouver and that the problem of IDA in this group has not improved since 1993. The finding that at least 30% of Caucasian and 19% of Chinese infants had low iron stores shows that substantial numbers of infants in Vancouver also have poor iron status. Clearly some infants with depleted iron stores, such as those from disadvantaged families may be at risk for developing IDA due to feeding practices inconsistent with current recommendations (Schwartz & Evers, 1998; Moffatt et al., 1994), and may be more vulnerable to the health and developmental consequences imposed by IDA (McLoyd, 1998; Miller, 1998; Horowitz, 1989).

Policy Implications:

- **Given the known detrimental consequences of IDA in infancy and the lack of conclusive evidence that low iron stores does not impact negatively on infant health and development, the findings here suggest the need for improvements in strategies for both primary and secondary prevention of IDA among infants in Vancouver. These findings suggest that further improvements in prevention strategies for IDA are particularly important for Caucasian infants in the 2nd half of the first year of life.**

Caucasian infants appear to be at a significantly higher risk than Chinese infants for both IDA and low iron stores at 8-12 mths of age, and for low iron stores at 13-17 mths of age. The results indicate that the apparently higher risk of poor iron status among Caucasian infants is due to their feeding practices. The types and quantities of complementary foods fed, in particular the introduction of MPF later than 9 mths of age, and subsequent low intakes of MPF and thus heme iron by Caucasian infants fed low iron milk as their primary milk feeding appear to play an important role in the risk of poor iron status.

Implications for Measurement:

- **Infants can be identified for risk of IDA on the basis of age, ancestry and feeding practices.**

Implications for Practice:

- **Particular attention should be paid by health professionals to assess the feeding practices of Caucasian infants >6 mths of age, particularly those being breast-fed, to ensure that the intake of MPF is >30 g/day, and that the intake of cows' milk/ milk products is not >800 g/day.**

The key strategy currently used in Canada for the prevention of IDA among breast-fed infants is the recommendation that iron-fortified infant cereals be introduced at 4-6 mths of age. Importantly, this study suggests that the intake of meat and cows' milk/milk products may be a more robust predictor of poor iron status than the intake of iron-fortified infant cereal in infants 8-26 mths of age. Clearly, important information is available to show that iron-fortified infant cereals are efficacious in decreasing the risk of IDA among breast-fed infants who consume adequate amounts of cereal on a consistent basis (Walter et al., 1993). It is not clear, however, whether the cereal intakes of free-living populations of breast-fed infants are adequate to prevent iron deficiency. Cereal intake varies widely among individual infants (Gerber Infant Nutrition Survey, 1989; Zlotkin et al., 1981; Walter et al., 1993; Skinner et al., 1997), and breast-fed infants tend to consume less cereal than formula-fed infants (Walter et al., 1993). Indeed in this study, the intake of MPF and cows' mil/milk products were more important in predicting risk of low iron stores and IDA than the intake of iron-fortified infant cereals. Increasing meat intake (Engelmann et al., 1998; Yeung & Zlotkin, 2000) and avoiding unmodified cows' milk (Moffatt et al., 1994) during infancy have been shown to be efficacious in preventing iron deficiency.

Studies suggest that current strategies aimed at the prevention of IDA are not accessible or effective for infants from disadvantaged backgrounds (Schwartz & Evers, 1998; Moffatt et al., 1994). Importantly, this study shows that

current strategies for prevention of IDA also may not be accessible or effective for infants from more advantaged socio-economic circumstances, such as those from Caucasian ancestries. Our findings and previous work in Vancouver (Williams et al., 1996) show that breast-feeding practices and the introduction of iron-fortified cereal among Caucasian infants are consistent with current recommendations (CPS et al., 1998). However, this study shows that feeding recommendations regarding iron supplementation of infants weaned from breast-feeding prior to 9 mths of age, introduction of meats, and feeding of cows' milk are not accessible or effective among substantial numbers of Caucasian infants. Clearly there are gaps in the current strategies for IDA prevention. These gaps might be addressed by evaluating the predisposing, enabling and reinforcing factors that influence the dietary patterns found here to place infants at risk for poor iron status. Whether these dietary risk patterns are due to factors such as misinterpretation or mixed messages about healthy eating for infants and adults, inaccessibility due to financial or language barriers or a lack of feeding or skills remains to be determined. Community-based nutrition education that considers the determinants of inappropriate infant feeding practices, and that is culturally appropriate, tailored to the individual needs of pregnant women and families with infants, and delivered in the home has been shown to be effective in improving infant feeding practices (Morrow et al., 1999; Guldan et al., 2000). Moreover, community-based nutrition education that was provided in the home and that included counselling about infant feeding and growth monitoring, not only improved infant feeding practices, but decreased rates of anemia and improved rates of growth in a recent randomized controlled trial in rural Sichuan, China (Guldan et al., 2000).

Implications for Policy & Practice:

- **These results have important implications for controlling IDA among Caucasian infants in Vancouver. Application of these culturally-specific dietary patterns to primary prevention initiatives for iron deficiency, and tailoring messages aimed at health professionals and parents has the potential value in making primary prevention initiatives more effective. Other complementary and alternative primary prevention strategies, such as community-based nutrition education, are needed to fill the gaps of current IDA prevention strategies and should be investigated.**
- **Infant feeding policies and recommendations should place more emphasis on strategies to ensure an adequate intake of heme iron or alternatives to this, particularly in infants being breast-fed. Infant feeding recommendations aimed at the prevention of IDA should include the specific recommendation that meats be**

introduced by 6-7 mths of age, and provide guidelines for the quantities of meat-containing complementary foods that need to be fed to ensure an adequate intake of heme iron.

5.5.2 *The Value of Dietary Assessment Instruments for Classifying Infants by Iron Status:*

This study has demonstrated that dietary assessment instruments could be used to categorize infants as having normal or poor iron status. These findings suggest that for infants 8-12 mths of age, both the feeding history and the characteristics of the current diet, i.e. the types and quantities of primary milk feedings and complementary foods, are important considerations for assessing the risk of poor iron status using dietary predictors. Although whether an 8-12 mth old infant was breast-fed >6 mths or not appears to be an important question for identifying infants at risk for IDA, this information is not a useful question for identifying infants at risk for low iron stores. However, whether or not an 8-12 mth old infant was supplemented with iron, or fed cows' milk prior to 9 mths of age, appear to be potentially important questions for identifying infants at risk for either IDA or low iron stores. Consistent with the risk factors relating to feeding history, the quantity of iron-fortified infant formula was negatively, and the quantities of human milk and cows' milk and milk products were positively associated with the risk of poor iron status at 8-12 mths of age. Further, the quantity of the major food source of heme iron (i.e. MPF) consumed during the 2 weeks recorded in the FFQ was negatively associated with poor iron status at 8-12 mths of age.

Implications for Measurement:

- **Questionnaires designed to assess the iron status of infants 8-12 mths of age should include questions addressing the infant's feeding history and the types and quantities of primary milk feedings and complementary foods currently being fed.**

For infants 13-26 mths of age, these findings suggest that the infant's current diet rather than feeding history is the more important consideration for assessing the risk of poor iron status using dietary predictors. Feeding history does not account for some important determinant of iron intake or absorption. Indeed, the FFQ found clear differences in the current types and quantities of foods fed during the weaning period among infants with poor iron status and normal iron status at 13-26 mths of age. This suggests that the current intake and sources of iron are important for assessing the risk for poor iron status in infants older than one year of age. In particular, the quantity of the major food source of heme

iron (i.e. MPF) and complementary foods containing solely non-heme iron (i.e. 'other cereals' and soy-based products) consumed during 2-weeks FFQ was negatively associated with IDA and low iron stores.

Implications for Measurement:

- **Questionnaires designed to assess the iron status of infants 13-26 mths of age should include questions addressing the types and quantities of primary milk feedings and complementary foods currently being fed.**

Our findings show that the FFQ developed here has potential as a valuable research instrument for assessing iron nutrition among infants 8-26 mths of age from Caucasian and Chinese ancestries. The significant relations found between serum ferritin, sTfR and sTfR:ferritin, the biochemical indices of iron status, and the dietary intakes of total and heme iron determined by the FFQ show that our FFQ has criterion validity and provided a useful indicator of the infant's actual iron intake. Further support for the value of the FFQ is demonstrated by its relative validity compared with a 3d-FR.

Implications for Policy and Practice:

- **The FFQ has the potential to advance research, policy and practice in iron nutrition in infancy and prevention of IDA.**

Although the risk of iron deficiency involves more than dietary determinants, a package of dietary risk factors may provide a useful proxy for screening infants at risk for IDA. The key dietary patterns associated with IDA and low iron stores identified here were: 1) not having been fed an iron-fortified infant formula or given supplemental iron; 2) having been fed cows' milk prior to 9 mths of age; 3) having been fed ≥800 g cows' milk or milk products/day in the previous 2 weeks; and 4) having been fed <30 g MPF/day in the previous 2 weeks. Our understanding about the iron content and bioavailability of these dietary factors, together with other important considerations such as possible GI bleeding associated with early introduction of cows' milk, support the plausibility of these patterns of predictors of risk for IDA and low iron stores.

Implications for Practice:

- **Medical and health professionals should receive training and information to be able to identify infants with dietary patterns predictive of IDA, and to provide appropriate educational strategies to address patterns that are considered to place infants at risk.**

Implications for Measurement:

- **A brief assessment tool that considers key dietary patterns that are associated with the risk of IDA might be a valuable addition to current prevention strategies.**

Implications for Policy:

- **The brief dietary screening tool developed here has the potential to advance policy and practice in the area of IDA prevention in infancy by identifying infants at risk for poor iron status so that primary prevention strategies can be initiated.**

5.5.3 *The Value of sTfR to Assess Iron Status in Infancy:*

This study concurs with others that sTfR does not change with age, but did identify gender and race-related differences in sTfR values. It is possible that these differences were due to other factors that may vary by gender or ethnicity, such as feeding practices, iron supplementation, or growth velocity.

Implications for Measurement:

- **Further studies are needed to better understand the nature of the sTfR difference between Caucasian and Chinese and between male and female infants, and the need to control these variables in the design of studies on the use of sTfR measures in infancy.**
- **Studies with larger numbers of infants are warranted to establish reference standards for sTfR based on commercially available assays, and to confirm our findings.**

sTfR is a sensitive marker of IDA in infancy, but lacks both sensitivity to low iron stores, and specificity to IDA and low iron stores. However, it is possible that in this study, as in many other studies with young infants, infection may have been a significant confounder in the use of serum ferritin as a measure of low iron stores.

Implications for Measurement:

- **Future studies examining the clinical utility of sTfR in infancy should include an objective measure of recent infection or inflammation (such as C-reactive protein) to aid in the interpretation of serum ferritin values.**
- **The presence of infection should be considered and controlled for in the design of future studies.**

Implications for Policy

- **Considering the lack of availability and high cost of sTfR analyses, sTfR is currently not an option for diagnostic and screening purposes. Further studies including cost/benefit analyses are warranted to further investigate the utility of sTfR as a diagnostic and screening test for iron deficiency using more recently available commercial assays.**

5.6 Future Directions

Although this study provides important information on the prevalence of low iron stores and IDA and the associated dietary risk factors among Caucasian and Chinese infants aged 8-26 mths in Vancouver it does not provide any information on the extent or causes of iron deficiency in other high risk groups. With prevalence rates of IDA ranging from 25-50% among infants from First Nations, South East Asian and low-income families (Lehmann et al., 1992; Moffatt et al., 1991; Cruz et al., 1990; Whalen et al., 1997; Sawchuk et al., 1996), it is likely that infants from other social and cultural backgrounds may be at an even higher risk for IDA than the Caucasian and Chinese infants targeted in this study. Thus, it is very important that further work be done to elucidate the prevalence of IDA and low iron stores and the associated risk factors among low-income families, particularly those that are "hard to reach", as well as infants from First Nations, South East Asian and vegetarian families.

As the feeding practices and food consumption patterns of Caucasian infants were found to place them at risk for IDA while that of Chinese infants protected them from developing IDA, this study suggests that development and evaluation of primary prevention efforts that are culturally specific are likely to be important for decreasing the prevalence of IDA among breast-fed infants in Vancouver. The findings of this study suggest that the feeding pattern of Caucasian infants may place them at particular risk of iron deficiency. It is important that further work be done to understand the underlying determinants the feeding patterns of Caucasian mothers, particularly

those who breast-feed >6 mths. The parents in this study tended to be older (78% of mothers were >30 years of age) and a significant proportion of the Caucasian parents had vegetarian diets or eating patterns that reflected vegetarian tendencies (27%). It is possible that health concerns or ethical issues guide family food choices, and thus, increasing the intake of meat in the infant diet may not be acceptable or practical for these parents. Thus, future research in this area should include investigation of the underlying determinants of the particular feeding behaviors and food consumption patterns (e.g. the parents' knowledge, skills, attitudes, beliefs and social and economic environment) of Caucasian mothers who breast-feed >6 mths. This information is important so that strategies aimed at the prevention of IDA can be designed in a culturally appropriate, practical manner that is acceptable to the parents' health, social and economic context, and be targeted through the most effective channels.

Future studies are also needed to develop and test commercial and home-prepared meat-based weaning foods, and guidelines for feeding of meat-based weaning foods. A meat-based weaning food development study should include an evaluation of the acceptability and practicality of these foods to parents and infants. A field intervention study will then be needed to investigate the efficacy and effectiveness of these meat-based weaning foods for preventing IDA among breast-fed infants. Alternatives to meat-based weaning foods for prevention of IDA should also be developed, and their efficacy and safety investigated for parents who choose not to feed meats to their infants.

The findings of this study suggest that dietary assessment can be important to identify infants at risk for IDA in infancy. This study did not, however, examine the role that other factors, such as genetic variability in the absorption of dietary iron, or iron endowment at birth, play in determining an infant's risk for iron deficiency. Future studies examining the determinants of iron status in infancy should measure or control for other important factors that may influence iron status in infancy such as maternal iron status, iron supplementation during pregnancy, and the length of time between birth and cord clamping. Future studies should also be planned to examine genetic variability and possible polymorphisms of iron absorption in infancy. For example, the consequences of high iron intakes (from iron-fortified infant formula or iron supplements) could be studied in infants genetically predisposed to hemochromatosis. This could be investigated using a cross-sectional sample of infants, determining possible HLA halotypes linked to hemochromatosis, and relating this to their serum ferritin levels (as a proxy for storage iron), while providing an objective measure of infection, and their history of use of iron-fortified formula and iron

supplements, and intakes of iron. Future directions in this area could also involve investigation of possible mutations in genes regulating membrane iron transport causing iron deficiency, as well as iron overload.

This study also found that sTfR values were higher in males than females, and in Caucasian than in Chinese infants. Further studies are needed to confirm these gender and race-related differences, and investigate whether this is a normal physiological phenomenon or indicative of an increased risk for IDA among infants who are Caucasian or male, and if so whether or not the gender and race-related differences are due to nutritional factors.

Secondary prevention (early detection) of iron deficiency is also important because early detection of infants at risk for, or with early stages of iron deficiency is critical to prevent potential negative consequences of IDA, such as increased infections, impaired growth and delayed cognitive and motor development. Future directions in this area could include the testing of the brief dietary screening tools developed in this study to assess the predictability and effectiveness of the dietary patterns to predict poor iron status in free-living infants in a community setting. This might include determination of the utility of the proposed dietary screening tools for detecting infants at risk for IDA and low iron stores by comparison with biochemical indices of iron status. The possibility that different screening tools for infants 8-12 and 13-26 mths of age might be more robust for predicting infants with poor iron status should also be examined in future research. In addition, it is important to evaluate the feasibility, practicality, and acceptability of these dietary screening tools in a community setting for both parents and health professionals. The CART tree with 2 decision choices presented in this study has the potential to be a adapted to a brief, simple, visual tool that might lend itself to inclusion in routine infant assessments, such as an immunization or a well-baby clinics. Future work could also consider the usefulness of such a tool as a relatively quick and inexpensive instrument to assess risk for IDA among hard to reach, low-income, low education and minority groups. Considering the higher expected prevalence of poor iron status among these groups, it is possible that the predictive value of the dietary screening tool found in our study may be higher with these other groups of infants.

Although the FFQ developed here has potential as a valuable research instrument for assessing iron nutrition among infants 8-26 mths of age from Caucasian and Chinese ancestries, future research is warranted to address measurement issues not addressed in this study, and to establish its validity in other infant populations. Further research is warranted to specifically address the predictive validity and reliability of the FFQ, including both intra- and inter-observer reliability. The degree of over- or under-estimation of absolute food and nutrient intakes by

this FFQ also needs to be established. Future research might involve validation of the FFQ for total energy intake using doubly-labeled water. Validation of the FFQ for energy intake would contribute a valuable research instrument to advance the field of infant nutrition, and allow the FFQ nutrient intake measurements to be corrected for energy intake.

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DEMOGRAPHIC AND INFANT FEEDING QUESTIONNAIRE

(to be completed with nutritionist)

SUBJECT NUMBER

CLINIC DATE Day Month Year

CLINIC NUMBER

BABY'S BIRTH DATE Day Month Year

Information obtained from the demographic and infant feeding history questionnaire will assist us in targeting infant nutrition programs more effectively. Although we greatly appreciated your participation, participation is voluntary and you do not have to answer any question(s) you do not wish.

A Nutritionist will be available to answer any questions you might have about this questionnaire and to review "Section B - Infant Feeding History" with you.

Please answer questions for both parents/guardians as applicable.

SECTION A - DEMOGRAPHIC INFORMATION

Please Check the Appropriate Response

A1. I am the baby's:

- ☐ Mother
- ☐ Father
- ☐ Relative
- ☐ Nanny
- ☐ Other (specify) _____

A2. What is your age?

	Baby's mother	Baby's father
< 20 years	☐	☐
20-24 years	☐	☐
25-29 years	☐	☐
30-34 years	☐	☐
35+ years	☐	☐

A3. What is your present living status?
(You may check more than one)

- ☐ Living alone
- ☐ Living with spouse/partner
- ☐ Living with family or relatives
- ☐ Living with friends

A4. What is your marital status?
(check only one)

- ☐ Legally married/common-law
- ☐ Separated but still legally married
- ☐ Divorced
- ☐ Widowed
- ☐ Never married (single)

A5. How many children, in total live in the household? ☐☐

A6. Please check the highest level of schooling that you have completed.

	Mother		Father	
	Some	Completed	Some	Completed
Secondary (high) school?	☐	☐	☐	☐
Community college, technical or vocational training	☐	☐	☐	☐
University	☐	☐	☐	☐
Graduate degree	☐	☐	☐	☐
Other training? (specify)	☐ _____	☐	☐ _____	☐

A7. What is your usual occupation?

Mother _____

Father _____

A8. Which of the following describes your family income per year?

- ☐ Less than $10,000
- ☐ $10,000 - $19,999
- ☐ $20,000 - $29,999
- ☐ $30,000 - $39,999
- ☐ $40,000 - $49,999
- ☐ $50,000 - $59,999
- ☐ $60,000 - $69,999
- ☐ $70,000 - over

A9. Were you born in Canada?

Mother ☐ Yes
☐ No (please state country of birth) _____

Father ☐ Yes
☐ No (please state country of birth)_____

A10. How many years have you lived in Canada?

Mother _____ yrs

Father _____ yrs

A11. What language is spoken most often at home?

i) English ☐

ii) French ☐

ii) Other ☐ specify _____

A12. Canadians belong to many ethnic or cultural groups. To which ethnic or cultural group(s) do you belong (please consider your usual social/cultural practices)? Mark or specify more than one, if applicable. Please answer for mother and father of the child as applicable.

	Child's Mother	Child's Father
British, specify country	☐ _____	☐ _____
French, specify	☐ _____	☐ _____
European, specify country	☐ _____	☐ _____
First Nations, specify	☐ _____	☐ _____
Asian, specify country	☐ _____	☐ _____
Latin American, specify country	☐ _____	☐ _____
Arab, specify country	☐ _____	☐ _____
Canadian,	☐	☐
Other, specify	☐ _____	☐ _____

A13. Are you: *(Mark or specify more than one, if applicable)*

	Child's Mother	Child's Father
Chinese	☐	☐
South Asian (East Indian, Punjabi, Sri Lankan, Pakistani, etc.)	☐	☐
South East Asian (Filipino, Indonesian, Laotian, Vietnamese, etc.)	☐	☐
White/Caucasian (European, etc.)	☐	☐
Other - Please specify, _____	☐	☐

A14. Canadians often have food related practices and beliefs about food which are associated with a particular ethnic or cultural background(s). Which ethnic or cultural background(s) do you associate **your usual food related practices** with?

For example: Western/North American, British, Vietnamese, Chinese, Mediterranean, Hindu, Moslem, Sikh, etc.

_____

_____

A15. Do you **exclude** any of foods from your family diet?

Mother ☐ Yes (Specify below)
☐ No

Father ☐ Yes (Specify below)
☐ No

☐ Beef
☐ Pork
☐ Poultry
☐ Fish
☐ Eggs
☐ Dairy products
☐ Nuts, seeds or peanut butter
☐ Vegetables
☐ Fruit
☐ Breads/Cereals
☐ Pasta
☐ Rice
☐ Beans, peas or lentils

Comments _____

_____

A16. Does your family have any particular diet practices for medical, religious, or other reasons?

Yes ☐ (please describe below)

No ☐

Comments _____

_____

SECTION B - INFANT FEEDING HISTORY

Please Check the Appropriate Response

B1. Was your baby ever breast-fed?

Yes ☐ (go to B2)

No ☐ (go to B5)

B2. Has your baby been introduced (by bottle or cup) to 8oz (~240 ml) or more of formula or other milk per week?

Yes ☐ If yes, at what age? _____ month(s)

No ☐

B3. Is your baby still being breast-fed?

Yes ☐

No ☐ If no, at what age was it completely stopped? _____ month(s)

B4. Was breast-feeding supplemented or replaced with **infant formula**, ie. >8 ounces (240ml) per week of formula) ?

Yes ☐ (Go to B5)

No ☐ (Go to B7)

B5. If your baby was given an infant formula, what type(s) were used and at what age were these introduced or changed?

	Check if used	Age started	Age changed/ stopped	Specify type or brand name
		mos	mos	
a) regular formula (low iron)	☐	_____	_____	_____
		_____	_____	_____
b) formula with iron (iron-fortified)	☐	_____	_____	_____
		_____	_____	_____
c) soy-based formula (not soy milk)	☐	_____	_____	_____
		_____	_____	_____
d) other formula	☐	_____	_____	_____

Comments: _____

_____

B6. If your child is still drinking formula, **how much** do they drink per day?

_____ oz.

Brand/Type _____ Comments _____

B7. Was breast-feeding or formula feeding supplemented or replaced with cows' milk, goats' milk, soy milk or other beverages?

Yes ☐

No ☐ (Go to B10)

B8. At what age was your child started on cows' milk, goats' milk, soy milk or other beverages?

	Age (months)	Type
Cow's milk	_____	____ Whole ____ 2% ____ 1% ____ Skim
Goat's milk	_____	
Soy milk (not formula)	_____	____ Unsweetened ____ Sweetened
Other	_____	Please specify _____

B9. What type of milk is your child currently drinking?

			How much per day?
Cow's milk	Whole	☐	_____
	2%	☐	_____
	1%	☐	_____
	Skim	☐	_____
Other (please specify) _____			_____

B10. Does your child eat solid foods?

Yes ☐ (Go to B11)

No ☐ (Go to B14)

B11. **At what age were the following foods introduced to your child? If your child has stopped eating any of these foods, please specify at what age. If your child still currently eats the food, please indicate with a ✓.**

Food Type	**Age started (months)** **(if applicable)**	Age stopped (months) **(if applicable)**	**Comments** **eg. Why stopped, brand, or type**
Commercial infant cereals			
Commercial toddler cereals			
Cold packaged cereal (specify type)			
Cooked cereal or other home prepared cereal (specify type)			
Cooked rice			
Cooked pasta			
Breads/ crackers			
Red Meat (eg. beef or pork)			
Lamb			
Chicken			
Fish			
Egg yolk			
Dried peas, beans or lentils			
Dairy products (eg. cheeses, yogurt)			
Fruits			
Fruit Juices (specify type)			
Vegetables			
other foods (please specify)			

B12. Have you introduced your child to an infant/toddler cereal?

Yes ☐ (Go to B13)

No ☐ (Go to B14)

B13. If Yes, what type of infant/toddler cereal did you introduce?

☐ Commercial infant/toddler cereal
(Please specify brand and type of cereal)

Brand	Type
_____	_____
_____	_____
_____	_____

☐ congee

☐ cereal from a health food store

☐ other, please specify
_____

B14. If you have not introduced infant/toddler cereal, please specify why?

_____

_____

B15. When you first started using infant cereal, what did you use to prepare it?

☐ Water

☐ Breast-milk

☐ Formula

☐ Cow's milk

☐ Fruit juice

☐ Other, please specify _____

B16. In general, how nutritious do you feel your child's diet is?

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair, or
- ☐ Poor

B17. In general, how would you describe your child's eating habits?

- ☐ Always a fussy eater
- ☐ Often a fussy eater
- ☐ Sometimes a fussy eater
- ☐ Seldom a fussy eater
- ☐ Never a fussy eater
- ☐ Excellent appetite
- ☐ Very good appetite
- ☐ Good appetite
- ☐ Fair appetite
- ☐ Poor appetite

B18. Does baby go to play group, babysitter's home, day care centre or nursery school once a week or more?

☐ Yes ☐ No

If yes, How many days a week? _____
How many hours a day? _____
About how many children attend with your child? _____

B19. How many of the following prepare the child's food **(from 6 months on)**?

- ☐ Mother
- ☐ Father
- ☐ Grandmother
- ☐ Grandfather
- ☐ Nanny/baby sitter
- ☐ Daycare
- ☐ Other

specify _____

Thank you for your time and cooperation in completing this questionnaire.

THANK YOU

FOOD RECORD PACKAGE
PART 1

GUIDELINES FOR KEEPING A FOOD RECORD

Your child's food record should be a detailed description of the types and amounts of all foods and drinks your child has over a period of 24 hours. A food record that is completed accurately can provide valuable information about the nutritional content of your child's **usual** diet. To assess your child's diet record correctly, we must be able to clearly **picture** the foods and beverages that you have recorded.

Please keep a record of **everything that your child eats or drinks** on the attached forms, for 3 days (2 weekdays and 1 weekend day)

☞ **STEP 1** For all the food and beverages your child eats/drinks from 12am to 12am, please note the time(s), what the eating occasion was called (eg. breakfast or snack), where the food was eaten (eg. at daycare), and with whom.

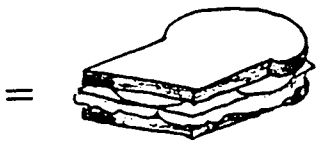
☞ **STEP 2** **DESCRIBE ALL THE FOODS AND BEVERAGES YOUR CHILD ACTUALLY EATS**

Tell us as much as you can about the foods that your child eats. **INCLUDE AS MUCH DETAIL AS POSSIBLE (TYPE** of food, **BRAND NAME** if applicable, and the **CONTENT OF MIXED DISHES)**. **For example:** If your child eats cookies, please tell us what type (eg. arrowroot) and the brand name (eg. Peak Frean's or home-made). If your child drinks milk, tell us if it is canned or fresh, and whether it is whole, 2% or skim.

YOU CAN DESCRIBE MIXED FOODS AS IF YOU WERE WRITING A RECIPE
Everyone has their own way of making everyday foods - please tell us how you do it.

☞ **For example, if you made a cheese sandwich:**
- What type of bread and cheese did you use?
- Did you add margarine or butter?
- Did you use mayonnaise or salad dressing?
- Did you add lettuce or tomato slices?
- How much of each item did you use?

2 slices whole wheat bread | 1 oz slice cheese | 2 teaspoons mayonnaise | 2 slices tomato | 1 leaf lettuce



1 cheese sandwich

If you did not make the food yourself, describe the contents as best as you can.

- **For example, if your child had 1 cup of tuna casserole,** let us know that it was about 1/2 macaroni, 1/4 tuna, and 1/4 peas and celery.

- STEP 3 <u>TELL US HOW MUCH IS ACTUALLY EATEN.</u>

You can describe the amount eaten in as many ways as you like. Please record as accurately as possible the amounts **ACTUALLY EATEN** by your child.

For example, you might record:

	Volume	Size	Weight
1/2 jar of Heinz vegetable stew *as*	1/4 cup	1/2 - 213 g jar	100 g
1/2 a large egg *as*	2 tablespoons	1/2 large egg	1 oz or 30 g

- STEP 4 <u>ANY COMMENTS?</u>

As you know, children do not always eat all the food they are offered. If this is the case, please record in the comments section.

<u>REMEMBER: PLEASE TRY TO RECORD IMMEDIATELY AFTER EACH MEAL AND SNACK</u>

If you take your child out to eat, take your food record with you. If you take your child to a sitter's or daycare be sure to check what your child has eaten while there. You may want to give them a copy of the food record package. Ask the sitter or somebody at the daycare to record everything your child has to eat or drink. If you pack a lunch for your child, ask the sitter or somebody at the daycare to send home all food which was not eaten. You can then record what is sent and what is returned. Also ask them to record any shared snacks or foods your child eats. Please try to keep track throughout the day - it is easy to forget exactly what was eaten if you don't.

IS YOUR CHILD STILL BREAST-FEEDING OR FORMULA FEEDING?

If you are breast-feeding, please record each time you breast-feed throughout the day or night and the length of time for each feeding. Also record any **milk, formula or juices given in a cup or bottle** and the amount that your child actually drinks.

If you have any questions, please call Patty Williams at 875-3537 or Paula Waslen at 875-2418.

Subject No. _____

FOOD RECORD PACKAGE: PART 2

FOOD RECORD EXAMPLE

Last Name: *Smith* **First Name:** *Johnny* **Age:** *10 months*
Day #: *2* **Day of Week:** *Monday* **Date:** *March 2, 1995*

TIME & PLACE	STEP 1 Describe all the foods and beverages your child actually eats.	STEP 2 How much is actually eaten? (specify volume, measure or weight)	COMMENTS	FOR OFFICE USE ONLY
Breakfast 8:00 at home	*Milupa Toddler Breakfast, mixed with milk (whole)*	*3 Tbsp*	*fussy with cereal*	
	white toast with margarine	*1/2 slice without crust*	*runny nose*	
	egg, mashed	*2 tbsp*		
	apple juice	*2 oz*		
10:30	*breast-fed*	*20 min total*		
12:00	*Heinz Mixed Beef & Vegetables, Junior*	*1/2 of 213g bottle*		
	Mashed banana	*1/4*		
	whole milk	*6 oz*		
Snack at sitters	*cheesie*	*1*		
	etc.			

Did you give your child a vitamin/mineral supplement on this day? (Y/N) *Y*
If yes, please state the type, brand name, and the amount given. *Fer-in-sol 0.6ml*
Was this a fairly typical day for your child? (Y/N) *N*
If not, please give reason(s): *Johnny seems to be getting a cold.*

Subject No. _____

FOOD RECORD PACKAGE: PART 2

FOOD RECORD EXAMPLE

Last Name: *Smith* **First Name:** *Sarah* **Age:** *2 years*
Day #: *1* **Day of Week:** *Sunday* **Date:** *March 1,1995*

TIME & PLACE	STEP 1 Describe all the foods and beverages your child actually eats.	STEP 2 How much is actually eaten? (specify volume, measure or weight)	COMMENTS	FOR OFFICE USE ONLY
Breakfast 8:00 at home	*Kellogs Rice Krispies* *beef sausage* *pure orange juice* *blueberries*	*2 Tbsp* *1/2 4-inch sausage* *4 oz* *1/4 cup*	*left milk in bowl offered toast but did not touch*	
Snack 10:00 at home	*fruit leather* *cold beef sausage*	*1/2 package* *1/2 4"*	*left from breakfast*	
Lunch 12:00 at home	*tuna roll* *-6" bun* *-1/4 cup tuna* *-1 Tbsp mayonnaise* *-1 tsp butter* *-piece lettuce*	*1/8th roll*	*refused rest*	
	nectarine *2% milk* *strawberry yogurt*	*1/4 small* *4 oz* *1 Tbsp*	*didn't like yogurt*	
Snack 2:30 at home	*Ritz Cracker* *apple juice*	*2* *3 oz*		
Dinner 5:00 at home	*fish(sole)-egged, floured and fried* *cooked white rice* *green beans* *Koolaid*	*1 oz* *3 Tbsp* *2 tsp* *2 oz*	*fussy (sleepy) at supper* *stole from brother!*	
Before bed at home	*turtle chocolate* *Post alphabets* *2% milk*	*1* *8 pieces* *4 oz*		

Did you give your child a vitamin/mineral supplement on this day? (Y/N) *N*
If yes, please state the type, brand name, and the amount given. *Flinstones Multivitamin 1 chewable tablet*
Was this a fairly typical day for your child? (Y/N) *N*
If not, please give reason(s): *Sarah was running a temperature.*

FOOD RECORD PACKAGE: PART 3

Subject No. _____

FOOD RECORD

Last Name: _____ First Name: _____ Age: _____

Record Day#: _____ Day of Week: _____ Date: _____

TIME & PLACE	STEP 1 Describe all the foods and beverages your child actually eats.	STEP 2 How much is actually eaten? (specify volume, measure or weight)	STEP 3 Comments	FOR OFFICE USE ONLY

FOOD RECORD (cont'd)

Record Day#: _____ **Day of Week:** _____ **Date:** _____

TIME & PLACE	STEP 1 Describe all the foods and beverages your child actually eats.	STEP 2 How much is actually eaten? (specify volume, measure or weight)	STEP 3 Comments	FOR OFFICE USE ONLY

Did you give your child a vitamin/mineral supplement on this day? (Y/N) _____

If yes, please state the type, brand name, and the amount given. _____

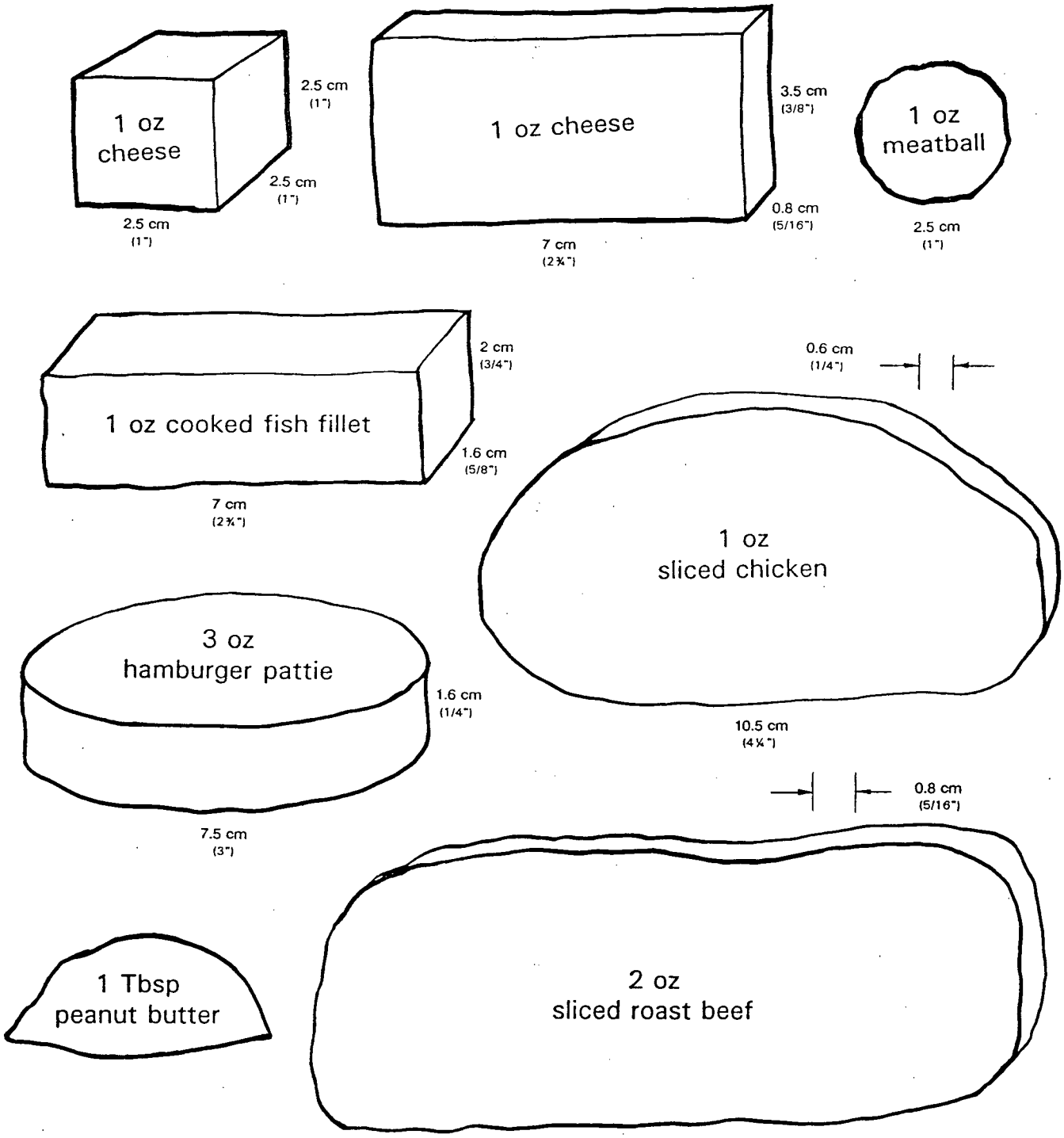
_____

Was this a fairly typical day for your child? (Y/N) _____

If not, please give reason(s): _____

_____

Sample Food Measurements
(Actual Sizes)



FOOD FREQUENCY QUESTIONNAIRE

(TO BE COMPLETED BY NUTRITIONIST)

Subject Number _____ **Interviewer** _____

Parent's Name Last _____ First _____

Child's Name Last _____ First _____

Child's DOB Day _____ Month _____ Year _____

Child's Age _____ months

Date of Follow-up Visit

Day _____ Month _____ Year _____

Day of week _____

Location of Visit _____

Main Respondent: child's

- ☐ mother
- ☐ father
- ☐ sister
- ☐ brother
- ☐ grandparent
- ☐ other _____

This questionnaire is designed to determine your child's usual food intake over the last two weeks. Please think about all the foods and beverages your child eats and drinks both at home and away from home.

Part 1. I will be asking you about many different foods and drinks. For every food please tell me whether your child has had this food or beverage at least once in the last two weeks. If YES, then I will ask you to tell me the number of times per day, or for foods eaten less than once per day, how many times in the last two weeks. Then I will ask you to tell me the serving size, or how much, your child usually eats. Please report the amount your child usually eats, not the amount you usually prepare or offer.

Note: If child eats only purchased infant, junior or toddler foods, please skip to page 21.

Here are some examples showing how the chart will be completed:

	Has your child eaten this food at least once in the last two weeks?		How many times per day or in the last two weeks?		How much does your child usually eat/drink each time?		
Example #1 "Sarah drinks whole milk once a day - about 1/2 a cup each time" **You would show that on the chart like this:**							
Whole milk & beverages made with it	○ Yes ○ No	___	○ Day ○ Week	○ 1/2 cup	○ 3/4 c	○ 1 c	Other _____
Example #2 "Sarah eats bread in a sandwich for lunch about three times a week, two slices each time but she does not eat the crust (equal to 1/2 slice bread)" **You would record that on the chart like this:**							
Bread & Rolls	○ Yes ○ No	___	○ Day ○ Week	○ 1/4 slice	○ 1/2 slice	○ 1 slice	Other _____
Example #3 "Sarah only eats fish about twice per month. She usually eats only 1 TBSP" **You would show that on the food chart like this:**							
Fish	○ Yes ○ No	___	○ Day ○ Week	○ 1/2 oz	○ 1 oz	○ 2 oz	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Milk *(include milk used in cereals and drinks made with milk)*							
Skim milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
1% milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
2% milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Whole milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Evaporated milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Sweetened condensed milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Chocolate milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Milkshake	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Soy beverage	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Rice beverage	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Goat's milk	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____
Other milk products _____	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other _____

Cheese, Eggs & Yogurt

Hard cheese (cheddar, Swiss)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other _____
Part-skim or low fat cheese (eg. lite cheeses, regular mozzarella)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other _____
"Lite" mozzarella cheese	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other _____
Processed cheese slices (including on sandwiches and hamburgers)	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice (¼ oz)	○ ½ slice (½ oz)	○ 1 slice (1 oz)	Other _____
Lite processed cheese slices (including on sandwiches and hamburgers)	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice (¼ oz)	○ ½ slice (½ oz)	○ 1 slice (1 oz)	Other _____
Cottage cheese, creamed	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-5 Tbsp	○ ⅓ cup	Other _____
Cottage cheese, 1% or 2%	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-5 Tbsp	○ ⅓ cup	Other _____
Cheese spread (eg. Cheeze Whiz)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Lite cheese spreads (eg. Lite Cheeze Whiz)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other _____
Soy cheese	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other _____
Goat cheese	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other _____
Paneer	○ Yes ○ No	___	○ Day ○ Week	○ ½ inch cube	○ 1 inch cube	○ 2 inch cube	Other _____
Whole egg, all forms (eg. scrambled, hard boiled)	○ Yes ○ No	___	○ Day ○ Week	○ ¼ egg or less	○ ½ egg	○ 1 egg	Other _____
Egg yolk only	○ Yes ○ No	___	○ Day ○ Week	○ ¼ egg or less	○ ½ egg yolk	○ 1 egg yolk	Other _____
Egg white only	○ Yes ○ No	___	○ Day ○ Week	○ ¼ egg or less	○ ½ egg white	○ 1 egg white	Other _____
Yogurt	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (60g)	○ small carton (125g)	○ large carton (175g)	Other _____
Yogurt, 1% or 2%	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (60g)	○ small carton (125g)	○ large carton (175g)	Other _____
Aspartame sweetened yogurt	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (60g)	○ small carton (125g)	○ large carton (175g)	Other _____
"Minigo" (Yoplait fresh cheese product)	○ Yes ○ No	___	○ Day ○ Week	○ ½ small	○ small carton (60g)	○ large carton (125g)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Other cheese, yogurt or egg product: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			
Breakfast Cereals							
Whole grain hot cereals (eg. rolled oats, Red River)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Cream of wheat	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Rice congee, with meat	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Cold cereals, plain or with sugar coating (eg. Corn Flakes, Rice Krispies, Cheerios, Frosted Flakes, Fruit Loops)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Bran or multigrain type cereals (Shreddies, Bran Flakes, Corn Bran, Fruit & Fibre)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Granola type cereal	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Other breakfast cereals: _____	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Breads, Rolls, Muffins & Other Grains							
Bread, dinner roll, white, enriched	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice or roll	○ ½ slice or roll	○ 1 slice or roll	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Whole grain bread, dinner roll	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice or roll	○ ½ slice or roll	○ 1 slice or roll	Other _____
Pita bread, bagel, english muffin, white, enriched	○ Yes ○ No	___	○ Day ○ Week	○ ⅛	○ ¼	○ ½	Other _____
Pita bread, bagel, english muffin, wholegrain	○ Yes ○ No	___	○ Day ○ Week	○ ⅛	○ ¼	○ ½ (8 oz)	Other _____
Hotdog or hamburger bun	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ bun	○ ½ bun	○ ¾-1 bun	Other _____
Bran or wholewheat muffin, small (40g)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-1	Other _____
Cake muffin, small (40g) eg. plain, chocolate chip, blueberry, banana or corn	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-1	Other _____
Scones (40g), all varieties	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Pancakes, waffles or French toast (35g)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Wholegrain pancakes, waffles or French toast (35g)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Rice cakes	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Chapatti or roti	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Parantha, plain	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Steamed bun, plain	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Tortilla, flour or corn	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Any pasta or noodle, cooked	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Rice noodles	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Instant noodles	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Rice, any type, cooked	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Other grain products: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

Meat, Fish, Poultry & Alternatives

Beef (including, deli sliced, smoke meat, steak, roast, ground, etc.)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Pork (including deli slices, steak, roast, chops, etc.)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Wild game (fresh, frozen, dried)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Lamb (including roast, chops, etc.)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Liver, any type	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Chicken, turkey or other poultry (including deli sliced, roast, etc.)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Chicken nuggets	○ Yes ○ No	___	○ Day ○ Week	○ 1 piece (½ oz)	○ 2 pieces (1 oz)	○ 3 pieces (1½ oz)	Other _____
Chicken fingers or strips	○ Yes ○ No	___	○ Day ○ Week	○ 1 piece (1 oz)	○ 2 pieces (2 oz)	○ 3 pieces (3 oz)	Other _____
Duck	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Fish, canned, fresh, frozen (eg. tuna, salmon, sushi)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Shellfish (eg. prawns, shrimp, crab)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Wieners	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other _____
Bacon	○ Yes ○ No	___	○ Day ○ Week	○ 1 slice	○ 2 slices	○ 3 slices	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Sausages	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other _____
Processed meats (eg. bologna, salami, chicken loaf)	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Firm or medium firm tofu or soybean curd	○ Yes ○ No	___	○ Day ○ Week	○ 1 inch cube	○ 2 inch cube	○ ½ cup	Other _____
Soft or dessert tofu	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other _____
Soy (tofu) burger, vegetarian patty	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ pattie	○ ½ pattie	○ ¾ pattie	Other _____
Soy (tofu) wiener, vegetarian weiner	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ wiener	○ ½ wiener	○ ¾ wiener	Other _____
Tahini (sesame seed paste)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 1 ½ Tbsp	Other _____
Peanut butter or other nut butter	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 1 ½ Tbsp	Other _____
Dry peas, beans, lentils, legumes, cooked	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼-⅓ cup	○ ½ cup	Other _____
Other meats or alternatives: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Combination Dishes							
Mixed dishes made with beef (eg. casseroles, hamburger helper, lasagna, spaghetti meat sauce)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Mixed dishes made with fish (eg. casserole)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Mixed dishes made with pork	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Mixed dishes made with lamb	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Canned pasta, with meat (eg. ravioli)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Canned pasta, without meat	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Homemade macaroni and cheese, other pasta dishes with cheese	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Boxed macaroni & cheese (eg. Kraft Dinner)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Pastry/pies, meat filled (eg. sausage rolls, meat pies)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ pie or roll	○ ¼ pie or roll	○ ½ pie or roll	Other _____
Filled buns, baked or steamed, meat filled	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ bun	○ ¼ bun	○ ½ bun	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Perogies, potato & cheese filled	○ Yes ○ No	___	○ Day ○ Week	○ ½	○ 1	○ 2	Other _____
Perogies, potato & onion filled	○ Yes ○ No	___	○ Day ○ Week	○ ½	○ 1	○ 2	Other _____
Enchiladas, cheese filled	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ 6 inch	○ ½ 6 inch	○ 1 whole 6 inch	Other _____
Enchiladas, meat filled	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ 6 inch	○ ½ 6 inch	○ 1 whole 6 inch	Other _____
Pizza with cheese and no meat	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice	○ ½ slice	○ 1 slice	Other _____
Pizza with cheese and meat	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice	○ ½ slice	○ 1 slice	Other _____
Pizza rolls/pizza pockets	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other _____
Quiche with meat	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ 5 Tbsp	Other _____
Quiche without meat	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ 5 Tbsp	Other _____
Mixed dishes made with cooked lentils, beans or peas (eg. lentil stew or soup)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ½ cup	Other _____
Other mixed dishes: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Soups							
Broth type eg. veg beef, chicken noodle	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other _____
Homemade broth type with meat	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other _____
Cream-type soup	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other _____
Soup made with meat and bones	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other _____
Other type of soup: _____	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other _____
Vegetables (canned, fresh or frozen)							
Broccoli	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Carrots	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Corn, creamed or niblets	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Green peas	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Spinach, cooked	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Green beans, string beans, yellow beans	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Potatoes, mashed, baked, salad or boiled	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
French fries, home fries, pan fries	○ Yes ○ No	___	○ Day ○ Week	○ 1-4 pieces	○ 5-9 pieces	○ 10 or more	Other _____
Squash, all types	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Cabbage	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Brussel sprouts	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 pieces	○ 3-4 pieces	○ ¼ cup	Other _____
Raw salad vegetables (tomato, cucumber, peppers)	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup	○ ¼ cup	○ ½ cup	Other _____
Spinach salad	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup	○ ¼ cup	○ ½ cup	Other _____
Bean salad	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Other vegetables: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

	Has your child eaten this food at least once in the last two weeks?		*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Fruit (canned, fresh, or frozen)								
Apples, applesauce	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp (⅛ small)	○ 3 Tbsp (¼ small)	○ ¼ cup (½ small)	Other _____
Bananas	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ ⅛ small	○ ¼ small	○ ½ small	Other _____
Oranges	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 sections	○ ¼-½ orange	○ 1 whole	Other _____
Grapefruit	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 sections	○ ¼ fruit	○ ¼ fruit	Other _____
Pears, peaches, nectarines, plums	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ ¼ fruit (1 Tbsp)	○ ½ fruit (⅛ cup)	○ 1 whole (¼ cup)	Other _____
Grapes	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2	○ ⅛-¼ cup	○ ½ cup	Other _____
Raisins, prunes, other dried fruit	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2	○ 3-5	○ 6-8	Other _____
Melon (eg. canteloupe, honeydew, watermelon)	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ ⅛ cup	○ ¼ cup	○ ½ cup	Other _____
Lychee	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2	○ 3-4	○ 5-6	Other _____
Strawberries	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ¼ cup	Other _____

	Has your child eaten this food at least once in the last two weeks?		*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Other berries (eg. blueberries, raspberries)	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ¼ cup	Other _____
Fruit cocktail or fresh fruit salad	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ¼ cup	Other _____
Other fruits: _____	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	usual amount _____			

Beverages

Orange juice & other citrus juices (eg. grapefruit, "Five Alive")	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Apple juice	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Other fruit juices (eg. grape, pear cranberry,papaya, pineapple)	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Prune juice	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Tomato & mixed vegetable juices (eg. V8 juice)	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Carrot juice	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Sweetened fruit drinks including crystals & boxed varieties (eg. Tang, Kool-Aid, Ribena)	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Soft drinks, regular	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Soft drinks, diet	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Carbonated fruit drinks (eg. Koala Springs, Snapple)	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Tea	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Coffee	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Other beverages: _____	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____

Desserts & Snacks

Custard	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Pudding	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Jello	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Ice cream, ice milk, sherbet, frozen yogurt	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ 1 scoop (½ cup)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Popsicle or Mr. Freezie	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other _____
Cake	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 bites	○ ½ slice	○ 1 slice	Other _____
Pop Tarts pastry	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾	Other _____
Pie	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 bites	○ 1/16 pie	○ ⅛ pie	Other _____
Fruit crisps (eg. apple crisp, berry strudel)	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 bites	○ ⅛ cup	○ ¼ cup	Other _____
Cookies (eg. peanut butter, chocolate chip, raisin, oatmeal)	○ Yes ○ No	___	○ Day ○ Week	○ ½ cookie	○ 1 whole	○ 2	Other _____
Other cookies (eg. arrowroot, digestives, teething biscuits)	○ Yes ○ No	___	○ Day ○ Week	○ ½ cookie	○ 1 whole	○ 2	Other _____
Plain or cheese crackers (eg. Ritz, cheese type, soda crackers)	○ Yes ○ No	___	○ Day ○ Week	○ 1	○ 2	○ 3	Other _____
Wheat crackers (eg. stone wheat thins, Triscuits, wholegrain soda crackers)	○ Yes ○ No	___	○ Day ○ Week	○ 1	○ 2	○ 3	Other _____
Potato chips, cheesies or tortilla chips	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 pieces	○ ¼ small bag	○ ½ small bag	Other _____
Popcorn	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 pieces	○ ¼ cup	○ ½ cup	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Peanuts, other nuts or seeds	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other _____
Other desserts & snacks: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

Miscellaneous

Chocolate bar	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ bar	○ ¼ bar	○ ½ bar	Other _____
Granola bar	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup	○ ¼ bar	○ ½ bar	Other _____
Fruit Roll-up, fruit leather	○ Yes ○ No	___	○ Day ○ Week	○ 1 square inch	○ 2 square inches	○ 1 whole	Other _____
Candy	○ Yes ○ No	___	○ Day ○ Week	○ taste	○ 1-2 pieces	○ 3-4 pieces	Other _____
Tomato ketchup	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2-3 Tbsp	Other _____
Other miscellaneous foods: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

Sugar, Fats, & Other Condiments

How often does your child eat the following foods?	Prompts:	≤ once per week	2-4 times per week	almost every day 5-7 times/week	2-3 times per day	4-5 times per day	Usual portion
Sugar	✓ cereal ✓ beverage	○	○	○	○	○	_____
Margarine or butter	✓ bread, bagels ✓ crackers ✓ muffins ✓ vegetables	○	○	○	○	○	_____
Cream cheese	✓ bread, bagels ✓ crackers ✓ muffins	○	○	○	○	○	_____
Mayonnaise	✓ bread	○	○	○	○	○	_____
Salad dressing	✓ vegetables	○	○	○	○	○	_____
Gravy	✓ vegetables ✓ meats	○	○	○	○	○	_____
Tartar sauce	✓ fish	○	○	○	○	○	_____
Sour cream	✓ vegetables	○	○	○	○	○	_____
Cheese sauce or cheese whiz	✓ vegetables ✓ noodles	○	○	○	○	○	_____
Soy sauce	✓ rice ✓ noodles ✓ vegetables	○	○	○	○	○	_____
Oyster sauce	✓ rice ✓ noodles ✓ vegetables	○	○	○	○	○	_____
Ketchup	✓ eggs ✓ meats ✓ rice ✓ vegetables	○	○	○	○	○	_____
Sweet spreads, eg. jams, jellies or honey	✓ bread, bagels ✓ crackers ✓ muffins	○	○	○	○	○	_____
Other	please specify _____	○	○	○	○	○	_____

	Has your child eaten this food at least once in the last two weeks?	*What type?*		*How many times per day or week?*	*How much does your child usually eat each time?*			
Purchased Infant, Junior & Toddler Foods								
Cereal (eg. rice, barley, oats or mixed)	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ 3 Tbsp or less dry	○ ¼ cup dry	○ ½ cup dry	Other _____
Cereal mixed with fruit and/ or yogurt	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ 3 Tbsp or less dry	○ ¼ cup dry	○ ½ cup dry	Other _____
Meat or poultry (eg. beef, pork, lamb, veal, ham, chicken or turkey)	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Liver	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Meat/poultry and rice/noodle dinner (eg. beef, pork, lamb or chicken)	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Vegetable & meat (eg. beef, pork, lamb, chicken or turkey)	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Vegetables	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more

	Has your child eaten this food at least once in the last two weeks?	*What type?*		*How many times per day or week?*	*How much does your child usually eat each time?*			
Fruits	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Prunes	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Fruit dessert (eg. Tutti Frutti)	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Fruit yogurt dessert	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Custard or pudding	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Other purchased baby foods: _____	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more

Part 2

2.1 Are you currently breast-feeding?

○ YES

○ NO

times per day ___ usual time per feeding _____

2.2 Are you currently giving your child a commercial infant formula?

○ YES [Please go to Q. 2.2(a)]

○ NO [Please go to Q. 2.3]

2.2(a)

	What brands/types of formula do you usually give your child?	Color of Label	How many times per day or week does your child drink formula?	How much does your child usually drink per feeding?
(1)	_____	_____	___times per ○ day ○ week	_____
(2)	_____	_____	___times per ○ day ○ week	_____
(3)	_____	_____	___times per ○ day ○ week	_____

2.3 Have you ever given your child a vitamin/mineral supplement?

○ YES (Please go to Q. 2.4)

○ NO

2.4

	What Brands/Types of supplements?	At what age?	About how much?	
(1)	_____	_____months to	_____mL per	○ day ○ week
	_____	_____months	_____tablet(s)	○ month
(2)	_____	_____months to	_____mL per	○ day ○ week
	_____	_____months	_____tablet(s)	○ month
(3)	_____	_____months to	_____mL per	○ day ○ week
	_____	_____months	_____tablet(s)	○ month

Please indicate the types of milk fed to your baby at the hospital and at each month during the first 26 months.

Type of Milk Feeding	Never	At Hospital	Months											
			1	2	3	4	5	6	7	8	9	10	11	12
Breast-Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Infant Formula														
Regular (low iron)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Formula with iron (fortified)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soya-based formula	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cows Milk														
Whole	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
skim milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goats Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soy Milk (not formula)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Type of Milk Feeding	Months													
	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Breast-Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Infant Formula														
Regular (low iron)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Formula with iron (fortified)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soya-based formula	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cows Milk														
Whole	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
skim milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goats Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soy Milk (not formula)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Thank you for taking the time to complete this questionnaire and for your valuable participation in this study.

MIXED DISHES MADE WITH BEEF - FFQ AVG

Serving Size: 100.00 g (3.53 oz-wt.)
Serves: 9.00
Cost: --

Amount for 9 servings	Food Item	Amount for 1 serving	Cost	Foodlist ESHA Code
100 g	Beef+Noodles+TomatoSce(Hamburger Helper)	11.1111 g	-	56153
100 g	SPAGHETTI & MEATBALLS+TOMATO SCE-RECIPE	11.1111 g	-	100418
100 g	FAST FOOD-BURRITO W/ BEEF+CHEESE+CHILIES	11.1111 g	-	103995
100 g	BEEF & VEGETABLE STEW-RECIP	11.1111 g	-	100042
100 g	CHOP SUEY WITH MEAT-RECIPE	11.1111 g	-	100188
100 g	Lasagna w/Meat-Homemade	11.1111 g	-	56108
100 g	Beef Stroganoff	11.1111 g	-	11008
100 g	Shepherd's Pie (Beef)	11.1111 g	-	56231
100 g	BEEF POT PIE-BAKED FROM RECIPE	11.1111 g	-	100045

Nutrients per Serving

Calories	149.12	Fat - Total	6.97 g
Protein	9.60 g	Saturated Fat	2.65 g
Carbohydrates	12.19 g	Vitamin A RE	48.63 RE
Dietary Fiber	0.48 g	Vitamin C	5.84 mg
% Calories from fat	42 %	% Calories from carbs	33 %

MIXED DISHES MADE WITH BEEF - FFQ AVG

Analysis Weight: 100.00 g (3.53 oz-wt.) = 6.67 Tablespoon
User Code: 506001
Cost: --
This item was last modified on 02/20/98

Food Item

Basic Components	
Calories	149.12
Protein	9.60 g
Carbohydrates	12.19 g
Dietary Fiber	0.48 g
Soluble Fiber	0.24 g
InSoluble Fiber	-- g
Sugar - Total	-- g
Monosaccharides	-- g
Disaccharides	-- g
Other Carbs	-- g
Fat - Total	6.97 g
Saturated Fat	2.65 g
Mono Fat	2.81 g
Poly Fat	0.92 g
Trans Fatty Acids	-- g
Cholesterol	31.46 mg
Water	89.99 g
Ash	1.74 g
Vitamins	
Vitamin A IU	464.18 IU
Vitamin A RE	48.63 RE
A - Beta Carotene	-- mg
A - Carotenoid	-- RE
A - Retinol	-- RE
Thiamin-B1	0.11 mg
Riboflavin-B2	0.15 mg
Niacin-B3	1.98 mg
Niacin Equiv.	0.81 mg
Vitamin-B6	0.12 mg
Vitamin-B12	0.46 mcg
Biotin	-- mcg
Vitamin C	5.84 mg
Vitamin D IU	-- IU
Vitamin D mcg	-- mcg
Vit E-Alpha Equiv.	0.26 mg
Vitamin E IU	0.39 IU
Vitamin E mg	0.26 mg
Folate	7.79 mcg
Vitamin K	-- mcg
Pantothenic Acid	0.20 mg
Minerals	
Boron	-- mg
Calcium	37.93 mg
Chloride	-- mg
Chromium	-- mcg
Copper	-- mg
Fluoride	-- mg
Iodine	-- mcg
Iron	1.59 mg
Magnesium	11.16 mg
Manganese	0.04 mg
Molybdenum	-- mcg
Phosphorus	97.83 mg
Potassium	232.56 mg
Selenium	-- mcg
Sodium	371.75 mg
Zinc	1.06 mg
Saturated Fats	
4:0-Butyric	-- g
6:0-Caproic	-- g
8:0-Caprylic	-- g
10:0-Capric	-- g
12:0-Lauric	-- g
14:0-Myristic	-- g
15:0-Pentadecanoic	-- g
16:0-Palmitic	-- g
17:0-Margaric	-- g
18:0-Stearic	-- g
20:0-Arachidic	-- g
22:0-Behenate	-- g
24:0-Lignoceric	-- g
Mono Fats	
14:1-Myristol	-- g
15:1-Pentadecenoic	-- g
16:1-Palmitol	-- g
17:1-Heptadecenoic	-- g
18:1-Oleic	-- g
20:1-Eicosen	-- g
22:1-Erucic	-- g
24:1-Nervonic	-- g
Poly Fats	
18:2-Linoleic	- g
18:3-Linolenic	- g
18:4-Stearidon	- g
20:3-Eicosatrienoic	- g
20:4-Arachidon	- g
20:5-EPA	- g
22:5-DPA	- g
22:6-DHA	- g
Other Fats	
Omega 3 Fatty Acids	- g
Omega 6 Fatty Acids	- g
Amino Acids	
Alanine	- g
Arginine	- g
Aspartate	- g
Cystine	- g
Glutamate	- g
Glycine	- g
Histidine	- g
Isoleucine	- g
Leucine	- g
Lysine	- g
Methionine	- g
Phenylalanine	- g
Proline	- g
Serine	- g
Threonine	- g
Tryptophan	- g
Tyrosine	- g
Valine	- g
Other	
Alcohol	- g
Caffeine	0 mg
Artif Sweetener - Total	- mg
Aspartame	- mg
Saccharin	- mg
Sugar Alcohol	- g
Organic Acids	- mg
Choline	- mg
Taurine	- mg

Appendix F. List of USER Codes for all Foods for which Food Composition Data was added to the ESHA Database.

ESHA	Item Name	User Code	Database
	ALACTAMIL	210012	c:\fpwin\data\user__
	All natural Teething biscuit-HT	221003	c:\fpwin\data\user__
	APPLE 3RD, GB	241048	c:\fpwin\data\user__
	APPLES, 1ST, GB, CDN	310040	c:\fpwin\data\user__
	APPLES, APPLESAUCE - FFQ AVG	509006	c:\fpwin\data\user__
	APRICOTS,3RD,GB,CDN	310032	c:\fpwin\data\user__
	Arrowhead-puffed corn cereal	272000	c:\fpwin\data\user__
	Arrowhead-puffed rice cereal	272001	c:\fpwin\data\user__
	ARROWROOT COOKIES, GB, CDN	310043	c:\fpwin\data\user__
	BANANA & CREAM-2nd-GB-Cdn	241036	c:\fpwin\data\user__
	BANANA O'S CEREAL	310001	c:\fpwin\data\user__
	Banana-2nd-GB-Cdn	241042	c:\fpwin\data\user__
	BARLEY CEREAL-1ST-DRY-GB-CDN	241000	c:\fpwin\data\user__
	BARTLETT PEARS JUNIOR, CDN	310044	c:\fpwin\data\user__
	BARTLETT PEARS, 1ST, GB, CDN	310021	c:\fpwin\data\user__
	BARTLETT PEARS, 3RD, GB, CDN	310053	c:\fpwin\data\user__
	becel margarine	300000	c:\fpwin\data\user__
	BEEF - FFQ AVG	505001	c:\fpwin\data\user__
	BEEF AND BEEF GRAVY, 2ND, GB	220103	c:\fpwin\data\user__
	BEEF STEW,3RD,GB,CDN	310030	c:\fpwin\data\user__
	beef stew-3rd-GB-Cdn	241028	c:\fpwin\data\user__
	BEEF WITH BROTH, STRAINED, HEINZ	220106	c:\fpwin\data\user__
	biter biscuit3rd-GB-Cdn	241034	c:\fpwin\data\user__
	BOK CHOY/CHOY SUM - FFQ AVG	230000	c:\fpwin\data\user__
	BONAMIL	210006	c:\fpwin\data\user__
	BONAMIL, WYETH	600007	c:\fpwin\data\user__
	Breton-50% less salt cracker	232004	c:\fpwin\data\user__
	Breton-whole wheat cracker	232003	c:\fpwin\data\user__
	BROCCOLI & CHICKEN,2ND,GB,CDN	310029	c:\fpwin\data\user__
	Broccoli & chicken-2nd GB	220052	c:\fpwin\data\user__
	BROCCOLI AND CHICKEN, 2ND, GB, CDN	310039	c:\fpwin\data\user__
	BROTH - FFQ AVG	507008	c:\fpwin\data\user__
	BROTH TYPE SOUP - FFQ AVG	507001	c:\fpwin\data\user__
	CAKE - FFQ AVG	511004	c:\fpwin\data\user__
	CANDY - FFQ AVG	512004	c:\fpwin\data\user__
	CANNED PASTA WITH MEAT - FFQ AVG	506005	c:\fpwin\data\user__
	CANNED PASTA WITHOUT MEAT - FFQ AVG	506006	c:\fpwin\data\user__
	CARNATION FOLLOW-UP FORMULA FROM POWDER		c:\fpwin\data\user__
	carnation follow-up formula-fullstrength	210026	c:\fpwin\data\user__
	carnation follow-up formula-liq conc	210007	c:\fpwin\data\user__
	Carnation Good Start	210008	c:\fpwin\data\user__
	CARROTS & BEEF,2ND,GB,CDN	310023	c:\fpwin\data\user__
	CARROTS, 1ST, GB, CDN	310037	c:\fpwin\data\user__
	CHAPATI	410003	c:\fpwin\data\user__
	CHAPATI OR ROTI - FFQ AVG	504008	c:\fpwin\data\user__
	CHEESE SAUCE OR WHIZ - FFQ AVG	513008	c:\fpwin\data\user__
	CHEESE-MOZZARELLA/PART SKIM MILK		c:\fpwin\data\user__
	CHI - BBQ PORK BUN	300020	c:\fpwin\data\user__
	CHI - BEAN CURD SHEET, MOIST		c:\fpwin\data\user__
	CHI - CHINESE BREAD, YELLOW BUN		c:\fpwin\data\user__
	CHI - DIM SUM, BEEF BALL		c:\fpwin\data\user__
	CHI - DIM SUM, BEEF RICE NOODLE		c:\fpwin\data\user__
	CHI - DRIED CRUSHED PORK	300555	c:\fpwin\data\user__
	CHI - DRIED SCALLOP		c:\fpwin\data\user__
	CHI - GLUTINOUS RICE FLOUR		c:\fpwin\data\user__
	CHI - HO FEN - RICE NOODLE	300016	c:\fpwin\data\user__
	CHI - HORLICKS DRINK		c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	CHI - INSTANT NOODLE	300010	c:\fpwin\data\user__
	CHI - JAPANESE PEAR	300021	c:\fpwin\data\user__
	CHI - LETTUCE		c:\fpwin\data\user__
	CHI - NEW YEAR CAKE, SWEET		c:\fpwin\data\user__
	CHI - PRESERVED SALTY DUCK EGG-COOKED		c:\fpwin\data\user__
	CHI - SHAN CHA		c:\fpwin\data\user__
	CHI - SHANGHAI NOODLE, COOKED		c:\fpwin\data\user__
	CHI - SPARROW NEST		c:\fpwin\data\user__
	CHI - STEAMED BUN, MANTOU	300007	c:\fpwin\data\user__
	CHI - WINTER MELON		c:\fpwin\data\user__
	Chi - Yault Drink	310046	c:\fpwin\data\user__
	CHI- BOK CHOY		c:\fpwin\data\user__
	CHI- MOA GUA/HAIRY SQUASH		c:\fpwin\data\user__
	CHI-(noodle)Lai Fan		c:\fpwin\data\user__
	CHI-(veg)Gai Lan-leaf&stem-raw		c:\fpwin\data\user__
	CHI-Anchovy fish (knife)	300002	c:\fpwin\data\user__
	CHI-CHOY SUM-RAW	230001	c:\fpwin\data\user__
	CHI-dim sum-shrimp dumpling		c:\fpwin\data\user__
	CHI-Fish sauce	300001	c:\fpwin\data\user__
	CHI-Herring fish (Flesh)		c:\fpwin\data\user__
	CHI-MIFEN-COOKED		c:\fpwin\data\user__
	CHI-PORK BONE BASED SOUP	300017	c:\fpwin\data\user__
	CHI-wheat flour string		c:\fpwin\data\user__
	CHI-WINTER MUSHROOM-RAW		c:\fpwin\data\user__
	CHICKEN AND CHICKEN GRAVY, 2ND, GB	220104	c:\fpwin\data\user__
	CHICKEN NOODLE.2ND.GB.CDN	310026	c:\fpwin\data\user__
	chicken noodle-3rd-GB-Cdn	241029	c:\fpwin\data\user__
	CHICKEN RICE W/VEG - 2ND - GB CDN	310020	c:\fpwin\data\user__
	CHICKEN RICE w/VEG, HEINZ, CDN	220051	c:\fpwin\data\user__
	CHICKEN WITH BROTH, STRAINED, HEINZ	220107	c:\fpwin\data\user__
	CHIPS/CHEESIES/TORTILLAS - FFQ AVG	511012	c:\fpwin\data\user__
	CHOCOLATE BAR - FFQ AVG	512001	c:\fpwin\data\user__
	chocolate milk 1%	220031	c:\fpwin\data\user__
	Christie-animal cracker	231010	c:\fpwin\data\user__
	Christie-arrowroot cookies	231001	c:\fpwin\data\user__
	Christie-cheese nips	231016	c:\fpwin\data\user__
	Christie-honey maid graham wafers	231000	c:\fpwin\data\user__
	Christie-multigrain thins	231005	c:\fpwin\data\user__
	Christie-peak freans shortcake biscuit	231002	c:\fpwin\data\user__
	Christie-pf arrowroot	231008	c:\fpwin\data\user__
	Christie-pf dark chocolate digestive	231003	c:\fpwin\data\user__
	Christie-quackers	231018	c:\fpwin\data\user__
	Christie-ritz bits cheese	231017	c:\fpwin\data\user__
	Christie-stonewheat thins	231004	c:\fpwin\data\user__
	Christie-stonewheat thins losalt	231011	c:\fpwin\data\user__
	COLD CEREALS, BRAN/MULTIGRAIN - FFQ AVG	503003	c:\fpwin\data\user__
	COLD CEREALS, PLAIN - FFQ AVG	503002	c:\fpwin\data\user__
	COOKIES - FFQ AVG	511007	c:\fpwin\data\user__
	CORN & BUTTERNUT SQUASH, EB	310048	c:\fpwin\data\user__
	CORN, CREAMED OR NIBLETS - FFQ AVG	508001	c:\fpwin\data\user__
	COTTAGE CHEESE, 1% OR 2% - FFQ AVG	502005	c:\fpwin\data\user__
	CREAM CHEESE - FFQ AVG	513003	c:\fpwin\data\user__
	CREAM TYPE SOUP - FFQ AVG	507002	c:\fpwin\data\user__
	D Vi Sol	290004	c:\fpwin\data\user__
	Dad's raisin oatmeal cookies	231006	c:\fpwin\data\user__
	Dad's-oatmeal cookies	231007	c:\fpwin\data\user__
	Dare-cinnamon snaps, lofat	232000	c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	Dare-digestive cookies	232001	c:\fpwin\data\user__
	DUCK - FFQ AVG	505006	c:\fpwin\data\user__
	EB DINNER - PASTA	210023	c:\fpwin\data\user__
	EB VEGETABLE SOUFFLE	514024	c:\fpwin\data\user__
	ENCHILADA, CHEESE - FFQ AVG	506009	c:\fpwin\data\user__
	ENCHILADA, MEAT FILLED - FFQ AVG	506010	c:\fpwin\data\user__
	Enfalac 20 w/out iron	210032	c:\fpwin\data\user__
	ENFALAC NEXT STEP, MJ	600001	c:\fpwin\data\user__
	ENFALAC W/IRON	600003	c:\fpwin\data\user__
	Enfalac w/iron-powder	210027	c:\fpwin\data\user__
	ENFALAC WITH IRON 20 CAL/OZ	210019	c:\fpwin\data\user__
	ENGLISH MUFFIN - ROMAN MEAL	270020	c:\fpwin\data\user__
	Escort-garden vegetable cracker		c:\fpwin\data\user__
	Escort-thin wheat cracker	231020	c:\fpwin\data\user__
	FARLEYS BISCUIT	72889	c:\fpwin\data\user__
	FIRM OR MEDIUM TOFU - FFQ AVG	505011	c:\fpwin\data\user__
	FISH - FFQ AVG	505007	c:\fpwin\data\user__
	FISH SOUP - FFQ AVG	507006	c:\fpwin\data\user__
	Five Alive Popdrink	261002	c:\fpwin\data\user__
	Fletcher's premium all meat frank	280000	c:\fpwin\data\user__
	FRENCH/PAN FRIES - FFQ AVG	508004	c:\fpwin\data\user__
	FRUIT COCKTAIL/SALAD - FFQ AVG	509005	c:\fpwin\data\user__
	FRUIT CRISPS - FFQ AVG	511006	c:\fpwin\data\user__
	FRUIT LEATHER/ROLL-UP - FFQ AVG	512003	c:\fpwin\data\user__
	GARDEN VEGETABLE.2ND.GB.CDN	310028	c:\fpwin\data\user__
	garden vegetables EB	220034	c:\fpwin\data\user__
	General Mills-cheerios	273001	c:\fpwin\data\user__
	GERBER BARLEY CEREAL 1ST. CDN. GB	310014	c:\fpwin\data\user__
	Golden Harvest Vegetable-EB	220030	c:\fpwin\data\user__
	GRANOLA - FFQ AVG	503004	c:\fpwin\data\user__
	GRANOLA BAR - FFQ AVG	512002	c:\fpwin\data\user__
	GRAVY - FFQ AVG	513006	c:\fpwin\data\user__
	Green beans & rice-EB	240001	c:\fpwin\data\user__
	Green beans-1st-GB-Cdn	241043	c:\fpwin\data\user__
	GREEN/STRING/YELLOW BEANS - FFQ AVG	508002	c:\fpwin\data\user__
	HAM WITH BROTH	220108	c:\fpwin\data\user__
	HARD CHEESE - FFQ AVG	502001	c:\fpwin\data\user__
	HEINZ - BARTLETT PEARS. BEGINNER		c:\fpwin\data\user__
	HEINZ APPLE JUICE. STR	220079	c:\fpwin\data\user__
	Heinz apple raisin-strained	220045	c:\fpwin\data\user__
	HEINZ APPLESAUCE, JR	220074	c:\fpwin\data\user__
	Heinz Barley Cereal, Cdn, Dry	220036	c:\fpwin\data\user__
	HEINZ BEEF NOODLES W/ VEG. CDN	220041	c:\fpwin\data\user__
	HEINZ BEEF STEW, JR, CDN	220047	c:\fpwin\data\user__
	HEINZ CARROTS. BEGINNER. CDN. 1ST STEP	220067	c:\fpwin\data\user__
	Heinz chicken with rice-strained	220044	c:\fpwin\data\user__
	Heinz corn-junior	220042	c:\fpwin\data\user__
	Heinz garden vegetables-junior	220043	c:\fpwin\data\user__
	Heinz green beans-junior	220048	c:\fpwin\data\user__
	Heinz Infantsoy Cereal	220038	c:\fpwin\data\user__
	HEINZ MIXED CEREAL W/ FRUIT. CDN	220039	c:\fpwin\data\user__
	HEINZ MIXED CEREAL, DRY. CDN	220082	c:\fpwin\data\user__
	Heinz mixed fruit-strained	220040	c:\fpwin\data\user__
	Heinz mixed vegetables-junior	220050	c:\fpwin\data\user__
	heinz nutrios cereal	220035	c:\fpwin\data\user__
	HEINZ OATMEAL CEREAL. DRY. CDN	220075	c:\fpwin\data\user__
	HEINZ PEACH YOGURT. STR	220071	c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	HEINZ PORK VEG CASSEROLE, TODDLER, CDN	310011	c:\fpwin\data\user__
	HEINZ RICE CEREAL, DRY, CDN	22065	c:\fpwin\data\user__
	HEINZ SWEET POTATOES, BEGINNER	220058	c:\fpwin\data\user__
	HEINZ SWEET POTATOES, JR	220059	c:\fpwin\data\user__
	Heinz turkey stew - junior		c:\fpwin\data\user__
	Heinz Tutti Frutti dessert-Junior	220037	c:\fpwin\data\user__
	Heinz vegetables and chicken-junior	220046	c:\fpwin\data\user__
	HEINZ WAX BEANS, BEGINNER, CDN	220049	c:\fpwin\data\user__
	Heinz-mixed fruit-junior	220053	c:\fpwin\data\user__
	Heinz-strawberries-junior	220054	c:\fpwin\data\user__
	Heinz-vegetables & ham-strained-Cdn	220083	c:\fpwin\data\user__
	HOMEMADE BROTH SOUP W/MEAT	507004	c:\fpwin\data\user__
	HOMEMADE PASTA AND CHEESE - FFQ AVG	506007	c:\fpwin\data\user__
	HOTDOG/HAMBURGER BUN - FFQ AVG	504005	c:\fpwin\data\user__
	HT BROWN RICE CEREAL	220028	c:\fpwin\data\user__
	Hugga bear-HT	221005	c:\fpwin\data\user__
	HUMMOUS FFQ	505016	c:\fpwin\data\user__
	ICE CREAM/MILK/SHERBET/YOGURT - FFQ AVG	511002	c:\fpwin\data\user__
	INFANT CEREAL - FFQ AVG	514001	c:\fpwin\data\user__
	INFANT CEREAL W/FRUIT/YOGURT - FFQ AVG	514002	c:\fpwin\data\user__
	INFANT CUSTARD OR PUDDING, JR - FFQ AVG	514011-2	c:\fpwin\data\user__
	INFANT CUSTARD OR PUDDING, STR - FFQ AVG	514011-1	c:\fpwin\data\user__
	INFANT CUSTARD OR PUDDING, TOD - FFQ AVG	514011-3	c:\fpwin\data\user__
	INFANT FDS, FRUIT DESSERT, JR - FFQ AVG	514009-2	c:\fpwin\data\user__
	INFANT FDS, FRUIT DESSERT, STR - FFQ AVG	514009-1	c:\fpwin\data\user__
	INFANT FDS, FRUIT DESSERT,TOD-FFQ AVG	514009-3	c:\fpwin\data\user__
	INFANT FDS, MEAT & POULTRY, JR- FFQ AVG	514003-2	c:\fpwin\data\user__
	INFANT FDS, MEAT & POULTRY, STR- FFQ AVG	514003-1	c:\fpwin\data\user__
	INFANT FDS, VEGETABLES, TOD-FFQ AVG	514006-3	c:\fpwin\data\user__
	INFANT FOODS, FRUITS, JR - FFQ AVG	514007-2	c:\fpwin\data\user__
	INFANT FOODS, FRUITS, STR - FFQ AVG	514007-1	c:\fpwin\data\user__
	INFANT FOODS, FRUITS, TOD - FFQ AVG	514007-3	c:\fpwin\data\user__
	INFANT FOODS, PRUNES, JR - FFQ AVG	514008-2	c:\fpwin\data\user__
	INFANT FOODS, PRUNES, STR - FFQ AVG	514008-1	c:\fpwin\data\user__
	INFANT FOODS, VEGETABLES, JR - FFQ AVG	514006-2	c:\fpwin\data\user__
	INFANT FOODS, VEGETABLES, STR - FFQ AVG	514006-1	c:\fpwin\data\user__
	INFANT FRUIT JUICE - FFQ AVG	514020	c:\fpwin\data\user__
	INFANT FRUIT YOG DESSERT, JR - FFQ AVG	514010-2	c:\fpwin\data\user__
	INFANT FRUIT YOG DESSERT, STR - FFQ AVG	514010-1	c:\fpwin\data\user__
	INFANT MEAT & RICE/NOODLE, STR-FFQ AVG	514004-1	c:\fpwin\data\user__
	INFANT MEAT & RICE/NOODLE,JR-FFQ	514004-2	c:\fpwin\data\user__
	INFANT MEAT & RICE/NOODLE,TOD-FFQ AVG	514004-3	c:\fpwin\data\user__
	INFANT MEAT AND RICE/NOODLE - FFQ AVG	514004	c:\fpwin\data\user__
	INFANT VEG AND MEAT, TOD-FFQ AVG	514005-3	c:\fpwin\data\user__
	INFANT VEGETABLE AND MEAT - FFQ AVG	514005	c:\fpwin\data\user__
	INFANT VEGETABLE AND MEAT, STR-FFQ AVG	514005-1	c:\fpwin\data\user__
	INFANT VEGETABLE AND MEAT,JR-FFQ AVG	514005-2	c:\fpwin\data\user__
	Instant brown rice cereal - HT	221000	c:\fpwin\data\user__
	Instant oatmeal w/banana cereal-HT	221002	c:\fpwin\data\user__
	ISOMIL DF	210010	c:\fpwin\data\user__
	KASHI INFANT CEREAL, 7 GRAIN	310000	c:\fpwin\data\user__
	Kellogg's corn pops	270000	c:\fpwin\data\user__
	Kellogg's crispix	270003	c:\fpwin\data\user__
	kellogg's Cruncheroos w/honey	270007	c:\fpwin\data\user__
	Kellogg's Froot loops	270001	c:\fpwin\data\user__
	Kellogg's Nutri-grain bar-apple cinnamon	270002	c:\fpwin\data\user__
	Kellogg's Nutrigrain Bars-peach	270008	c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	Kellogg's Rice Krispies	270005	c:\fpwin\data\user__
	Kellogg's-Apple Crisp Muslix	270006	c:\fpwin\data\user__
	Kellogg's-Frosted Flakes	270004	c:\fpwin\data\user__
	KFT - PEANUT BUTTER - SMOOTH		c:\fpwin\data\user__
	Kindervital Multivitamin Supplement	290000	c:\fpwin\data\user__
	Kraft-blackberry jelly	263000	c:\fpwin\data\user__
	Kraft-light peanut butter smooth	263002	c:\fpwin\data\user__
	Kraft-miracle whip	262003	c:\fpwin\data\user__
	Kraft-peanut butter smooth	263001	c:\fpwin\data\user__
	LAMB - FFQ AVG	505003	c:\fpwin\data\user__
	LAMB WITH LAMB BROTH, STRAINED, HEINZ	220109	c:\fpwin\data\user__
	Lasagna w/meat sauce-3rd GB	220055	c:\fpwin\data\user__
	LEGUMES, ALL TYPES - FFQ AVG	505013	c:\fpwin\data\user__
	LENTILS & BROWN RICE - EB	240004	c:\fpwin\data\user__
	Libby's maple style beans	281001	c:\fpwin\data\user__
	Libby's-brown beans in tomato sauce	281000	c:\fpwin\data\user__
	LITE PROCESSED CHEESE - FFQ AVG	502004	c:\fpwin\data\user__
	LIVER, ANY TYPE - FFQ AVG	505004	c:\fpwin\data\user__
	LOW FAT, PART SKIM CHEESE - FFQ AVG	502002	c:\fpwin\data\user__
	MACARONI TOMATO BEEF 2ND, GB	310015	c:\fpwin\data\user__
	MACARONI TOMATO BEEF, 3RD, GB, CDN	241040	c:\fpwin\data\user__
	Maple arrowroot-HT	221001	c:\fpwin\data\user__
	MARGARINE OR BUTTER - FFQ AVG	513002	c:\fpwin\data\user__
	MAYONNAISE - FFQ AVG	513004	c:\fpwin\data\user__
	McCain-orange peach punch	261000	c:\fpwin\data\user__
	McCain-Take 5 fruit punch	261001	c:\fpwin\data\user__
	McCain-tropical rev. fruit beverage		c:\fpwin\data\user__
	McDonald's-personal deluxe pizza	262001	c:\fpwin\data\user__
	MELON - FFQ AVG	509003	c:\fpwin\data\user__
	milupa babyfood - mixed vegetable	210031	c:\fpwin\data\user__
	Milupa babyfood, mixed cereal w/4 fruits	210003	c:\fpwin\data\user__
	Milupa babyfood, mixed cereal w/fruits	210025	c:\fpwin\data\user__
	Milupa babyfood-6 grain mixed cereal	210030	c:\fpwin\data\user__
	MILUPA CEREAL W/MIXED VEG	514022	c:\fpwin\data\user__
	Milupa oatmeal cereal	210028	c:\fpwin\data\user__
	Milupa rice cereal	210027	c:\fpwin\data\user__
	Milupa toddler b'fast-granulated biscuit	210023	c:\fpwin\data\user__
	Milupa toddler milk muesli w/fruit & nut	210029	c:\fpwin\data\user__
	MILUPA-babyfood mixed cereal	210026	c:\fpwin\data\user__
	Milupa-BF-banana rice cereal		c:\fpwin\data\user__
	Milupa-Milumil Full strength	210005	c:\fpwin\data\user__
	Milupa-todder-rice cereal,yogurt&fruit		c:\fpwin\data\user__
	MINI BAGEL, HORS D'OEURVES, OLAFSON'S	250003	c:\fpwin\data\user__
	MINIGO	200002	c:\fpwin\data\user__
	MINIGO	200002	c:\fpwin\data\user__
	MIXED CEREAL W/FRUIT, 2ND, GB, CDN	310052	c:\fpwin\data\user__
	MIXED CEREAL, 1ST, DRY, GB, CDN	310037	c:\fpwin\data\user__
	MIXED DISHES MADE WITH BEEF - FFQ AVG	506001	c:\fpwin\data\user__
	MIXED DISHES MADE WITH FISH - FFQ AVG	506002	c:\fpwin\data\user__
	MIXED DISHES MADE WITH LAMB - FFQ AVG	506004	c:\fpwin\data\user__
	MIXED DISHES MADE WITH LEGUMES - FFQ AVG	506011	c:\fpwin\data\user__
	MIXED DISHES MADE WITH PORK - FFQ AVG	506003	c:\fpwin\data\user__
	MIXED DISHES W/TOFU	506018	c:\fpwin\data\user__
	MIXED DISHES W/VEGETABLES - FFQ AVG	506017	c:\fpwin\data\user__
	MIXED DISHES WITH CHICKEN - FFQ AVG	506015	c:\fpwin\data\user__
	MIXED FRUIT 2ND, GB	310019	c:\fpwin\data\user__
	Mixed grain cereal-HT	221004	c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	MIXED VEGETABLES 2ND, GB	310018	c:\fpwin\data\user__
	Multigrain cheerio-Gen. Mills		c:\fpwin\data\user__
	Multigrain rice cake	231015	c:\fpwin\data\user__
	Newton-fig cookies	231012	c:\fpwin\data\user__
	NEXT STEP	210002	c:\fpwin\data\user__
	Nursoy-Full strength	210016	c:\fpwin\data\user__
	Nutramigen MJ	210017	c:\fpwin\data\user__
	OATMEAL W/BANANA & APPLE, GB, CDN	310050	c:\fpwin\data\user__
	Oatmeal cereal w/banana&apple-GB	241039	c:\fpwin\data\user__
	OATMEAL CEREAL,1ST,GB,CDN	241002	c:\fpwin\data\user__
	Oatmeal Cereal-1st-dry GB	241002	c:\fpwin\data\user__
	Olafson's multigrain bagel	250000	c:\fpwin\data\user__
	Olafson's sesame bagel	250001	c:\fpwin\data\user__
	Olafson's Whole wheat pita bread	250002	c:\fpwin\data\user__
	Olafson's-poppyseed bagel	250003	c:\fpwin\data\user__
	ORANGE, CITRUS JUICES - FFQ AVG	510001	c:\fpwin\data\user__
	Oreo-regular	231021	c:\fpwin\data\user__
	OTHER BERRIES (NOT STRAW) - FFQ AVG	509004	c:\fpwin\data\user__
	OTHER COOKIES (PLAIN) - FFQ AVG	511008	c:\fpwin\data\user__
	OTHER FRUIT JUICES - FFQ AVG	510002	c:\fpwin\data\user__
	PABLUM MIXED CEREAL W/FRUIT, CDN	310047	c:\fpwin\data\user__
	PABLUM MIXED CEREAL, DRY, CDN	220102	c:\fpwin\data\user__
	PABLUM OATMEAL CEREAL, CDN	220100	c:\fpwin\data\user__
	PABLUM RICE CEREAL	220101	c:\fpwin\data\user__
	PANCAKE SMALL MIX+EGG+MILK-PLAIN/BTRMLK	270010	c:\fpwin\data\user__
	PANCAKES, WAFFLES, FRENCH TST - FFQ AVG	504006	c:\fpwin\data\user__
	Paneer	410001	c:\fpwin\data\user__
	PARANTHA, PLAIN	410002	c:\fpwin\data\user__
	PARTSKIM CHEESE/REG MOZZA - FFQ AVG		c:\fpwin\data\user__
	Pasta dinner - EB	220029	c:\fpwin\data\user__
	PASTRY/PIE, MEAT FILLED - FFQ AVG	506008	c:\fpwin\data\user__
	Peach, Oatmeal, Banana-EB	240002	c:\fpwin\data\user__
	PEACHES 3RD, GB, CDN	310054	c:\fpwin\data\user__
	PEACHES, JR, HEINZ, CDN	220063	c:\fpwin\data\user__
	PEACHES,1ST,GB,CDN	310022	c:\fpwin\data\user__
	PEANUTS, NUTS, SEEDS - FFQ AVG	511011	c:\fpwin\data\user__
	PEAR/PEACH/PLUM/NECTARINE - FFQ AVG	509001	c:\fpwin\data\user__
	Peas & brown rice-EB	240006	c:\fpwin\data\user__
	Perogy-Potato & Cheddar Cheese	262002	c:\fpwin\data\user__
	PEROGY-POTATO CHEDDAR CHEESE-CHEEMO-CDN	270011	c:\fpwin\data\user__
	PEROGY-POTATO ONION-CHEEMO-CDN	270012	c:\fpwin\data\user__
	PIE - FFQ AVG	511005	c:\fpwin\data\user__
	PITA, BAGEL, ENGLISH MUFFIN - FFQ AVG	504003	c:\fpwin\data\user__
	PIZZA POCKETS/ROLLS - FFQ AVG	506012	c:\fpwin\data\user__
	PIZZA WITH MEAT - FFQ AVG	506013	c:\fpwin\data\user__
	PLAIN OR CHEESE CRACKERS - FFQ AVG	511009	c:\fpwin\data\user__
	Plums,Banana&Rice-EB	240005	c:\fpwin\data\user__
	Poly Vi Flor	290003	c:\fpwin\data\user__
	Poly Vi Sol	290002	c:\fpwin\data\user__
	POPSICLE OR MR. FREEZIE - FFQ AVG	511003	c:\fpwin\data\user__
	PORK - FFQ AVG	505002	c:\fpwin\data\user__
	potato & green bean dinner-EB	220033	c:\fpwin\data\user__
	POTATOES, MASHED/BOILED - FFQ AVG	508003	c:\fpwin\data\user__
	POULTRY - FFQ AVG	505005	c:\fpwin\data\user__
	Premium plus-plain cracker	231013	c:\fpwin\data\user__
	Premium plus-souper shapes	231009	c:\fpwin\data\user__
	PROCESSED CHEESE - FFQ AVG	502003	c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	PROCESSED MEATS - FFQ AVG	505010	c:\fpwin\data\user__
	Prunes & oatmeal-EB	240005	c:\fpwin\data\user__
	PRUNES, 2ND, GB, CDN	310034	c:\fpwin\data\user__
	PUDDING - FFQ AVG	511001	c:\fpwin\data\user__
	Quaker-banana nut lofat Grnla bar	271005	c:\fpwin\data\user__
	Quaker-cinnamon & spice I.Q.O	271000	c:\fpwin\data\user__
	Quaker-granola bar-Lofat apple berry	271001	c:\fpwin\data\user__
	Quaker-large flake oats	271002	c:\fpwin\data\user__
	Quaker-rice cake w/butter	271004	c:\fpwin\data\user__
	Quaker-rice cake w/cheddar	271003	c:\fpwin\data\user__
	QUICHE, 3 CHEESE, POUR-A-QUICHE	270015	c:\fpwin\data\user__
	RAISINS, DRIED FRUIT - FFQ AVG	509002	c:\fpwin\data\user__
	RAW SALAD VEGETABLES - FFQ AVG	508006	c:\fpwin\data\user__
	RICE CAKES - FFQ AVG	504009	c:\fpwin\data\user__
	RICE CEREAL 1ST DRY GB CDN	241001	c:\fpwin\data\user__
	RICE CONGEE, WATERY	420001	c:\fpwin\data\user__
	RICE CONGEE, WITH MEAT	420004	c:\fpwin\data\user__
	RICE DREAM	200001	c:\fpwin\data\user__
	RICE, SOFT 6:1	420002	c:\fpwin\data\user__
	RICOTTA/FETA - FFQ AVG	502011	c:\fpwin\data\user__
	ROGER		c:\fpwin\data\user__
	ROTI	410004	c:\fpwin\data\user__
	SALAD DRESSING - FFQ AVG	513005	c:\fpwin\data\user__
	SAUSAGES - FFQ AVG	505009	c:\fpwin\data\user__
	SHELLFISH - FFQ AVG	505008	c:\fpwin\data\user__
	SIM 20 WITH WHEY PLUS IRON	210011	c:\fpwin\data\user__
	SIMILAC 20 WITH WHEY		c:\fpwin\data\user__
	SIMILAC ADVANCE	600009	c:\fpwin\data\user__
	SIMILAC LF	210013	c:\fpwin\data\user__
	SIMILAC LF, ROSS	600005	c:\fpwin\data\user__
	SIMILAC20 WITH IRON	210001	c:\fpwin\data\user__
	SnackWell's potatoes thins-cheddar	231014	c:\fpwin\data\user__
	Snackwell-wheat cracker	231019	c:\fpwin\data\user__
	SOFT DRINKS, DIET - FFQ AVG	510006	c:\fpwin\data\user__
	SOFT DRINKS, REGULAR - FFQ AVG	510005	c:\fpwin\data\user__
	SOFT OR DESSERT TOFU - FFQ AVG	505012	c:\fpwin\data\user__
	SOUP WITH BONES AND MEAT - FFQ AVG	507003	c:\fpwin\data\user__
	SOUR CREAM - FFQ AVG	513007	c:\fpwin\data\user__
	SOY OR VEGETABLE PATTY - FFQ AVG	505014	c:\fpwin\data\user__
	SOY OR VEGETABLE WIENER - FFQ AVG	505015	c:\fpwin\data\user__
	Soya Loaf	200027	c:\fpwin\data\user__
	SOYA YOGURT HONEY-VANILLA 1.6% M.F., JF	262000	c:\fpwin\data\user__
	SOYALAC INFANT FORMULA	210004	c:\fpwin\data\user__
	SPAGHETTI TOMATO BEEF, 3RD. GB. CDN	310051	c:\fpwin\data\user__
	spaghetti with cheese EB	220026	c:\fpwin\data\user__
	Spinach & potatoes-EB	240000	c:\fpwin\data\user__
	SPINACH SALAD - FFQ AVG	508007	c:\fpwin\data\user__
	SQUASH, ALL TYPES - FFQ AVG	508005	c:\fpwin\data\user__
	SQUASH,1ST,GB,CDN	310025	c:\fpwin\data\user__
	STRAWBERRIES,2ND,GB,CDN	310045	c:\fpwin\data\user__
	Strawberries-3rd-GB-Cdn	241041	c:\fpwin\data\user__
	SUGAR - FFQ AVG	513001	c:\fpwin\data\user__
	summer vegetables EB	220032	c:\fpwin\data\user__
	Sweet potato-1st-GB-Cdn	241044	c:\fpwin\data\user__
	SWEET POTATOES,3RD,GB,CDN	310024	c:\fpwin\data\user__
	SWEET SPREADS, JAM - FFQ AVG	513009	c:\fpwin\data\user__
	SWEETENED FRUIT DRINK - FFQ AVG	510004	c:\fpwin\data\user__

ESHA	Item Name	User Code	Database
	SWEETENED SOYA BEVERAGE	200012	c:\fpwin\data\user__
	TATER GEMS, CARNATION, BAKED	270009	c:\fpwin\data\user__
	TOFU - ALMOND DESSERT	200025	c:\fpwin\data\user__
	TOFU - DESSERT	200024	c:\fpwin\data\user__
	TOFU - EXTRA FIRM	200021	c:\fpwin\data\user__
	TOFU - HERB	200026	c:\fpwin\data\user__
	TOFU - MEDIUM FIRM	200022	c:\fpwin\data\user__
	TOFU - SOFT	200023	c:\fpwin\data\user__
	TOMATO & MIXED VEG JUICE - FFQ AVG	510003	c:\fpwin\data\user__
	TORTILLA - FFQ AVG	410005	c:\fpwin\data\user__
	Tri Vi Sol	290001	c:\fpwin\data\user__
	TROPICAL FRUIT MEDLEY, 2ND, GB, CDN	310042	c:\fpwin\data\user__
	TURKEY WITH BROTH, STRAINED, HEINZ	220110135	c:\fpwin\data\user__
	UNSWEETENED SOYA BEVERAGE	200013	c:\fpwin\data\user__
	VANILLA CUSTARD DESSERT-2nd-GB-Cdn	241037	c:\fpwin\data\user__
	VEAL AND VEAL GRAVY, 2ND, GB	220105	c:\fpwin\data\user__
	VEAL WITH BROTH, STRAINED, HEINZ	220110	c:\fpwin\data\user__
	Veg chicken-3rd-GB-Cdn	241030	c:\fpwin\data\user__
	VEGETABLE BEEF 2ND, GB	310016	c:\fpwin\data\user__
	VEGETABLE HAM DINNER,3RD,GB,CDN	310031	c:\fpwin\data\user__
	VEGETABLE TURKEY,2ND,GB,CDN	310027	c:\fpwin\data\user__
	Vitalac	210009	c:\fpwin\data\user__
	Vitasoy	200028	c:\fpwin\data\user__
	WAFFLE-KELLOGG NUTRIGRAIN OAT & WHEAT	270014	c:\fpwin\data\user__
	WAFFLE-KELLOGG NUTRIGRAIN WHEAT BRAN	270013	c:\fpwin\data\user__
	WAFFLE-KELLOGG NUTRIGRAIN, HIGH FIBRE		c:\fpwin\data\user__
	WGRAIN PANCAKE, WAFFLE - FFQ AVG	504007	c:\fpwin\data\user__
	WGRAIN PITA, BAGEL, ENG MUF - FFQ AVG	504004	c:\fpwin\data\user__
	WHEAT CRACKERS - FFQ AVG	511010	c:\fpwin\data\user__
	WHITE BREAD/ROLL - FFQ AVG	504001	c:\fpwin\data\user__
	WHOLE EGG, ALL TYPES - FFQ AVG	502007	c:\fpwin\data\user__
	WHOLE GRAIN BREAD/ROLL - FFQ AVG	504002	c:\fpwin\data\user__
	WHOLE GRAIN HOT CEREALS - FFQ AVG	503001	c:\fpwin\data\user__
	Winter squash-EB	240003	c:\fpwin\data\user__
	YAM/SWEET POTATO - FFQ AVG	508008	c:\fpwin\data\user__
	YELLOW BEANS, 1ST, DRY, GB, CDN	310038	c:\fpwin\data\user__
	YOGURT, 1% - 2% - FFQ AVG	502009	c:\fpwin\data\user__
	YOGURT, 2% - 4% - FFQ AVG	502008	c:\fpwin\data\user__
	Yves-chili dog	260004	c:\fpwin\data\user__
	Yves-jumbo veggie dog (hot & spicy)	260005	c:\fpwin\data\user__
	Yves-tofu wiener	260001	c:\fpwin\data\user__
	Yves-vegetable burger	260002	c:\fpwin\data\user__
	Yves-vegetable patty	260000	c:\fpwin\data\user__
	Yves-veggie wiener	260003	c:\fpwin\data\user__

Search Results (Preview Food Item Record)

Names containing: ffq avg

ESHA	Item Name	User Code	Database
	APPLES, APPLESAUCE - FFQ AVG	509006	c:\fpwin\data\user__
	BEEF - FFQ AVG	505001	c:\fpwin\data\user__
	BOK CHOY/CHOY SUM - FFQ AVG	230000	c:\fpwin\data\user__
	BROTH - FFQ AVG	507008	c:\fpwin\data\user__
	BROTH TYPE SOUP - FFQ AVG	507001	c:\fpwin\data\user__
	CAKE - FFQ AVG	511004	c:\fpwin\data\user__
	CANDY - FFQ AVG	512004	c:\fpwin\data\user__
	CANNED PASTA WITH MEAT - FFQ AVG	506005	c:\fpwin\data\user__
	CANNED PASTA WITHOUT MEAT - FFQ AVG	506006	c:\fpwin\data\user__
	CHAPATI OR ROTI - FFQ AVG	504008	c:\fpwin\data\user__
	CHEESE SAUCE OR WHIZ - FFQ AVG	513008	c:\fpwin\data\user__
	CHIPS/CHEESIES/TORTILLAS - FFQ AVG	511012	c:\fpwin\data\user__
	CHOCOLATE BAR - FFQ AVG	512001	c:\fpwin\data\user__
	COLD CEREALS, BRAN/MULTIGRAIN - FFQ AVG	503003	c:\fpwin\data\user__
	COLD CEREALS, PLAIN - FFQ AVG	503002	c:\fpwin\data\user__
	COOKIES - FFQ AVG	511007	c:\fpwin\data\user__
	CORN, CREAMED OR NIBLETS - FFQ AVG	508001	c:\fpwin\data\user__
	COTTAGE CHEESE, 1% OR 2% - FFQ AVG	502005	c:\fpwin\data\user__
	CREAM CHEESE - FFQ AVG	513003	c:\fpwin\data\user__
	CREAM TYPE SOUP - FFQ AVG	507002	c:\fpwin\data\user__
	DUCK - FFQ AVG	505006	c:\fpwin\data\user__
	ENCHILADA, CHEESE - FFQ AVG	506009	c:\fpwin\data\user__
	ENCHILADA, MEAT FILLED - FFQ AVG	506010	c:\fpwin\data\user__
	FIRM OR MEDIUM TOFU - FFQ AVG	505011	c:\fpwin\data\user__
	FISH - FFQ AVG	505007	c:\fpwin\data\user__
	FISH SOUP - FFQ AVG	507006	c:\fpwin\data\user__
	FRENCH/PAN FRIES - FFQ AVG	508004	c:\fpwin\data\user__
	FRUIT COCKTAIL/SALAD - FFQ AVG	509005	c:\fpwin\data\user__
	FRUIT CRISPS - FFQ AVG	511006	c:\fpwin\data\user__
	FRUIT LEATHER/ROLL-UP - FFQ AVG	512003	c:\fpwin\data\user__
	GRANOLA - FFQ AVG	503004	c:\fpwin\data\user__
	GRANOLA BAR - FFQ AVG	512002	c:\fpwin\data\user__
	GRAVY - FFQ AVG	513006	c:\fpwin\data\user__
	GREEN/STRING/YELLOW BEANS - FFQ AVG	508002	c:\fpwin\data\user__
	HARD CHEESE - FFQ AVG	502001	c:\fpwin\data\user__
	HOMEMADE PASTA AND CHEESE - FFQ AVG	506007	c:\fpwin\data\user__
	HOTDOG/HAMBURGER BUN - FFQ AVG	504005	c:\fpwin\data\user__
	ICE CREAM/MILK/SHERBET/YOGURT - FFQ AVG	511002	c:\fpwin\data\user__
	INFANT CEREAL - FFQ AVG	514001	c:\fpwin\data\user__
	INFANT CEREAL W/FRUIT/YOGURT - FFQ AVG	514002	c:\fpwin\data\user__
	INFANT CUSTARD OR PUDDING, JR - FFQ AVG	514011-2	c:\fpwin\data\user__
	INFANT CUSTARD OR PUDDING, STR - FFQ AVG	514011-1	c:\fpwin\data\user__
	INFANT CUSTARD OR PUDDING, TOD - FFQ AVG	514011-3	c:\fpwin\data\user__
	INFANT FDS, FRUIT DESSERT, JR - FFQ AVG	514009-2	c:\fpwin\data\user__
	INFANT FDS, FRUIT DESSERT, STR - FFQ AVG	514009-1	c:\fpwin\data\user__
	INFANT FDS, FRUIT DESSERT,TOD-FFQ AVG	514009-3	c:\fpwin\data\user__
	INFANT FDS, MEAT & POULTRY, JR- FFQ AVG	514003-2	c:\fpwin\data\user__
	INFANT FDS, MEAT & POULTRY, STR- FFQ AVG	514003-1	c:\fpwin\data\user__
	INFANT FDS, VEGETABLES, TOD-FFQ AVG	514006-3	c:\fpwin\data\user__
	INFANT FOODS, FRUITS, JR - FFQ AVG	514007-2	c:\fpwin\data\user__
	INFANT FOODS, FRUITS, STR - FFQ AVG	514007-1	c:\fpwin\data\user__
	INFANT FOODS, FRUITS, TOD - FFQ AVG	514007-3	c:\fpwin\data\user__
	INFANT FOODS, PRUNES, JR - FFQ AVG	514008-2	c:\fpwin\data\user__
	INFANT FOODS, PRUNES, STR - FFQ AVG	514008-1	c:\fpwin\data\user__
	INFANT FOODS, VEGETABLES, JR - FFQ AVG	514006-2	c:\fpwin\data\user__

Search Results (Preview Food Item Record)

Names containing: ffq avg

ESHA	Item Name	User Code	Database
	INFANT FOODS, VEGETABLES, STR - FFQ AVG	514006-1	c:\fpwin\data\user__
	INFANT FRUIT JUICE - FFQ AVG	514020	c:\fpwin\data\user__
	INFANT FRUIT YOG DESSERT, JR - FFQ AVG	514010-2	c:\fpwin\data\user__
	INFANT FRUIT YOG DESSERT, STR - FFQ AVG	514010-1	c:\fpwin\data\user__
	INFANT MEAT & RICE/NOODLE, STR-FFQ AVG	514004-1	c:\fpwin\data\user__
	INFANT MEAT & RICE/NOODLE,TOD-FFQ AVG	514004-3	c:\fpwin\data\user__
	INFANT MEAT AND RICE/NOODLE - FFQ AVG	514004	c:\fpwin\data\user__
	INFANT VEG AND MEAT, TOD-FFQ AVG	514005-3	c:\fpwin\data\user__
	INFANT VEGETABLE AND MEAT - FFQ AVG	514005	c:\fpwin\data\user__
	INFANT VEGETABLE AND MEAT, STR-FFQ AVG	514005-1	c:\fpwin\data\user__
	INFANT VEGETABLE AND MEAT,JR-FFQ AVG	514005-2	c:\fpwin\data\user__
	LAMB - FFQ AVG	505003	c:\fpwin\data\user__
	LEGUMES, ALL TYPES - FFQ AVG	505013	c:\fpwin\data\user__
	LITE PROCESSED CHEESE - FFQ AVG	502004	c:\fpwin\data\user__
	LIVER, ANY TYPE - FFQ AVG	505004	c:\fpwin\data\user__
	LOW FAT, PART SKIM CHEESE - FFQ AVG	502002	c:\fpwin\data\user__
	MARGARINE OR BUTTER - FFQ AVG	513002	c:\fpwin\data\user__
	MAYONNAISE - FFQ AVG	513004	c:\fpwin\data\user__
	MELON - FFQ AVG	509003	c:\fpwin\data\user__
	MIXED DISHES MADE WITH BEEF - FFQ AVG	506001	c:\fpwin\data\user__
	MIXED DISHES MADE WITH FISH - FFQ AVG	506002	c:\fpwin\data\user__
	MIXED DISHES MADE WITH LAMB - FFQ AVG	506004	c:\fpwin\data\user__
	MIXED DISHES MADE WITH LEGUMES - FFQ AVG	506011	c:\fpwin\data\user__
	MIXED DISHES MADE WITH PORK - FFQ AVG	506003	c:\fpwin\data\user__
	MIXED DISHES W/VEGETABLES - FFQ AVG	506017	c:\fpwin\data\user__
	MIXED DISHES WITH CHICKEN - FFQ AVG	506015	c:\fpwin\data\user__
	ORANGE, CITRUS JUICES - FFQ AVG	510001	c:\fpwin\data\user__
	OTHER BERRIES (NOT STRAW) - FFQ AVG	509004	c:\fpwin\data\user__
	OTHER COOKIES (PLAIN) - FFQ AVG	511008	c:\fpwin\data\user__
	OTHER FRUIT JUICES - FFQ AVG	510002	c:\fpwin\data\user__
	PANCAKES, WAFFLES, FRENCH TST - FFQ AVG	504006	c:\fpwin\data\user__
	PARTSKIM CHEESE/REG MOZZA - FFQ AVG		c:\fpwin\data\user__
	PASTRY/PIE, MEAT FILLED - FFQ AVG	506008	c:\fpwin\data\user__
	PEANUTS, NUTS, SEEDS - FFQ AVG	511011	c:\fpwin\data\user__
	PEAR/PEACH/PLUM/NECTARINE - FFQ AVG	509001	c:\fpwin\data\user__
	PIE - FFQ AVG	511005	c:\fpwin\data\user__
	PITA, BAGEL, ENGLISH MUFFIN - FFQ AVG	504003	c:\fpwin\data\user__
	PIZZA POCKETS/ROLLS - FFQ AVG	506012	c:\fpwin\data\user__
	PIZZA WITH MEAT - FFQ AVG	506013	c:\fpwin\data\user__
	PLAIN OR CHEESE CRACKERS - FFQ AVG	511009	c:\fpwin\data\user__
	POPSICLE OR MR. FREEZIE - FFQ AVG	511003	c:\fpwin\data\user__
	PORK - FFQ AVG	505002	c:\fpwin\data\user__
	POTATOES, MASHED/BOILED - FFQ AVG	508003	c:\fpwin\data\user__
	POULTRY - FFQ AVG	505005	c:\fpwin\data\user__
	PROCESSED CHEESE - FFQ AVG	502003	c:\fpwin\data\user__
	PROCESSED MEATS - FFQ AVG	505010	c:\fpwin\data\user__
	PUDDING - FFQ AVG	511001	c:\fpwin\data\user__
	RAISINS, DRIED FRUIT - FFQ AVG	509002	c:\fpwin\data\user__
	RAW SALAD VEGETABLES - FFQ AVG	508006	c:\fpwin\data\user__
	RICE CAKES - FFQ AVG	504009	c:\fpwin\data\user__
	RICOTTA/FETA - FFQ AVG	502011	c:\fpwin\data\user__
	SALAD DRESSING - FFQ AVG	513005	c:\fpwin\data\user__
	SAUSAGES - FFQ AVG	505009	c:\fpwin\data\user__
	SHELLFISH - FFQ AVG	505008	c:\fpwin\data\user__
	SOFT DRINKS, DIET - FFQ AVG	510006	c:\fpwin\data\user__

Search Results (Preview Food Item Record)

Names containing: ffq avg

ESHA	Item Name	User Code	Database
	SOFT DRINKS, REGULAR - FFQ AVG	510005	c:\fpwin\data\user__
	SOFT OR DESSERT TOFU - FFQ AVG	505012	c:\fpwin\data\user__
	SOUP WITH BONES AND MEAT - FFQ AVG	507003	c:\fpwin\data\user__
	SOUR CREAM - FFQ AVG	513007	c:\fpwin\data\user__
	SOY OR VEGETABLE PATTY - FFQ AVG	505014	c:\fpwin\data\user__
	SOY OR VEGETABLE WIENER - FFQ AVG	505015	c:\fpwin\data\user__
	SPINACH SALAD - FFQ AVG	508007	c:\fpwin\data\user__
	SQUASH, ALL TYPES - FFQ AVG	508005	c:\fpwin\data\user__
	SUGAR - FFQ AVG	513001	c:\fpwin\data\user__
	SWEET SPREADS, JAM - FFQ AVG	513009	c:\fpwin\data\user__
	SWEETENED FRUIT DRINK - FFQ AVG	510004	c:\fpwin\data\user__
	TOMATO & MIXED VEG JUICE - FFQ AVG	510003	c:\fpwin\data\user__
	TORTILLA - FFQ AVG	410005	c:\fpwin\data\user__
	WGRAIN PANCAKE, WAFFLE - FFQ AVG	504007	c:\fpwin\data\user__
	WGRAIN PITA, BAGEL, ENG MUF - FFQ AVG	504004	c:\fpwin\data\user__
	WHEAT CRACKERS - FFQ AVG	511010	c:\fpwin\data\user__
	WHITE BREAD/ROLL - FFQ AVG	504001	c:\fpwin\data\user__
	WHOLE EGG, ALL TYPES - FFQ AVG	502007	c:\fpwin\data\user__
	WHOLE GRAIN BREAD/ROLL - FFQ AVG	504002	c:\fpwin\data\user__
	WHOLE GRAIN HOT CEREALS - FFQ AVG	503001	c:\fpwin\data\user__
	YAM/SWEET POTATO - FFQ AVG	508008	c:\fpwin\data\user__
	YOGURT, 1% - 2% - FFQ AVG	502009	c:\fpwin\data\user__
	YOGURT, 2% - 4% - FFQ AVG	502008	c:\fpwin\data\user__

DEMOGRAPHIC AND INFANT FEEDING QUESTIONNAIRE

參加者号碼
SUBJECT NUMBER ☐☐☐☐

CLINIC DATE 診所日期 Day日 ☐☐ Month月 ☐☐ Year年 ☐☐

診所号碼
CLINIC NUMBER ☐☐

BABY'S BIRTH DATE 嬰兒出生日期 Day日 ☐☐ Month月 ☐☐ Year年 ☐☐

Information obtained from the demographic and infant feeding history questionnaire will assist us in targeting infant nutrition programs more effectively. Although we greatly appreciated your participation, participation is voluntary and you do not have to answer any question(s) you do not wish.

A Nutritionist will be available to answer any questions you might have about this questionnaire and to review "Section B - Infant Feeding History" with you.

Please answer questions for both parents/guardians as applicable.

由此問卷所得的資料將會用來提高嬰兒營養/健康服務。您享有不回答某些問題的權利。我們非常謝謝您參加這項研究，當值的營養師會為您解答一切您不明白的問題，由其是第二部份關於嬰兒飲食問題。

SECTION A - DEMOGRAPHIC INFORMATION

Please Check the Appropriate Response

您是嬰兒的:
A1. I am the baby's:

- ☐ Mother 母親
- ☐ Father 父親
- ☐ Relative 親人
- ☐ Nanny 保母
- ☐ Other (specify) _____ 其他(請說明)

您的年齡是:
A2. What is your age?

		嬰兒母親 Baby's mother	嬰兒父親 Baby's father
20歲以下	< 20 years	☐	☐
20至24歲	20-24 years	☐	☐
25至29歲	25-29 years	☐	☐
30至34歲	30-34 years	☐	☐
35歲以上	35+ years	☐	☐

您現時居住的狀況 (可以✓多過一項)
A3. What is your present living status?
(You may check more than one)

- ☐ Living alone 獨居
- ☐ Living with spouse/partner 和配偶住
- ☐ Living with family or relatives 和親人住
- ☐ Living with friends 和朋友住

A4. What is your marital status? 您的婚姻狀況:
(check only one) (只可以✓一個)

- ☐ Legally married/common-law 已婚或同居
- ☐ Separated but still legally married 分居
- ☐ Divorced 已離婚
- ☐ Widowed 寡婦(或鰥夫)
- ☐ Never married (single) 未婚

您的家一共有幾多個兒童?
A5. How many children, in total live in the household? ☐☐個

教育程度
A6. Please check the highest level of schooling that you have completed.

	Mother 母親		Father 父親	
	曾就讀 Some	完成 Completed	曾就讀 Some	完成 Completed
Secondary (high) school? 中學	☐	☐	☐	☐
工業學院, 社區學院 Community college, technical or vocational training	☐	☐	☐	☐
University 大學	☐	☐	☐	☐
Graduate degree 碩士, 博士	☐	☐	☐	☐
Other training? 其他專業訓練 (specify) 請說明	☐	☐	☐	☐
	_____		_____	

A7. What is your usual occupation? 您們的職業

嬰兒的母親 Mother _____

嬰兒的父親 Father _____

您的家庭每年的總收入:

A8. Which of the following describes your family income per year?

- ☐ Less than $10,000 以下
- ☐ $10,000 - $19,999
- ☐ $20,000 - $29,999
- ☐ $30,000 - $39,999
- ☐ $40,000 - $49,999
- ☐ $50,000 - $59,999
- ☐ $60,000 - $69,999
- ☐ $70,000 - over 以上

A9. Were you born in Canada? 您是在加拿加出生嗎?

Mother 母親
- ☐ Yes 是
- ☐ No 不是, 我在 (please state country of birth) _____ 出生的

Father 父親
- ☐ Yes 是
- ☐ No 不是, 我在 (please state country of birth) _____ 出生的

A10. How many years have you lived in Canada? 您在加拿加大已住了:

母親 Mother _____ yrs 年

父親 Father _____ yrs 年

A11. What language is spoken most often at home? 您的常用語言是:

- i) English ☐ 英文
- ii) French ☐ 法文
- ii) Other ☐ specify 其他(請說明) _____

加拿大人是由來自不同國家，不同文化的人組成的。
您認為您是屬于那一個(或幾個)國家/文化呢？

A12. Canadians belong to many ethnic or cultural groups. To which ethnic or cultural group(s) do you belong (please consider your usual social/cultural practices)? Mark or specify more than one, if applicable. Please answer for mother and father of the child as applicable.

	Child's Mother 嬰兒母親	Child's Father 嬰兒父親
British, 英國人 specify country	☐ _____	☐ _____
French, 法國人 specify 請說明	☐ _____	☐ _____
European, 歐洲人 specify country 請說明國家	☐ _____	☐ _____
First Nations, 土著 specify 請說明	☐ _____	☐ _____
Asian 亞洲人 specify country 請說明國家	☐ _____	☐ _____
Latin American, 拉丁美洲人 specify country 請說明國家	☐ _____	☐ _____
Arab, 阿拉伯人 specify country	☐ _____	☐ _____
Canadian, 加拿大人	☐	☐
Other, specify 其他，請說明	☐ _____	☐ _____

您是：(如果您認為有需要，可以 ✓ 多過一格)

A13. Are you: *(Mark or specify more than one, if applicable)*

	Child's Mother 嬰兒母親	Child's Father 嬰兒父親
Chinese 中國人	☐	☐
South Asian (East Indian, Punjabi, Sri Lankan, Pakistani, etc.) 南亞 印度 斯里蘭卡 巴基斯坦 等	☐	☐
South East Asian (Filipino, Indonesian, Laotian, Vietnamese, etc.) 東南亞 (即菲律賓, 印尼, 寮國, 越南人等)	☐	☐
White/Caucasian (European, etc.) 白種/高卡索人	☐	☐
Other - Please specify, 其他，請說明 _____	☐	☐

加拿大人的飲食習慣都是受文化或宗教信仰的影響。您認為您的飲食習慣是屬于那一個文化或宗教呢？

A14. Canadians often have food related practices and beliefs about food which are associated with a particular ethnic or cultural background(s). Which ethnic or cultural background(s) do you associate **your usual food related practices** with?
例如：西方/北美，英國，越南，中國，伊斯蘭教等等。
For example: Western/North American, British, Vietnamese, Chinese, Mediterranean, Hindu, Moslem, Sikh, etc.

_____

_____

您們不吃以下那一種食物?

A15. Do you **exclude** any of foods from your family diet?

母親 Mother
- ☐ 有(請在食物旁邊的格內打✓) Yes (Specify below)
- ☐ No 沒有

父親 Father
- ☐ Yes (Specify below) 有(請在食物旁邊的格內打✓)
- ☐ No 沒有

- ☐ Beef 牛肉
- ☐ Pork 豬肉
- ☐ Poultry 雞,鴨,鳥類(家禽類)
- ☐ Fish 魚類
- ☐ Eggs 雞蛋
- ☐ Dairy products 奶類製品
- ☐ Nuts, seeds or peanut butter 果仁(花生,腰果,芝麻)
- ☐ Vegetables 蔬菜,瓜類
- ☐ Fruit 水果
- ☐ Breads/Cereals 穀類(麵包,麥片,饅頭)
- ☐ Pasta 粉,麵
- ☐ Rice 飯
- ☐ Beans, peas or lentils 豆類(綠豆,黑豆,白豆,紅豆)

Comments 其他(請說明) _____

_____

您的家人有沒有遵守任何飲食限制?(醫療上,宗教上,或其他理由)

A16. Does your family have any particular diet practices for medical, religious, or other reasons?

- 有 Yes ☐ (please describe below)(如果有,請說明)
- 沒有 No ☐

Comments 請說明 _____

_____

第二部份 — 嬰兒飲食問題

SECTION B - INFANT FEEDING HISTORY

請在空格內打✓來指示您的答案
Please Check the Appropriate Response

您的孩子有沒有曾經飲過母乳?
B1. Was your baby ever breast-fed?

有 Yes ☐ (go to B2) (請回答 B2)

沒有 No ☐ (go to B5) (不用回答 B2, B3, B4, 請由 B5 再開始答)

您的孩子有沒有曾經在一星期內飲用多過 (8安或1杯) 的其他奶品 (用奶粉開的) 或其他
B2. Has your baby been introduced (by bottle or cup) to 8oz (~240 ml) or more of formula or other milk per week?

有 Yes ☐ 如果有, 甚麼時候開始? (幾多歲?)
If yes, at what age? _____ month(s) 月

沒有 No ☐

您的孩子現在有沒有飲用母乳?
B3. Is your baby still being breast-fed?

有 Yes ☐

沒有 No ☐ 如果沒有, 甚麼時候完全停止? (月)
If no, at what age was it completely stopped? _____ month(s)

您有沒有曾經用奶粉開的奶來補充或取代母乳? (即多過8安士或1杯的奶)
B4. Was breast-feeding supplemented or replaced with **infant formula**, ie. >8 ounces (240ml) per week of formula) ?

有 Yes ☐ (Go to B5) (請回答 B5)

沒有 No ☐ (Go to B7) (請由 B7 開始答, 不用回答 B5, B6)

如果您的孩子有飲用過用奶粉調的奶，請說明曾用過那種奶粉，加甚麼時候開始或停止使用

B5. If your baby was given an infant formula, what type(s) were used and at what age were these introduced or changed?

請用✓來指示有用過的奶粉	Check if used	Age started 開始食年齡 mos月	Age 停食年齡 changed/ stopped mos月	Specify 奶粉牌子 type or brand name
普通奶粉 a) regular formula (low iron)	☐	____ ____	____ ____	_____ _____
含鐵質的奶粉 b) formula with iron (iron-fortified)	☐	____ ____	____ ____	_____ _____
用黃豆制的奶粉，沒有牛奶成份 c) soy-based formula (not soy milk)並不是豆漿	☐	____ ____	____ ____	_____ _____
其他奶粉 d) other formula	☐	____	____	_____

評語 Comments: _____

_____

如果您的孩子現時仍飲用奶粉，一天內飲多少？

B6. If your child is still drinking formula, **how much** do they drink per day?

_____ oz. 安士

Brand/Type 牌子 _____ Comments 評語 _____

B7. Was breast-feeding or formula feeding supplemented or replaced with cows' milk, goats' milk, soy milk or other beverages?
您有沒有曾經用過牛奶，羊奶，豆漿，或其他飲品來補充或取代母乳或奶粉調的奶？

有 Yes ☐

沒有 No ☐ →(Go to B10) (請由B10開始答)

您的孩子是甚麼時候開始飲用牛奶,羊奶,豆漿,或其他飲品?

B8. At what age was your child started on cows' milk, goats' milk, soy milk or other beverages?

		年齡(月) Age (months)	種類 Type			
牛奶	Cow's milk	____	____ 全脂 Whole	____ 2%	____ 1%	____ 脫脂 Skim
羊奶	Goat's milk	____				
豆漿	Soy milk (not formula)	____	____ 淡 Unsweetened		____ 甜 Sweetened	
其他	Other	____	Please specify 請說明 _____			

B9. What type of milk is your child currently drinking? 您的孩子現在飲:(請用✓來指示有飲的)

			How much per day? 一天飲的量
Cow's milk 牛奶	全脂 Whole	☐	_____
	2%	☐	_____
	1%	☐	_____
	脫脂 Skim	☐	_____
Other 其他 (請說明) (please specify)	_____		_____

B10. Does your child eat solid foods? 你的孩子現時有沒有進食固體食物?

有 Yes ☐ (Go to B11)

沒有 No ☐ (Go to B14) (不用答 B11, B12, B13, 請由 B14 開始答)

您的孩子是甚麼時候開始食(或試食)以下的食物?
如果有食物現時已沒有食的,請說明甚麼時候停止的。
如果現時還有食的東 ,請用✓在"停食年齡"的空格內。

B11. **At what age were the following foods introduced to your child? If your child has stopped eating any of these foods, please specify at what age. If your child still currently eats the food, please indicate with a ✓.**

	Food Type 食物	Age started (months) (if applicable) 開始年齡(月)	Age stopped (months) (if applicable) 停食年齡(月)	Comments eg. Why stopped, brand, or type 為甚麼停食,食物牌子
嬰兒麥片	Commercial infant cereals			牌子:
幼兒麥片	Commercial toddler cereals			牌子:
成人普通麥片	Cold packaged cereal (specify type)			牌子:
	Cooked cereal or other home prepared cereal (specify type)			
	Cooked rice 飯			
	Cooked pasta 粉,麵			
	Breads/ crackers 麵包,餅乾			
	Red Meat 牛肉, (eg. beef or pork)			
	Lamb 羊肉			
	Chicken 鷄肉			
	Fish 魚肉			
	Egg yolk 蛋黃			
	Dried peas, beans or lentils 乾豆類			
	Dairy products 奶品類(芝士,酸乳酪) (eg. cheeses, yogurt)			
	Fruits 水果			
	Fruit Juices 果汁 (specify type) (請說明甚麼汁)			
	Vegetables 蔬菜			
	other foods (please specify) 其他食物(請說明)			

您的孩子有沒有進食麥片或粥類食物?

B12. Have you introduced your child to an infant/toddler cereal?

有 Yes ☐ (Go to B13)(如果有,請繼續回答B13)

沒有 No ☐ (Go to B14)(如果沒有,不用回答B13,由B14開始答)

如果有,他(她)是食那一種呢? (請在有食過的食物旁邊打✓)

B13. If Yes, what type of infant/toddler cereal did you introduce?

☐ Commercial infant/toddler cereal 有牌子的嬰兒麥片 (請說明)
(Please specify brand and type of cereal)

Brand 牌子是: _____ Type 那一種? _____

☐ congee 粥

☐ cereal from a health food store 健康產品專門店出售的麥片

☐ other, please specify 其他,請說明 _____

為甚麼您沒有給您的孩子食麥片或粥類食物?

B14. If you have not introduced infant/toddler cereal, please specify why?

_____

_____

當您最初做嬰兒麥片(或粥),您是用甚麼來「開」/煮/做呢?

B15. When you first started using infant cereal, what did you use to prepare it?

☐ Water 水

☐ Breast-milk 母乳

☐ Formula 用奶粉開的奶

☐ Cow's milk 牛奶

☐ Fruit juice 果汁

☐ Other, please specify 其他,請說明 _____

您覺得您的孩子食的東西和習慣有營養嗎?

B16. In general, how nutritious do you feel your child's diet is?

- ☐ Excellent 十分之好
- ☐ Very good 幾好
- ☐ Good 好
- ☐ Fair, or 麻麻
- ☐ Poor 差

您會怎樣形容您 孩子的飲食習慣?

B17. In general, how would you describe your child's eating habits?

- ☐ Always a fussy eater 時時都揀擇 經常都很麻煩
- ☐ Often a fussy eater 很多時都揀擇
- ☐ Sometimes a fussy eater 有時揀擇
- ☐ Seldom a fussy eater 很少揀擇
- ☐ Never a fussy eater 從來都不揀擇
- ☐ Excellent appetite 非常之開胃
- ☐ Very good appetite 幾開胃
- ☐ Good appetite 開胃
- ☐ Fair appetite 麻麻地開胃
- ☐ Poor appetite 不開胃

您的孩子有沒有去托兒所,保母家,兒童遊戲中心,學校? (一星期一次或以上)

B18. Does baby go to play group, babysitter's home, day care centre or nursery school once a week or more?

☐ Yes有 ☐ No沒有

如果有, ①一星期幾多次?

If yes, How many days a week? _____

②每次幾多個小時? How many hours a day? _____

③在場一共有幾多個孩子嗎? About how many children attend with your child? _____

在您的孩子六個月大開始,有甚麼人做(煮)他(她)的食物?

B19. How many of the following prepare the child's food **(from 6 months on)**?

- ☐ Mother母親
- ☐ Father父親
- ☐ Grandmother祖母
- ☐ Grandfather祖父
- ☐ Nanny/baby sitter保母,
- ☐ Daycare 托兒所
- ☐ Other其他(請說明)

specify _____

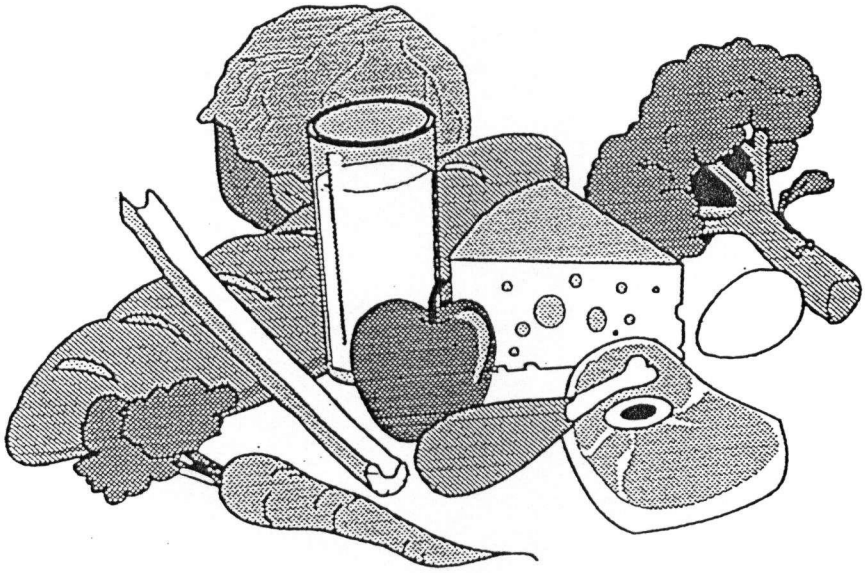
多謝您的時間!!

Thank you for your time and cooperation in completing this questionnaire.

THANK YOU

食物記錄手册
第一部份

食物記錄指引



飲食記錄是一份有關對閣下子/女在二十四小時內所進食的食物記錄，內容應包括詳細的食物、飲品種類及份量的描述。準確的飲食記錄可以提供閣下子/女日常飲食的營養資料。若要準確地分析閣下子/女的飲食記錄，我們需要清楚知道閣下所記錄的食物和飲品。

請閣下在附表上記錄貴子/女在三天中(兩個週日天和一個週末天)一切所吃的食物和飲品:

_____

_____

_____

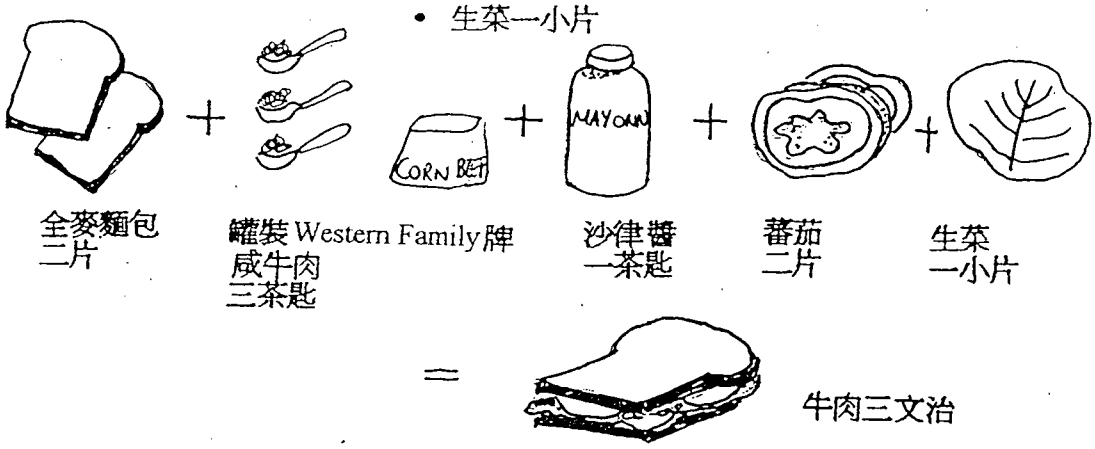
步驟一

從零晨十二時起至翌日晚上十二時止，請記下貴子/女一切所吃的食物及飲品的時間，進食性質（如早餐或小食等）及進食地點（如托兒所等），並記下與誰人一起進食。

步驟二

詳細描述貴子/女一切所吃的食物、飲品的種類及份量。
請儘量詳述食物、飲品的種類，包括牌子、菜式的用料等。
閣下可以以寫菜譜的方法來描述複雜的菜式或食品。
例如：

食物	*應記錄如下*
餅乾	麥維他消化餅二塊
奶	鮮奶，2%，八安士
曲奇餅	自製朱古力曲奇餅二塊，直徑約二吋
三文治	牛肉三文治，材料包括 • 全麥麵包二片 • 罐裝 Western Family 牌咸牛肉三茶匙 • 沙律醬一茶匙 • 蕃茄二片 • 生菜一小片



若果食物不是你們自己預備，請儘量描述其成份。例如：

食物	*應記錄如下*
乾炒牛河	乾炒牛河一碗(250mL)，材料包括 • 牛柳四安士，加糖、生抽各一茶匙調味 • 河粉四安士 • 栗米油一湯匙 • 老抽、生抽各一茶匙

步驟三

請記錄你的子/女已吃食物的份量。例如：

食物	*應記錄如下*
半瓶Heinz雜菜	份量約1/4杯
	重量約100克
	每瓶約重213克

步驟四

意見或評語

若果你的子/女如不吃你預備的食物，請記錄在評語一欄內。

請緊記在每餐或小食後立即記下曾進食的食物。

如同你的子/女外出食飯，請帶同食物記錄。如你的子/女日間在托兒所，請查詢你的子/女曾進食了甚麼。你們可以讓幼童看護記錄子/女曾進食的食物和與別人分享的食物。若你自備食物，請幼童看護退回一切剩下的食物。每次進食完畢後請立刻做記錄，否則就很容易忘記。

你的子/女是否仍然飲用母乳或奶粉?

若你仍餵哺母乳，請記錄每次開始餵哺的時間，和每次所需的時間。並請記下你的子/女所有曾飲用的牛奶、奶粉或果汁的份量。

若你仍有任何疑問，請電875-3537與Patty Williams聯絡。我們會在第一個記錄日之前回覆你們。

FOOD RECORD PACKAGE: PART 2

Subject No. _____

進食記錄手册:第二部份

FOOD RECORD EXAMPLE 進食記錄例子

Last Name 姓:陳 _____ First Name 名:大文 _____ Age 年齡:2 YEARS

Record Day# 記錄日 :1 _____ Day of Week 星期 :SUNDAY _____ Date 日期:MARCH 1, 1995 _____

TIME & PLACE 時間及地點	*STEP 1* 步驟一 Describe all the foods and beverages your child actually eats. 描述所有你兒童吃/喝了的食物和飲料	*STEP 2* 步驟二 How much is actually eaten? (specify volume, measure or weight) 吃了多少?(份量)	Comments 評語	FOR OFFICE USE ONLY 請勿填寫
早餐 上午八時正 家	"KELLOGS" RICE KRISPIES 牛肉腸 鮮橙汁 藍梅	二湯匙 半條,直徑約四吋 四安士 四份一量杯	剩餘奶 没有吃多士	
小吃 上午十時正 家	蘋果 牛肉腸	一個 半條,直徑約四吋	早餐時剩餘的	
午餐 十二時正 家	吞拿魚卷 -長麵包,直徑六吋 -1/4杯吞拿魚肉 -1湯匙奇妙醬 -1茶匙牛油 -一片生菜	1/8條	拒絕吃剩餘的魚卷	
晚餐 下午六時 家	炸魚柳(SOLE) 白飯 青豆	1安士 3湯匙 2安士	晚飯時打盹	

Did you give your child a vitamin/mineral supplement on this day? (Y/N)
你們的孩子今天有没有服食額外的維他命/礦物質?(有/没有) 有_____
If yes, please state the type, brand name, and the amount given.
若答"有",請說明種類,牌子,及服用份量:FLINSTONES MULTIVITAMIN一片 _____
Was this a fairly typical day for your child? (Y/N)
對你的孩子而言,今天所吃的是否和平常一樣?(是/否) 否_____
If not, please give reason(s):
若答"否",請說明原因: 大文正發燒 _____

FOOD RECORD PACKAGE: PART 3

Subject No. _____

進食記錄手册:第三部份

FOOD RECORD 進食記錄

Last Name 姓: _____ **First Name** 名: _____ **Age** 年齡: _____

Record Day# 記錄日: _____ **Day of Week** 星期: _____ **Date** 日期: _____

TIME & PLACE 時間及地點	*STEP 1* 步驟一 Describe all the foods and beverages your child actually eats. 描述所有你兒童吃/喝了的食物和飲料	*STEP 2* 步驟二 How much is actually eaten? (specify volume, measure or weight) 吃了多少?(份量)	Comments 評語	FOR OFFICE USE ONLY 請勿填寫

FOOD FREQUENCY QUESTIONNAIRE
食物及進食頻率問卷

(TO BE COMPLETED BY NUTRITIONIST)
（請由營養師填寫）

Subject Number 檔案編號 _____ **Interviewer** 接見人 _____

Parent's Name 家長姓名 Last 姓 _____ First 名 _____

Child's Name 兒童姓名 Last 姓 _____ First 名 _____

Child's DOB 兒童出生日期 Day 日 _____ Month 月 _____ Year 年 _____

Child's Age 兒童年齡 _____ months 月

Date of Follow-up Visit 探訪日期

Day 日 _____ Month 月 _____ Year 年 _____

Day of week 星期 _____

Location of Visit 探訪地點 _____

Main Respondent: 受訪者 child's 兒童的

- ☐ mother 母親
- ☐ father 父親
- ☐ sister 姊
- ☐ brother 兄
- ☐ grandparent 祖父母
- ☐ other 其他

_____

This questionnaire is designed to determine your child's usual food intake over the last two weeks. Please think about all the foods and beverages your child eats and drinks both at home and away from home.
這問卷是用來查詢貴 子女於過去的兩星期內的日常飲食，請想想貴 子女常吃的食物和飲品。

Part 1. I will be asking you about many different foods and drinks. For every food please tell me whether your child has had this food or beverage at least once in the last two weeks. If **YES**, then I will ask you to tell me the number of times per day, or for foods eaten less than once per day, how many times in the last two weeks. Then I will ask you to tell me the serving size, or how much, your child usually eats. Please report the amount your child usually eats, not the amount you usually prepare or offer.
第一部份：請從每種食物和飲品中，請想想你們的子女於過去的兩星期有沒有最少進食了一次。若答"是"，請告知我們每天進食該種食物的次數(包括少於一次) 和進食的份量。

Note: If child eats only purchased infant, junior or toddler foods, please skip to page 21.
若你們的子女只進食嬰兒食品，請轉第二十一頁。

Here are some examples showing how the chart will be completed:
例如：

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?	How many times per day or in the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?

Example #1 "Sarah drinks whole milk once a day - about 1/2 a cup each time"小玲每日飲奶一次, 每次半杯.
You would show that on the chart like this: 你們應記錄如下:

Whole milk & beverages made with it 全脂奶及其飲品	O Yes是 O No否	____	O Day日 OWeek星期	O 1/2 cup杯	O 3/4 c杯	O 1 c杯	Other 其他 _____

Example #2 "Sarah eats bread in a sandwich for lunch about three times a week, two slices each time but she does not eat the crust (equal to 1/2 slice bread)" 小玲每星期有三次以三文治爲午餐，每次都吃了兩片麵包，但她卻不吃麵包皮(相等於剩下半片麵包)
You would record that on the chart like this: 你們應記錄如下:

Bread & Rolls 麵包及餐包	O Yes是 O No否	____	O Day日 OWeek星期	O 1/4 slice片	O 1/2slice片	O 1 slice片	Other 其他 _____

Example #3 "Sarah only eats fish about twice per month. She usually eats only 1 TBSP"小玲每月只吃魚兩次，每次吃一湯匙
You would show that on the food chart like this: 你們應記錄如下:

Fish 魚	O Yes是 O No否	____	O Day日 OWeek星期	O 1/2 oz安士	O 1 oz安士	O 2 oz安士	Other 其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?	How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?				

Milk *(include milk used in cereals and drinks made with milk)*

奶類食品

Skim milk 脫脂奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
1% milk 1 % 鮮奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
2% milk 2 % 鮮奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Whole milk 全脂奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Evaporated milk 淡奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Sweetened condensed milk 煉奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Chocolate milk 朱古力奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Milkshake 奶昔	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Soy beverage 豆奶	O Yes 是 O No 否	——	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Rice beverage 米類飲料	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Goat's milk 羊奶	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____
Other milk products 其他 _____	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ cup 杯 (2 oz)	O ½ cup 杯 (4 oz)	O 1 cup 杯 (8 oz)	Other 其他 _____

Cheese, Eggs & Yogurt
芝士、蛋、乳酪

Hard cheese (cheddar, Swiss) 硬芝士（車打/瑞士芝士）	O Yes 是 O No 否	O Day日 O Week 星期	O 1 Tbsp湯匙 grated磨碎	O 2 Tbsp湯匙 grated磨碎 (¼ oz)	O 1 inch cube方塊 (1 oz)	Other 其他 _____
Part-skim or low fat cheese (eg. lite cheeses, regular mozzarella) 低脂芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1 Tbsp湯匙 grated磨碎	O 2 Tbsp湯匙 grated磨碎 (¼ oz)	O 1 inch cube方塊 (1 oz)	Other 其他 _____
"Lite" mozzarella cheese 低卡路里芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1 Tbsp湯匙 grated磨碎	O 2 Tbsp湯匙 grated磨碎 (¼ oz)	O 1 inch cube方塊 (1 oz)	Other 其他 _____
Processed cheese slices (including on sandwiches and hamburgers) 切片芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1 Tbsp湯匙 grated磨碎	O ½ slice片 (½ oz)	O 1 slice片 (1 oz)	Other 其他 _____
Lite processed cheese slices (including on sandwiches and hamburgers) 低卡路里切片芝士	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ slice片 (¼ oz)	O ½ slice片 (½ oz)	O 1 slice片 (1 oz)	Other 其他 _____
Cottage cheese, creamed 忌廉農場芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O 3-5 Tbsp湯匙	O ⅓ cup杯	Other 其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有没有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Cottage cheese, 1% or 2% 農場芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O 3-5 Tbsp湯匙	O ½ cup杯	Other 其他 _____
Cheese spread (eg. Cheeze Whiz) 芝士醬	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 tsp茶匙	O 1 Tbsp湯匙	O 2 Tbsp湯匙	Other 其他 _____
Lite cheese spreads (eg. Lite Cheeze Whiz) 低卡路里芝士醬	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 tsp茶匙	O 1 Tbsp湯匙	O 2 Tbsp湯匙	Other 其他 _____
Soy chees 豆類芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1 Tbsp湯匙 grated磨碎	O 2 Tbsp湯匙 grated磨碎 (¼ oz)	O 1 inch cube方塊 (1 oz)	Other 其他 _____
Goat cheese 山羊芝士	O Yes 是 O No 否	O Day日 O Week 星期	O 1 Tbsp湯匙 grated磨碎	O 2 Tbsp湯匙 grated磨碎 (¼ oz)	O 1 inch cube方塊 (1 oz)	Other 其他 _____
Paneer 印式芝士	O Yes 是 O No 否	O Day日 O Week 星期	O ½ inch cube ½ 吋方塊	O 1 inch cube 1 吋方塊	O 2 inch cube 2 吋方塊	Other 其他 _____
Whole egg, all forms (eg. scrambled, hard boiled) 蛋(任何形式,如炒,煎,等)	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ egg or less ¼ 蛋或少於	O ½ egg ½ 蛋	O 1 egg 1蛋	Other 其他 _____
Egg yolk only 淨蛋黃	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ egg or less ¼ 蛋或少於	O ½ egg yolk ½ 蛋黃	O 1 egg yolk 1蛋黃	Other 其他 _____
Egg white only 淨蛋白	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ egg or less ¼ 蛋或少於	O ½ egg white ½ 蛋白	O 1 egg white 1蛋白	Other 其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?				
Yogurt 乳酪	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (60g)	O small carton小盒 (125g)	O large carton大盒 (175g)	Other 其他 _____
Yogurt, 1% or 2% 乳酪	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (60g)	O small carton小盒 (125g)	O large carton大盒 (175g)	Other 其他 _____
Aspartame sweetened yogurt 含代糖乳酪	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (60g)	O small carton小盒 (125g)	O large carton大盒 (175g)	Other 其他 _____
"Minigo" (Yoplait fresh cheese product) "Minigo"芝士產品	O Yes 是 O No 否	____	O Day日 O Week 星期	O ½ small carton ½小盒(30g)	O small carton小盒 (60g)	O large carton大盒 (125g)	Other 其他 _____
Other cheese, yogurt or egg product 其他 _____	O Yes 是 O No 否	____	O Day日 O Week 星期	usual amount 普通份量_____			

Breakfast Cereals
早餐穀類食物

Whole grain hot cereals (eg. rolled oats, Red River) 熱食穀類(例如麥皮)	O Yes 是 O No 否	____	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 _____
Cream of wheat	O Yes 是 O No 否	____	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 _____
Rice congee, with meat 粥(含肉)	O Yes 是 O No 否	____	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Bran or wholewheat muffin, small (40g) 全麥或穀殼小鬆餅	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-1	Other其他 _____
Cake muffin, small (40g) eg. plain, chocolate chip, blueberry, banana or corn 小鬆餅	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-1	Other其他 _____
Scones (40g), all varieties 各式士干包	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Pancakes, waffles or French toast (35g) 班戟，窩夫或西多士	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Wholegrain pancakes, waffles or French toast (35g) 全麥班戟，窩夫或西多士	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Rice cake 米餅	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Chapatti or roti 印式薄餅/麵包	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Parantha, plain 印式麵包	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Steamed bun, plain 饅頭,花卷,銀絲卷	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Tortilla, flour or corn 墨西哥薄餅/粟米片	O Yes 是 O No 否	O Day日 O Week 星期	O ½-¼	O ½	O ¾-one whole整個	Other其他 _____
Any pasta or noodle, cooked 各式意粉或麵，已熟	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2Tbsp湯匙	O ¼ cup杯	O ½ cup杯	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Cold cereals, plain or with sugar coating (eg. Corn Flakes, Rice Krispies, Cheerios, Frosted Flakes, Fruit Loops) 凍食穀類(如栗米片)	O Yes 是 O No 否	___	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 ___
Bran or multigrain type cereals (Shreddies, Bran Flakes, Corn Bran, Fruit & Fibre) 粗或多種纖維穀類	O Yes 是 O No 否	___	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 ___
Granola type cereal 粗纖維餅類	O Yes 是 O No 否	___	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 ___
Other breakfast cereals: 其他 ___	O Yes 是 O No 否	___	O Day日 O Week 星期	O ⅛ cup or less ⅛杯或少於	O ¼ cup杯	O ½ cup杯	Other其他 ___

Breads, Rolls, Muffins & Other Grains 麵包、鬆餅及其他穀類食物

Bread, dinner roll, white, enriched 白麵包，餐包	O Yes 是 O No 否	___	O Day日 O Week 星期	O ¼ slice片 or roll或個	O ½ slice片 or roll或個	O 1 slice片 or roll或個	Other其他 ___
Whole grain bread, dinner roll 全麥麵包，餐包	O Yes 是 O No 否	___	O Day日 O Week 星期	O ¼ slice片 or roll或個	O ½ slice片 or roll或個	O ½ slice片 or roll或個	Other其他 ___
Pita bread, bagel, english muffin, white, enriched 白希臘包，貝太包，英式鬆餅	O Yes 是 O No 否	___	O Day日 O Week 星期	O ½	O ¼	O ½	Other其他 ___
Pita bread, bagel, english muffin, wholegrain 全麥希臘包，貝太包，英式鬆餅	O Yes 是 O No 否	___	O Day日 O Week 星期	O ⅛	O ¼	O ½ (8 oz)	Other其他 ___
Hotdog or hamburger bun 熱狗包/漢堡包	O Yes 是 O No 否	___	O Day日 O Week 星期	O ⅛-¼ bun個	O ½ bun個	O ¾-1 bun個	Other其他 ___

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有没有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Rice noodles 米粉	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1-2Tbsp湯匙	O ¼ cup杯	O ½ cup杯	Other其他 _____
Instant noodles 即食麵	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1-2Tbsp湯匙	O ¼ cup杯	O ½ cup杯	Other其他 _____
Rice, any type, cooked 飯	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1-2Tbsp湯匙	O ¼ cup杯	O ½ cup杯	Other其他 _____
Other grain products: 其他 _____	O Yes 是 / O No 否	O Day日 / O Week 星期	usual amount普通份量_____			

Meat, Fish, Poultry & Alternatives
肉，魚，家禽類

Beef (including, deli sliced, smoke meat, steak, roast, ground, etc.) 牛肉(包括餐肉, 煙肉,燒,免治等)	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Pork (including deli slices, steak, roast, chops, etc.) 豬肉(包括餐肉, 燒, 肉扒等)	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Wild game (fressh, frozen, dried) 野味(包括:新鮮, 雪藏,乾貨)	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Lamb (including roast, chops, etc.) 羊	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Liver, any type 肝	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有没有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Chicken, turkey or other poultry (including deli sliced, roast, etc.) 雞,火雞及其他家禽	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Chicken nuggets 炸雞塊	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 piece塊 (½ oz)	O 2 pieces塊 (1 oz)	O 3 pieces塊 (1½ oz)	Other其他 _____
Chicken fingers or strips 炸雞條	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 piece塊 (½ oz)	O 2 pieces塊 (1 oz)	O 3 pieces塊 (3 oz)	Other其他 _____
Duck 鴨	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Fish, canned, fresh, frozen (eg. tuna, salmon, sushi) 魚,包括罐裝,新鮮,雪藏,魚生等	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Shellfish (eg. prawns, shrimp, crab) 有殼魚類(如:蝦,蟹,龍蝦等)	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____
Wieners 熱狗腸/香腸	O Yes 是 / O No 否	O Day日 / O Week 星期	O ¼	O ½	O 1 whole條	Other其他 _____
Bacon 煙肉	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 slice片	O 2 slices片	O 3 slices片	Other其他 _____
Sausages 肉腸	O Yes 是 / O No 否	O Day日 / O Week 星期	O ¼	O ½	O 1 whole條	Other其他 _____
Processed meats (eg. bologna, salami, chicken loaf) 各式餐肉,火腿	O Yes 是 / O No 否	O Day日 / O Week 星期	O 1 Tbsp湯匙 (½ oz)	O 2 Tbsp湯匙 (1 oz)	O 4 Tbsp湯匙 (2 oz)	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Firm or medium firm tofu or soybean curd 硬/中硬豆腐或豆腐乾	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1 inch cube 一吋方塊	O 2 inch cube 二吋方塊	O ½ cup杯	Other其他 _____
Soft or dessert tofu 滑豆腐或豆腐花	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1-2 tsp茶匙	O 1 Tbsp湯匙	O 2 Tbsp湯匙	Other其他 _____
Soy (tofu) burger, vegetarian patty 素(豆腐)肉餅	O Yes 是 O No 否 ___	O Day日 O Week 星期	O ⅙-¼ pattie塊	O ½ pattie塊	O ¾ pattie塊	Other其他 _____
Soy (tofu) wiener, vegetarian weiner 素(豆腐)腸	O Yes 是 O No 否 ___	O Day日 O Week 星期	O ⅙-¼ wiener條	O ½ wiener條	O ¾ wiener條	Other其他 _____
Tahini (sesame seed paste) 芝麻醬	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1-2 tsp茶匙	O 1 Tbsp湯匙	O 1½ Tbsp湯匙	Other其他 _____
Peanut butter or other nut butter 花生醬或其他果仁醬	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1-2 tsp茶匙	O 1 Tbsp湯匙	O 1½ Tbsp湯匙	Other其他 _____
Dry peas, beans, lentils, legumes, cooked 乾豆類,已熟	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ¼-⅓ cup杯	O ½ cup杯	Other其他 _____
Other meats or alternatives: 其他 _____	O Yes 是 O No 否 ___	O Day日 O Week 星期	usual amount普通份量 _____			

Combination Dishes
各類混合菜式

Mixed dishes made with beef (eg casseroles, hamburger helper, lasagna, spaghetti meat sauce) 牛肉類	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅓-½ cup杯	O ½ cup杯	Other其他 _____
Mixed dishes made with fish (eg. Casserole) 魚類	O Yes 是 O No 否 ___	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅙-¼ cup杯	O ½ cup杯	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Mixed dishes made with pork 豬肉類	O Yes 是 O No 否 —	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Mixed dishes made with lamb 羊肉類	O Yes 是 O No 否 —	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Canned pasta, with meat (eg. Ravioli) 罐裝意粉(含肉)	O Yes 是 O No 否 —	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Canned pasta, without meat 罐裝意粉(不含肉)	O Yes 是 O No 否 —	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Homemade macaroni and cheese, other pasta dishes with cheese 自製芝士通心粉,及其他芝士意粉	O Yes 是 O No 否 —	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Boxed macaroni & cheese (eg. Kraft Dinner) 盒裝芝士通心粉	O Yes 是 O No 否 —	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Pastry/pies, meat filled (eg. sausage rolls, meat pies) 批(肉餡)	O Yes 是 O No 否 —	O Day日 O Week 星期	O ⅛ pie or roll個	O ¼ pie or roll個	O ½ pie or roll個	Other其他 _____
Filled buns, baked or steamed, meat filled麵包(肉餡)	O Yes 是 O No 否 —	O Day日 O Week 星期	O ⅛ bun個	O ¼ bun個	O ½ bun個	Other其他 _____
Perogies, potato & cheese filled 西式餃子(薯仔芝士餡)	O Yes 是 O No 否 —	O Day日 O Week 星期	O ½	O 1	O 2	Other其他 _____
Perogies, potato & onion filled 西式餃子(薯仔洋蔥餡)	O Yes 是 O No 否 —	O Day日 O Week 星期	O ½	O 1	O 2	Other其他 _____
Enchiladas, cheese filled 墨西哥薄餅卷,芝士餡	O Yes 是 O No 否 —	O Day日 O Week 星期	O ⅛-¼ 6 inch六吋	O ½ 6 inch六吋	O 1 whole個 6 inch六吋	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Enchiladas, meat filled 墨西哥薄餅卷,肉餡	O Yes 是 O No 否	O Day日 O Week 星期	O ¼-½ 6 inch六吋	O ½ 6 inch六吋	O 1 whole個 6 inch六吋	Other其他 _____
Pizza with cheese and no meat 芝士薄餅	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ slice片	O ½ slice片	O 1 slice片	Other其他 _____
Pizza with cheese and meat 芝士和肉薄餅	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ slice片	O ½ slice片	O 1 slice片	Other其他 _____
Pizza rolls/pizza pockets 薄餅卷	O Yes 是 O No 否	O Day日 O Week 星期	O ¼	O ½	O 1 whole個	Other其他 _____
Quiche with meat 蛋餡餅(含肉)	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O 3-4 Tbsp湯匙	O 5 Tbsp湯匙	Other其他 _____
Quiche without meat 蛋餡餅(不含肉)	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O 3-4 Tbsp湯匙	O 5 Tbsp湯匙	Other其他 _____
Mixed dishes made with cooked lentils, beans or peas (eg. lentil stew or soup) 豆類菜式	O Yes 是 O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O 3-4 Tbsp湯匙	O 5 Tbsp湯匙	Other其他 _____
Other mixed dishes: 其他 _____	O Yes 是 O No 否	O Day日 O Week 星期	usual amount普通份量_____			

Soups
湯

Broth type eg. veg beef, chicken noodle 清湯類(如菜,牛肉,雞麵等)	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ cup杯	O ½ cup杯	O ¾ cup杯	Other其他 _____
Homemade broth type with meat 自製肉類清湯	O Yes 是 O No 否	O Day日 O Week 星期	O ¼ cup杯	O ½ cup杯	O ¾ cup杯	Other其他 _____

	Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Cream-type soup 忌廉湯類	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	¼ cup杯	½ cup杯	¾ cup杯	_____
Soup made with meat and bones 肉及骨湯類	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	¼ cup杯	½ cup杯	¾ cup杯	_____
Other type of soup 其他 _____	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	¼ cup杯	½ cup杯	¾ cup杯	_____

Vegetables (canned, fresh or frozen)
蔬菜(罐頭,新鮮或雪藏)

Broccoli 西蘭花(百加利)	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____
Carrots甘筍	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____
Corn, creamed or niblets 粟米,粟米蓉或粟米粒	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____
Green peas 青豆	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____
Spinach, cooked 菠菜,已熟	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____
Green beans, string beans, yellow beans 豆角,長青豆,黃豆角	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____
Potatoes, mashed, baked, salad or boiled馬鈴薯(薯蓉,烘,沙律,或煮熟)	O Yes 是		O Day日	O	O	O	Other其他
	O No 否	——	O Week 星期	1 Tbsp湯匙	2-3 Tbsp湯匙	4 Tbsp湯匙	_____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?			How many times per day or per week over the last two weeks? 每天或每星期吃多少次?		How much does your child usually eat/drink each time? 每次吃多少?		
French fries, home fries, pan fries 薯條	O Yes 是 O No 否	——	O Day日 O Week 星期	O 1-4 pieces 1-4 條	O 5-9 pieces 5-9 條	O 10 or more 10 條或多於	Other其他 _____
Squash, all types 各式瓜菜	O Yes 是 O No 否	——	O Day日 O Week 星期	O 1 Tbsp湯匙	O 2-3 Tbsp湯匙	O 4 Tbsp湯匙	Other其他 _____
Cabbage 椰菜	O Yes 是 O No 否	——	O Day日 O Week 星期	O 1 Tbsp湯匙	O 2-3 Tbsp湯匙	O 4 Tbsp湯匙	Other其他 _____
Brussel sprouts 小椰菜	O Yes 是 O No 否	——	O Day日 O Week 星期	O 1-2 pieces個	O 3-4 pieces個	O ¼ cup杯	Other其他 _____
Raw salad vegetables (tomato, cucumber, peppers) 雜菜沙律	O Yes 是 O No 否	——	O Day日 O Week 星期	O ⅛ cup杯	O ¼ cup杯	O ½ cup杯	Other其他 _____
Spinach salad 菠菜沙律	O Yes 是 O No 否	——	O Day日 O Week 星期	O ⅛ cup杯	O ¼ cup杯	O ½ cup杯	Other其他 _____
Bean salad 豆沙律	O Yes 是 O No 否	——	O Day日 O Week 星期	O 1 Tbsp湯匙	O 2-3 Tbsp湯匙	O 4 Tbsp湯匙	Other其他 _____
Other vegetables: 其他 _____	O Yes 是 O No 否	——	O Day日 O Week 星期	usual amount普通份量_____			

Fruit (canned, fresh, or frozen)
水果(罐頭,新鮮或雪藏)

Apples, applesauce 蘋果,蘋果醬	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2 Tbsp 湯匙 (½small小)	O 3 Tbsp 湯匙 (¼ small小)	O ¼ cup杯 (½ small小)	Other其他 _____
Bananas 香蕉	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O ⅛ small 小條	O ¼small 小條	O ½ small 小條	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有没有最少吃了一次這種食物?			How many times per day or per week over the last two weeks? 每天或每星期吃多少次?		How much does your child usually eat/drink each time? 每次吃多少?			
Oranges 橙	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2 sections 塊	O ¼-½ orange個	O 1 whole個	Other其他 _____
Grapefruit 西柚	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2 sections 塊	O ¼ fruit個	O 1 fruit個	Other其他 _____
Pears, peaches, nectarines, plums 梨子,桃,水蜜桃,李子	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O ¼ fruit個 (1 Tbsp 湯匙)	O ½ fruit個 (⅛ cup杯)	O 1 whole個 (¼ cup杯)	Other其他 _____
Grapes 葡提子	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Raisins, prunes, other dried fruit葡萄乾,西梅,其他乾果	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2	O 3-5	O 6-8	Other其他 _____
Melon (canteloupe, honeydew & watermelon) 西瓜,蜜瓜,皺紋瓜	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O ⅛ cup杯	O ¼ cup杯	O ½ cup杯	Other其他 _____
Lychee 荔枝	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2	O 3-4	O 5-6	Other其他 _____
Strawberries 士多啤梨	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2 Tbsp 湯匙	O 3-4 Tbsp 湯匙	O ¼ cup杯	Other其他 _____
Other berries (eg. blueberries, raspberries) 其他莓類	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2 Tbsp 湯匙	O 3-4 Tbsp 湯匙	O ¼ cup杯	Other其他 _____
Fruit cocktail or fresh fruit salad 雜果或雜果沙律	O Yes是 O No否	O unswt 不含糖 O swt 含糖	——	O Day日 O Week 星期	O 1-2 Tbsp 湯匙	O 3-4 Tbsp 湯匙	O ¼ cup杯	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?	How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?

Other fruits 其他 _____	O Yes是 O No否	O unswt 不含糖 O swt 含糖	O Day日 O Week 星期	usual amount普通份量_____

Beverages
飲品類

Orange juice & other citrus juices (eg. grapefruit, "Five Alive") 橙汁及其他果酸飲品	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Apple juice 蘋果汁	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Other fruit juices (eg. grape, pear cranberry,papaya, pineapple)其他果汁	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Prune juice 西梅汁	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Tomato & mixed vegetable juices (eg. V8 juice) 蕃茄汁及菜汁	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Carrot juice 甘筍汁	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Sweetened fruit drinks including crystals & boxed varieties (eg. Tang, Kool-Aid, Ribena) 含糖果汁(如利賓納)	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Soft drinks, regular 汽水	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Soft drinks, diet 減肥汽水	O Yes 是 O No 否	____	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Carbonated fruit drinks (eg. Koala Springs, Snapple) 有汽果汁	O Yes 是 ____ O No 否	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Tea 茶	O Yes 是 ____ O No 否	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Coffee 咖啡	O Yes 是 ____ O No 否	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____
Other beverages: 其他 _____	O Yes 是 ____ O No 否	O Day日 O Week 星期	O ¼ cup杯 (2 oz)	O ½ cup杯 (4 oz)	O ¾ cup杯 (6 oz)	Other其他 _____

Desserts & Snacks
甜品和小食

Custard 燉蛋	O Yes 是 ____ O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Pudding 布甸	O Yes 是 ____ O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Jello 果子凍	O Yes 是 ____ O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O ½ cup杯	Other其他 _____
Ice cream, ice milk, sherbet, frozen yogurt 雪糕,雪葩,軟雪糕	O Yes 是 ____ O No 否	O Day日 O Week 星期	O 1-2 Tbsp湯匙	O ⅛-¼ cup杯	O 1 scoop杓子 (½ cup杯)	Other其他 _____
Popsicle or Mr. Freezie 冰棒/雪條	O Yes 是 ____ O No 否	O Day日 O Week 星期	O ¼	O ½	O 1 whole個	Other其他 _____
Cake 蛋糕	O Yes 是 ____ O No 否	O Day日 O Week 星期	O 1-2 bites口	O ½ slice片	O 1 slice片	Other其他 _____

	Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有没有最少吃了一次這種食物?		How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?			
Pop Tarts pastry	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	⅛-¼	½	¾	_____
Pie 批	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1-2 bites口	1/16 pie批	⅛ pie批	_____
Fruit crisps (eg. apple crisp, berry strudel) 水果批	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1-2 bites口	⅛ cup杯	¼ cup杯	_____
Cookies (eg. peanut butter, chocolate chip, raisin, oatmeal)各式曲奇餅	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	½ cookie塊	1 whole個	2	_____
Other cookies (eg. arrowroot, digestives, teething biscuits) 各式餅乾	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	½ cookie塊	1 whole個	2	_____
Plain or cheese crackers (eg. Ritz, cheese type, soda crackers)克力架	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1	2	3	_____
Wheat crackers (eg stone wheat thins, Triscuits, wholegrain soda crackers) 全麥克力架	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1	2	3	_____
Potato chips, cheesies or tortilla chips 薯片, 芝士條或栗米片	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1-2 pieces片	¼ small bag小袋	½ small bag小袋	_____
Popcorn 爆谷	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1-2 pieces片	¼ cup杯	½ cup杯	_____
Peanuts, other nuts or seeds 花生及其他果仁	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1-2 tsp 茶匙	1 Tbsp湯匙	2 Tbsp湯匙	_____
Other desserts & snacks 其他 _____	O Yes 是	____	O Day日	usual amount 普通份量 _____			
	O No 否		O Week 星期				

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有没有最少吃了一次這種食物?	How many times per day or per week over the last two weeks? 每天或每星期吃多少次?	How much does your child usually eat/drink each time? 每次吃多少?

Miscellaneous

Chocolate bar 朱古力條	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	⅛ bar條	¼ bar條	½ bar條	_____
Granola bar 高纖維條	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	⅛ cup杯	¼ bar條	½ bar條	_____
Fruit Roll-up, fruit leather 果汁糖塊	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1 square inch 平方吋	2 square inches 平方吋	1 whole 塊	_____
Candy 糖	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	taste 口	1-2 pieces塊	3-4 pieces塊	_____
Tomato ketchup 茄汁	O Yes 是	____	O Day日	O	O	O	Other其他
	O No 否		O Week 星期	1-2 tsp 茶匙	1 Tbsp 湯匙	2-3 Tbsp 湯匙	_____
Other miscellaneous foods: 其他 _____	O Yes 是	____	O Day日	usual amount 普通份量_____			
	O No 否		O Week 星期				

Sugar, Fats, & Other Condiments 糖、油及其他醬料

How often does your child eat the following foods? 你的們子女常吃以下的食品嗎？	Prompts:		≤ once per week 每星期一次或以下	2-4 times per week 每星期二至四次	almost every day 5-7 times/week 每星期五至七次	2-3 times per day 每日二至三次	4-5 times per day 每日四至五次	Usual portion 常用份量
Sugar糖	✓ cereal ✓ beverage	穀片 飲料	○	○	○	○	○	_____
Margarine or butter 人造牛油/牛油	✓ bread, bagels ✓ crackers ✓ muffins ✓ vegetables	麵包，猶太包 克力架 鬆餅 菜	○	○	○	○	○	_____
Cream cheese 忌廉芝士	✓ bread, bagels ✓ crackers ✓ muffins	麵包，猶太包 克力架 鬆餅	○	○	○	○	○	_____
Mayonnaise 白沙律醬	✓ bread	麵包	○	○	○	○	○	_____
Salad dressing 沙律醬/汁	✓ vegetables	菜	○	○	○	○	○	_____
Gravy 肉汁	✓ vegetables ✓ meats	菜 肉	○	○	○	○	○	_____
Tartar sauce 海鮮汁	✓ fish	魚	○	○	○	○	○	_____
Sour cream 酸忌廉	✓ vegetables	菜	○	○	○	○	○	_____
Cheese sauce or cheese whiz 芝士汁	✓ vegetables ✓ noodles	菜 粉麵	○	○	○	○	○	_____
Soy sauce 豉油	✓ rice ✓ noodles ✓ vegetables	飯 粉麵 菜	○	○	○	○	○	_____
Oyster sauce 蠔油	✓ rice ✓ noodles ✓ vegetables	飯 粉麵 菜	○	○	○	○	○	_____

How oftwen does your child eat the following foods? 你的們子女常吃以下的食品嗎？	Prompts:		≤ once per week 每星期一次或以下	2-4 times per week 每星期二至四次	almost every day 5-7 times/week 每星期五至七次	2-3 times per day 每日二至三次	4-5 times per day 每日四至五次	Usual portion 常用份量
Ketchup 茄汁	✓ eggs ✓ meats ✓ rice ✓ vegetables	蛋 肉 飯 菜	○	○	○	○	○	_____
Sweet spreads, eg. jams, jellies or honey 果占，蜜糖	✓ bread, bagels ✓ crackers ✓ muffins	麵包 猶太包 克力架 鬆餅	○	○	○	○	○	_____
Other其他	please specify _____	請說明	○	○	○	○	○	_____

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?	What type? 何種類型?	How many times per day or week? 每天或每星期吃多少次?	How much does your child usually eat each time? 每次吃多少?				

Purchased Infant, Junior & Toddler Foods
嬰兒、幼兒及幼童食品

Cereal (eg. rice, barley, oats or mixed) 穀類食品(飯,米,麥皮,等)	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	___	O Day 日 O Week 星期	O 3 Tbsp or less 湯匙或少於 dry 乾	O ¼ cup 杯 dry 乾	O ½ cup 杯 dry 乾	Other 其他 ___
Cereal mixed with fruit and/ or yogurt 穀類食品, 加水果或/及乳酪	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	___	O Day 日 O Week 星期	O 3 Tbsp or less 湯匙或少於 dry 乾	O ¼ cup 杯 dry 乾	O ½ cup 杯 dry 乾	Other 其他 ___
Meat or poultry (eg. beef, pork, lamb, veal, ham, chicken or turkey) 肉或家禽類	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	___	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Liver 肝	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	___	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Meat/poultry and rice/noodle dinner (eg. beef, pork, lamb or chicken) 晚餐: 肉或家禽加飯/麵	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	___	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Vegetable & meat (eg. beef, pork, lamb, chicken or turkey) 菜及肉類	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	___	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於

Has your child eaten this food at least once in the last two weeks? 你們的子女於過去的兩星期有沒有最少吃了一次這種食物?	What type? 何種類型?	How many times per day or week? 每天或每星期吃多少次?		How much does your child usually eat each time? 每次吃多少?			
Vegetables 蔬菜	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Fruits 水果	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Prunes 西梅	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Fruit dessert (eg. Tutti Frutti) 水果甜品	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Fruit yogurt dessert 水果乳酪甜品	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Custard or pudding 布甸或燉蛋	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於
Other purchased baby foods:其他 _____	O Yes 是 O No 否	O strained 已過濾 O junior 幼兒食用 O toddler 幼童食用	—	O Day 日 O Week 星期	O ¼ jar or less 瓶或少於	O ½ jar 瓶	O ¾ jar 瓶	O whole jar or more 整瓶或多於

Part 2
第二部份

2.1 **Are you currently breast-feeding?**
你現在有沒有餵哺人奶？

O YES有 times per day ___ usual time per feeding _____
O NO沒有 每天_____次 每次需時_____

2.2 **Are you currently giving your child a commercial infant formula?**
你的嬰兒現在有沒有飲用市面售賣的嬰兒奶水/粉？

O YES有 [Please go to Q. 2.2(a)] [請答第 2.2(a)題]

O NO沒有 [Please go to Q. 2.3] [請答第 2.3 題]

2.2(a)	What brands/types of formula do you usually give your child? 你常選購哪種牌子/種類的奶水/粉?	Color of Label 招紙的顏色	How many times per day or week does your child drink formula? 每天或每星期飲用多少次？	How much does your child usually drink per feeding? 每次飲用的份量有多少？
(1)	_____	_____	__times per O day 日 __次 每 O week 星期	_____
(2)	_____	_____	__times per O day 日 __次 每 O week 星期	_____
(3)	_____	_____	__times per O day 日 __次 每 O week 星期	_____

2.3 **Have you ever given your child a vitamin/mineral supplement?**
你的嬰兒有沒有服用任何額外的維他命/礦物質？

O YES有 (Please go to Q. 2.4) [請答第 2.4題]

O NO沒有

2.4	What Brands/Types of supplements? 何種類型或牌子？	At what age? 服用時期	About how much? 份量？	
(1)	_____	_____months月 to至 _____months月	_____mL per每 _____tablet(s)粒	O day日 O week星期 O month月
(2)	_____	_____months月 to至 _____months月	_____mL per每 _____tablet(s)粒	O day日 O week星期 O month月
(3)	_____	_____months月 to至 _____months月	_____mL per每 _____tablet(s)粒	O day日 O week星期 O month月

Please indicate the types of milk fed to your baby at the hospital and at each month during the first 26 months.
請提供有關你的嬰兒在頭二十六個月中，包括在醫院和每個月曾飲用的奶類飲料。

Type of Milk Feeding 曾飲用的奶類	Never 從來沒有	At Hospital 在醫院	Age (Months) 年齡 (月)											
			1	2	3	4	5	6	7	8	9	10	11	12
Breast-Milk 人奶	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Infant Formula 嬰兒奶水														
Regular (low iron) 普通(低鐵質)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Formula with iron (fortified) 高鐵質	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soya-based formula 豆奶	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cows Milk 牛奶														
Whole 全脂	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
skim milk 脫脂	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goats Milk 羊奶	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soy Milk (not formula) 豆漿	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other 其他	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Type of Milk Feeding 曾飲用的奶類	Age (Months) 年齡(月)													
	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Breast-Milk 人奶	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Infant Formula 嬰兒奶水														
Regular (low iron) 普通(低鐵質)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Formula with iron (fortified) 高鐵質	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soya-based formula 豆奶	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cows Milk 牛奶														
Whole 全脂	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
skim milk 脫脂	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goats Milk 羊奶	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soy Milk (not formula) 豆漿	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other 其他	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Thank you for taking the time to complete this questionnaire and for your valuable participation in this study.
謝謝你們抽空填妥這份問卷並參予是項研究。

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同意事項

大溫地區嬰兒與幼兒進食習慣研究

研究者: Dr. Sheila M. Innis

計劃摘要

此研究的目的包括：一、調查大溫地區八至二十六個月大的幼兒的進食習慣；二、發展一系列飲食習慣問題，以用作辨認面臨營養不足的幼兒。

此研究不會有任何危險。我明白若我參予，我會：

1. 讓我的子／女接受體重、身高和頭圍的量度。
2. 提供我的文化及社交背景，內容絕對保密。
3. 與營養師一起完成一份有關我子／女在二十四小時內進食的問卷。
4. 依照營養師的指示，記錄我子／女三天內(包括兩個週日天及一個週末天)所吃的食物。
5. 與營養師一起完成一份有關我子／女日常進食習慣的問卷。
6. 若我子／女被懷疑面臨營養不足，我容許註冊護士或技術員從我嬰兒的手指或腳跟刺取小量血液樣本來測試我子／女的營養情況。若我願意參予此部份研究，我會簽署另一份同意書。

參加這項研究的好處是我能獲得營養師對我子／女的飲食的評估，所提供的資料有助於辨認面臨營養不足的幼兒。參加這項研究，第一次的會面約莫需要一至二小時，來完成「進食習慣問卷」和「二十四小時進食記錄問卷」，然後約需要每天半至一小時來完成那份「三天進食記錄表」。我和我子／女的姓名將會保密和不會出現在任何的研究報告上，我亦隨時可以拒絕我子／女繼續參予此研究。若我對研究程序有任何疑問，我可以致電 875-3537與營養師 Patty Williams或875-2418與Dr. Sheila M. Innis聯絡。

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同意事項

大溫地區八至二十六個月大嬰兒的體內鐵質狀態與哺養情況

研究者: Dr. Sheila M. Innis

計劃摘要

此研究的目的是根據大溫地區八至二十六個月大的嬰兒飲食方面攝取鐵質之程度，來找出嬰兒低鐵質狀態和貧血的普遍程度。

此研究不會有任何危險。我和我的嬰兒將會參予，我同意並容許卑詩兒童醫院的註册護士或技術員從我嬰兒的手指或腳跟刺取小量(大約十分之一茶匙)血液樣本來測試我兒體內鐵質狀態，這刺取只會引起短暫的不安，但不會產生任何痛楚或危險。

我會如常照顧和護理我的嬰兒，我亦隨時可以拒絕我的嬰兒繼續參予此研究，若我對研究程序有任何疑問，我可以致電875-3537與Patty Williams或875-2418與Dr. Sheila M. Innis聯絡。

同意書

我對此研究的目的和程序經已獲悉，我並明白拒絕我的嬰兒繼續參予此研究並不會影響日後我對嬰兒的照顧和護理，我和我嬰兒的姓名將會保密和不會出現在任何的研究報告上。

我願意我的嬰兒_____參予此項鐵質狀態的研究。我亦收到此份同意書的副本。

簽署:_____ 日期:_____
(家長或監護人)

與嬰兒的關係:_____ 日期:_____

見証人:_____ 日期:_____

研究者簽署:_____ 日期:_____

PERSONAL DATA

Appendix L. Personal Data Form.

Subject Number	Clinic Number	Clinic Date	Day	Month	Year

Mother's First Name: _____ Surname: _____

Father's First Name: _____ Surname: _____

Baby's First Name: _____ Surname: _____

Baby's Birthdate: _____ Baby's Sex: Male ___ Female ___

Address: _____ Address if changed: _____

_____ _____

_____ _____

Postal Code: _____ Postal Code: _____

Home phone: _____ Alternate phone: _____

Physician: _____

Address: _____ Postal Code: _____

_____

_____ Telephone: _____

ANTHROPOMETRIC DATA

CLINIC	Measure 1	Measure 2	Measure 3
1. Weight, gm (10g difference)	_____	_____	_____
2. Crown-Heel Length, cm (0.4 cm)	_____	_____	_____
3. Head Circumference, cm (0.2 cm)	_____	_____	_____

BIRTH

1. Weight	_____lbs _____oz	_____kg
2. Length	_____inches	_____cm
3. Head Circumference	_____inches	_____cm

Comments _____

_____

Nutritionist _____

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INFORMED CONSENT

Feeding Practices Among Infants and Toddlers in Vancouver
Principal Investigator: Dr. Sheila M. Innis

Summary of Project:
The purpose of this study is two-fold: 1) to examine the dietary intake and feeding practices of infants 9 to 24 months of age living in Vancouver, and 2) to develop a short series of diet questions to use in identifying toddlers at risk for nutritional deficiencies.

This study involves no risk. I understand that by participating, I will:

1. Allow my child's weight, length/height, and head circumference to be measured.
2. Provide confidential information on my social/cultural background.
3. Answer a questionnaire on my child's diet over the last 24 hours with the study nutritionist.
4. Keep a diet record for 3 days (2 week days and 1 weekend day) for my child at home as instructed by a nutritionist.
5. Complete a questionnaire of my child's usual food intake with the study nutritionist.
6. Allow a registered technologist or nurse to obtain a small blood sample from my child (from a heel or finger prick) **ONLY IF** he/she has been identified to be at risk for nutritional deficiency. I will sign a separate consent form if I am willing to participate in this part of the study.

The benefit I will receive from this study is an assessment of my child's dietary intake by a nutritionist. Our participation will contribute valuable information for identifying other infants at risk for nutritional deficiencies. My participation in this study will require 1-2 hours of my time to complete questionnaires and 24 hour dietary recall on the first day of my participation, then about 30-60 minutes during each of the next 3 days to record my childs food intake.

My name, my child's name and the information we provide will be treated confidentially, by use of code numbers, and will not be used in any report of this study. I may refuse to participate or withdraw from the study at any time without jeopardy. If I have any questions about the study I may contact Patty Williams, Dietitian/Nutritionist at 875-3537 or 875-2418, or Dr. Sheila Innis at 875-2431.

CONSENT

The objectives and procedures of the study have been explained to me to my satisfaction, and I understand that my child and I may withdraw from the study at any time. Refusal to participate or voluntary withdrawal from the study will not jeopardize me or my child in any way. My name and my child's name will be treated confidentially during the study and will not be mentioned in any report or publications of study results. If I have any concerns about my or my child's treatment or rights as research subjects, I may telephone Dr. R.D. Spratley, Director of Research Services at 822-8595.

I _____ *voluntarily give consent for*
(please print)

my infant _____ *to participate in the study on*
(please print)

feeding practices, and I acknowledge receipt of a copy of the consent form.

SIGNED: _____ *DATE:* _____

RELATIONSHIP TO INFANT: _____

WITNESS: _____ *DATE:* _____

INVESTIGATOR'S SIGNATURE: _____

DATE: _____

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INFORMED CONSENT

Prevalence of Low Iron Status and Feeding Practices of 9 - 24 Month Old Infants in Vancouver
Principal Investigator: Dr. Sheila M. Innis

Summary of Project:
The purpose of this study is to define the prevalence of low iron status and iron deficiency anemia in 9-24 month old infants in Vancouver according to level of dietary iron intake.

The study involves no risk. My infant and I will participate by allowing a small blood sample (about 1/10th teaspoon) to be taken by a registered technologist or nurse from B.C. Children's Hospital from a heel or finger prick for testing iron status. The prick may cause very brief discomfort, but otherwise no pain or risk.

The care and treatment of my infant will be the same as if he/she were not a participant in this study. I may decline or withdraw any participation at any time. If I have any questions about the study procedures and my infant's participation, I may contact Patty Williams or Dr. Sheila M. Innis at 875-3537 or 875-2418.

CONSENT

The objectives and procedures of the study have been explained to my satisfaction. Refusal to participate will not jeopardize the future care of my infant. My or my infant's name will be treated confidentially and will not be mentioned in any report of the study.

I voluntarily give consent for my infant _____ to participate in the study of iron status, and I acknowledge receipt of a copy of the consent form.

SIGNED: _____ *DATE:* _____
(Parent or person legally authorized to give consent)

RELATIONSHIP TO INFANT: _____

WITNESS: _____ *DATE:* _____

INVESTIGATOR'S SIGNATURE: _____ *DATE:* _____

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同意事項

大溫地區嬰兒與幼兒進食習慣研究

研究者: Dr. Sheila M. Innis

計劃摘要

此研究的目的包括：一、調查大溫地區八至二十六個月大的幼兒的進食習慣；
二、發展一系列飲食習慣問題，以用作辨認面臨營養不足的幼兒。

此研究不會有任何危險。我明白若我參予，我會：

1. 讓我的子／女接受體重、身高和頭圍的量度。
2. 提供我的文化及社交背景，內容絕對保密。
3. 與營養師一起完成一份有關我子／女在二十四小時內進食的問卷。
4. 依照營養師的指示，記錄我子／女三天內(包括兩個週日天及一個週末天)所吃的食物。
5. 與營養師一起完成一份有關我子／女日常進食習慣的問卷。
6. 若我子／女被懷疑面臨營養不足，我容許註册護士或技術員從我嬰兒的手指或腳跟刺取小量血液樣本來測試我子／女的營養情況。若我願意參予此部份研究，我會簽署另一份同意書。

參加這項研究的好處是我能獲得營養師對我子／女的飲食的評估，所提供的資料有助於辨認面臨營養不足的幼兒。參加這項研究，第一次的會面約莫需要一至二小時，來完成「進食習慣問卷」和「二十四小時進食記錄問卷」，然後約需要每天半至一小時來完成那份「三天進食記錄表」。我和我子／女的姓名將會保密和不會出現在任何的研究報告上，我亦隨時可以拒絕我子／女繼續參予此研究。若我對研究程序有任何疑問，我可以致電 875-3537與營養師 Patty Williams或875-2418與Dr. Sheila M. Innis聯絡。

同意書

我對此研究的目的和程序經已獲悉，我明白我有權隨時讓我子／女退出此研究；我並明白拒絕我的嬰兒繼續參予此研究並不會影響日後我對嬰兒的照顧和護理，我和我嬰兒的姓名將會保密和不會出現在任何的研究報告上。若我有任何有關我子／女在研究中程序和權利上的問題，我可以致電822-8595與研究服務總監 Dr. R.D. Spratley 聯絡。

我_____願意我子／女_____
參予此進食習慣研究。我亦收到此份同意書的副本。

簽署:_____ 日期:_____

與幼兒的關係:_____

見証人:_____ 日期:_____

研究者簽署:_____ 日期:_____

(中文譯文內容以英文原文爲準)

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同意事項

大溫地區八至二十六個月大嬰兒的體內鐵質狀態與哺養情況

研究者: Dr. Sheila M. Innis

計劃摘要

此研究的目的是根據大溫地區八至二十六個月大的嬰兒飲食方面攝取鐵質之程度，來找出嬰兒低鐵質狀態和貧血的普遍程度。

此研究不會有任何危險。我和我的嬰兒將會參予，我同意並容許卑詩兒童醫院的註册護士或技術員從我嬰兒的手指或腳跟刺取小量(大約十分之一茶匙)血液樣本來測試我兒體內鐵質狀態，這刺取只會引起短暫的不安，但不會產生任何痛楚或危險。

我會如常照顧和護理我的嬰兒，我亦隨時可以拒絕我的嬰兒繼續參予此研究，若我對研究程序有任何疑問，我可以致電875-3537與Patty Williams或875-2418與Dr. Sheila M. Innis聯絡。

同意書

我對此研究的目的和程序經已獲悉，我並明白拒絕我的嬰兒繼續參予此研究並不會影響日後我對嬰兒的照顧和護理，我和我嬰兒的姓名將會保密和不會出現在任何的研究報告上。

我願意我的嬰兒_____參予此項鐵質狀態的研究。我亦收到此份同意書的副本。

簽署:_____ 日期:_____
(家長或監護人)

與嬰兒的關係:_____ 日期:_____

見証人:_____ 日期:_____

研究者簽署:_____ 日期:_____

(中文譯文內容以英文原文爲準)

FOOD FREQUENCY QUESTIONNAIRE

(TO BE COMPLETED BY NUTRITIONIST)

Subject Number **Interviewer**

Parent's Name Last First

Child's Name Last First

Child's DOB Day Month Year

Child's Age months

Date of Follow-up Visit

Day Month Year

Day of week

Location of Visit

Main Respondent: child's

- ☐ mother
- ☐ father
- ☐ sister
- ☐ brother
- ☐ grandparent
- ☐ other _____

This questionnaire is designed to determine your child's usual food intake over the last two weeks. Please think about all the foods and beverages your child eats and drinks both at home and away from home.

Part 1. I will be asking you about many different foods and drinks. For every food please tell me whether your child has had this food or beverage at least once in the last two weeks. If YES, then I will ask you to tell me the number of times per day, or for foods eaten less than once per day, how many times in the last two weeks. Then I will ask you to tell me the serving size, or how much, your child usually eats. Please report the amount your child usually eats, not the amount you usually prepare or offer.

Note: If child eats only purchased infant, junior or toddler foods, please skip to page 21.

Here are some examples showing how the chart will be completed:

	Has your child eaten this food at least once in the last two weeks?	How many times per day or in the last two weeks?				How much does your child usually eat/drink each time?	
Example #1 "Sarah drinks whole milk once a day - about 1/2 a cup each time" **You would show that on the chart like this:**							
Whole milk & beverages made with it	○ Yes ○ No	___	○ Day ○ Week	○ 1/2 cup	○ 3/4 c	○ 1 c	Other _____
Example #2 "Sarah eats bread in a sandwich for lunch about three times a week, two slices each time but she does not eat the crust (equal to 1/2 slice bread)" **You would record that on the chart like this:**							
Bread & Rolls	○ Yes ○ No	___	○ Day ○ Week	○ 1/4 slice	○ 1/2 slice	○ 1 slice	Other _____
Example #3 "Sarah only eats fish about twice per month. She usually eats only 1 TBSP" **You would show that on the food chart like this:**							
Fish	○ Yes ○ No	___	○ Day ○ Week	○ 1/2 oz	○ 1 oz	○ 2 oz	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Milk *(include milk used in cereals and drinks made with milk)*							
Skim milk 100647	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
1% milk 100602	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
2% milk 100600	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Whole milk 100646	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Evaporated milk 100674	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Sweetened condensed milk 100608	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Chocolate milk 100612	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Milkshake 100617	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Soy beverage 103513	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Rice beverage 200001	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___

	Has your child eaten this food at least once in the last two weeks?		*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Goat's milk 100613	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___
Other milk products ___	○ Yes ○ No	300671 55 100687	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ 1 cup (8 oz)	Other ___

Cheese, Eggs & Yogurt

Hard cheese (cheddar, Swiss) 502001	○ Yes ○ No		___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other ___
Part-skim or low fat cheese (eg. lite cheeses, regular mozzarella) 502002	○ Yes ○ No		___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other ___
"Lite" mozzarella cheese 100644	○ Yes ○ No		___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other ___
Processed cheese slices (including on sandwiches and hamburgers) 502003	○ Yes ○ No		___	○ Day ○ Week	○ ¼ slice (¼ oz)	○ ½ slice (½ oz)	○ 1 slice (1 oz)	Other ___
Lite processed cheese slices (including on sandwiches and hamburgers) 502004	○ Yes ○ No		___	○ Day ○ Week	○ ¼ slice (¼ oz)	○ ½ slice (½ oz)	○ 1 slice (1 oz)	Other ___
Cottage cheese, creamed 100562	○ Yes ○ No		___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-5 Tbsp	○ ⅛ cup	Other ___
Cottage cheese, 1% or 2% 502005	○ Yes ○ No		___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-5 Tbsp	○ ⅛ cup	Other ___
Cheese spread (eg. Cheeze Whiz) 100638	○ Yes ○ No		___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other ___

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Lite cheese spreads (eg. Lite Cheeze Whiz) 100695	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other ___
Soy cheese 200027	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other ___
Goat cheese 100684	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp grated	○ 2 Tbsp grated (¼ oz)	○ 1 inch cube (1 oz)	Other ___
Paneer 410001	○ Yes ○ No	___	○ Day ○ Week	○ ½ inch cube	○ 1 inch cube	○ 2 inch cube	Other ___
Whole egg, all forms (eg. scrambled, hard boiled) 502007	○ Yes ○ No	___	○ Day ○ Week	○ ¼ egg or less	○ ½ egg	○ 1 egg	Other ___
Egg yolk only 100657	○ Yes ○ No	___	○ Day ○ Week	○ ¼ egg or less	○ ½ egg yolk	○ 1 egg yolk	Other ___
Egg white only 100623	○ Yes ○ No	___	○ Day ○ Week	○ ¼ egg or less	○ ½ egg white	○ 1 egg white	Other ___
Yogurt 502008	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (60g)	○ small carton (125g)	○ large carton (175g)	Other ___
Yogurt, 1% or 2% 502009	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (60g)	○ small carton (125g)	○ large carton (175g)	Other ___
Aspartame sweetened yogurt 502009	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (60g)	○ small carton (125g)	○ large carton (175g)	Other ___
"Minigo" (Yoplait fresh cheese product) 200002	○ Yes ○ No	___	○ Day ○ Week	○ ½ small	○ small carton (60g)	○ large carton (125g)	Other ___

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Other cheese, yogurt or egg product: _____	○ Yes ○ No	100577 100701 262000	___	○ Day ○ Week	usual amount _____ 502011 310046		
Breakfast Cereals							
Whole grain hot cereals (eg. rolled oats, Red River) 503001	○ Yes ○ No		___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Cream of wheat 101602	○ Yes ○ No		___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Rice congee, with meat 420001 (without meat) 420004 (with meat)	○ Yes ○ No		___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Cold cereals, plain or with sugar coating (eg. Corn Flakes, Rice Krispies, Cheerios, Frosted Flakes, Fruit Loops) 503002	○ Yes ○ No		___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Bran or multigrain type cereals (Shreddies, Bran Flakes, Corn Bran, Fruit & Fibre) 503003	○ Yes ○ No		___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Granola type cereal 503004	○ Yes ○ No		___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Other breakfast cereals: _____	○ Yes ○ No	72889 101560 210008 101640 420002	___	○ Day ○ Week	○ ⅛ cup or less	○ ¼ cup	○ ½ cup	Other _____
Breads, Rolls, Muffins & Other Grains							
Bread, dinner roll, white, enriched 504001	○ Yes ○ No		___	○ Day ○ Week	○ ¼ slice or roll	○ ½ slice or roll	○ 1 slice or roll	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Whole grain bread, dinner roll 504002	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice or roll	○ ½ slice or roll	○ 1 slice or roll	Other _____
Pita bread, bagel, english muffin, white, enriched 504003	○ Yes ○ No	___	○ Day ○ Week	○ ⅛	○ ¼	○ ½	Other _____
Pita bread, bagel, english muffin, wholegrain 504004	○ Yes ○ No	___	○ Day ○ Week	○ ⅛	○ ¼	○ ½ (8 oz)	Other _____
Hotdog or hamburger bun 504005	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ bun	○ ½ bun	○ ¾-1 bun	Other _____
Bran or wholewheat muffin, small (40g) 100292	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-1	Other _____
Cake muffin, small (40g) eg. plain, chocolate chip, blueberry, banana or corn 100291	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-1	Other _____
Scones (40g), all varieties 42071	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Pancakes, waffles or French toast (35g) 504006	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Wholegrain pancakes, waffles or French toast (35g) 504007	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Rice cakes 44064	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Chapatti or roti 504008	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Parantha, plain 410002	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Steamed bun, plain 300007	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Tortilla, flour or corn 410005	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾-one whole	Other _____
Any pasta or noodle, cooked 103880	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Rice noodles 300016	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Instant noodles 300010	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Rice, any type, cooked 103883	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼ cup	○ ½ cup	Other _____
Other grain products: _____	○ Yes ○ No	___ 103822 103809 42540	○ Day ○ Week	usual amount _____ 100546 100483			

Meat, Fish, Poultry & Alternatives

Beef (including, deli sliced, smoke meat, steak, roast, ground, etc.) 505001	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Pork (including deli slices, steak, roast, chops, etc.) 505002	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Wild game (fresh, frozen, dried) 103760	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Lamb (including roast, chops, etc.) 505003	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Liver, any type 505004	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Chicken, turkey or other poultry (including deli sliced, roast, etc.) 505005	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Chicken nuggets 103965	○ Yes ○ No	___	○ Day ○ Week	○ 1 piece (½ oz)	○ 2 pieces (1 oz)	○ 3 pieces (1½ oz)	Other ___
Chicken fingers or strips 15162	○ Yes ○ No	___	○ Day ○ Week	○ 1 piece (1 oz)	○ 2 pieces (2 oz)	○ 3 pieces (3 oz)	Other ___
Duck 505006	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Fish, canned, fresh, frozen (eg. tuna, salmon, sushi) 505007	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Shellfish (eg. prawns, shrimp, crab) 505008	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other ___
Wieners 101505	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other ___
Bacon 102022	○ Yes ○ No	___	○ Day ○ Week	○ 1 slice	○ 2 slices	○ 3 slices	Other ___

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Sausages 505009	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other _____
Processed meats (eg. bologna, salami, chicken loaf) 505010	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp (½ oz)	○ 2 Tbsp (1 oz)	○ 4 Tbsp (2 oz)	Other _____
Firm or medium firm tofu or soybean curd 505011	○ Yes ○ No	___	○ Day ○ Week	○ 1 inch cube	○ 2 inch cube	○ ½ cup	Other _____
Soft or dessert tofu 505012	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other _____
Soy (tofu) burger, vegetarian patty 505014	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ pattie	○ ½ pattie	○ ¾ pattie	Other _____
Soy (tofu) wiener, vegetarian weiner 505015	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ wiener	○ ½ wiener	○ ¾ wiener	Other _____
Tahini (sesame seed paste) 102830	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 1½ Tbsp	Other _____
Peanut butter or other nut butter 103565	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 1½ Tbsp	Other _____
Dry peas, beans, lentils, legumes, cooked 505013	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ¼-⅓ cup	○ ½ cup	Other _____
Other meats or alternatives: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

505016
62206
7622
300555

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Combination Dishes							
Mixed dishes made with beef (eg. casseroles, hamburger helper, lasagna, spaghetti meat sauce) 506001	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Mixed dishes made with fish (eg. casserole) 506002	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Mixed dishes made with pork 506003	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Mixed dishes made with lamb 506004	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Canned pasta, with meat (eg. ravioli) 506005	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Canned pasta, without meat 506006	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Homemade macaroni and cheese, other pasta dishes with cheese 506007	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Boxed macaroni & cheese (eg. Kraft Dinner) 57059	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other ___
Pastry/pies, meat filled (eg. sausage rolls, meat pies) 506008	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ pie or roll	○ ¼ pie or roll	○ ½ pie or roll	Other ___
Filled buns, baked or steamed, meat filled 300020	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ bun	○ ¼ bun	○ ½ bun	Other ___

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Perogies, potato & cheese filled 270011	○ Yes ○ No	___	○ Day ○ Week	○ ½	○ 1	○ 2	Other ___
Perogies, potato & onion filled 270012	○ Yes ○ No	___	○ Day ○ Week	○ ½	○ 1	○ 2	Other ___
Enchiladas, cheese filled 506009	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ 6 inch	○ ½ 6 inch	○ 1 whole 6 inch	Other ___
Enchiladas, meat filled 506010	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼ 6 inch	○ ½ 6 inch	○ 1 whole 6 inch	Other ___
Pizza with cheese and no meat 104072	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice	○ ½ slice	○ 1 slice	Other ___
Pizza with cheese and meat 506013	○ Yes ○ No	___	○ Day ○ Week	○ ¼ slice	○ ½ slice	○ 1 slice	Other ___
Pizza rolls/pizza pockets 506012	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other ___
Quiche with meat 56098	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ 5 Tbsp	Other ___
Quiche without meat 270015	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ 5 Tbsp	Other ___
Mixed dishes made with cooked lentils, beans or peas (eg. lentil stew or soup) 506011	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ½ cup	Other ___
Other mixed dishes: ___	○ Yes ○ No 506015 506017 506018	___	○ Day ○ Week	usual amount ___ 56314 56111			

	Has your child eaten this food at least once in the last two weeks?		*How many times per day or per week over the last two weeks?*	*How much does your child usually eat/drink each time?*			
Soups							
Broth type eg. veg beef, chicken noodle 507001	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other ___
Homemade broth type with meat 57525	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other ___
Cream-type soup 507002	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other ___
Soup made with meat and bones 300017	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup	○ ½ cup	○ ¾ cup	Other ___
Other type of soup: ___	○ Yes ○ No	___ 507006 507008 101313	○ Day ○ Week	○ ¼ cup	○ ½ cup 50180 50013	○ ¾ cup	Other ___
Vegetables (canned, fresh or frozen)							
Broccoli 102670	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other ___
Carrots 102677	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other ___
Corn, creamed or niblets 508001	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other ___
Green peas 102694	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other ___
Spinach, cooked 102485	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other ___

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Green beans, string beans, yellow beans 508002	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Potatoes, mashed, baked, salad or boiled 508003	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
French fries, home fries, pan fries 508004	○ Yes ○ No	___	○ Day ○ Week	○ 1-4 pieces	○ 5-9 pieces	○ 10 or more	Other _____
Squash, all types 508005	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Cabbage 102674	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Brussel sprouts 102229	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 pieces	○ 3-4 pieces	○ ¼ cup	Other _____
Raw salad vegetables (tomato, cucumber, peppers) 508006	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup	○ ¼ cup	○ ½ cup	Other _____
Spinach salad 508007	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup	○ ¼ cup	○ ½ cup	Other _____
Bean salad 6255	○ Yes ○ No	___	○ Day ○ Week	○ 1 Tbsp	○ 2-3 Tbsp	○ 4 Tbsp	Other _____
Other vegetables: _____	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

230000
102256
508008
101723
6257

	Has your child eaten this food at least once in the last two weeks?		*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Fruit (canned, fresh, or frozen)								
Apples, applesauce 509006	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp (⅛ small)	○ 3 Tbsp (¼ small)	○ ¼ cup (½ small)	Other ___
Bananas 101943	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ ⅛ small	○ ¼ small	○ ½ small	Other ___
Oranges 101957	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 sections	○ ¼-½ orange	○ 1 whole	Other ___
Grapefruit 101785	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 sections	○ ¼ fruit	○ ¼ fruit	Other ___
Pears, peaches, nectarines, plums 509001	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ ¼ fruit (1 Tbsp)	○ ½ fruit (⅛ cup)	○ 1 whole (¼ cup)	Other ___
Grapes 101797	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2	○ ⅛-¼ cup	○ ½ cup	Other ___
Raisins, prunes, other dried fruit 509002	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2	○ 3-5	○ 6-8	Other ___
Melon (eg. canteloupe, honeydew, watermelon) 509003	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ ⅛ cup	○ ¼ cup	○ ½ cup	Other ___
Lychee 101820	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2	○ 3-4	○ 5-6	Other ___
Strawberries 101983	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ¼ cup	Other ___

	Has your child eaten this food at least once in the last two weeks?		*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Other berries (eg. blueberries, raspberries) 509004	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ¼ cup	Other _____
Fruit cocktail or fresh fruit salad 509005	○ Yes ○ No	○ unswt ○ swt	___	○ Day ○ Week	○ 1-2 Tbsp	○ 3-4 Tbsp	○ ¼ cup	Other _____
Other fruits: _____	○ Yes ○ No 101809 3220 101895	○ unswt ○ swt	___	○ Day ○ Week 101863 101856	usual amount _____			
Beverages								
Orange juice & other citrus juices (eg. grapefruit, "Five Alive") 510001	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Apple juice 101703	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Other fruit juices (eg. grape, pear cranberry,papaya, pineapple) 510002	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Prune juice 101915	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Tomato & mixed vegetable juices (eg. V8 juice) 510003	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Carrot juice 102623	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Sweetened fruit drinks including crystals & boxed varieties (eg. Tang, Kool-Aid, Ribena) 510004	○ Yes ○ No		___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Soft drinks, regular 510005	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Soft drinks, diet 510006	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Carbonated fruit drinks (eg. Koala Springs, Snapple) 20011	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Tea 103139	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Coffee 103103	○ Yes ○ No	___	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____
Other beverages: _____	○ Yes ○ No	___ 103146 100651 100692	○ Day ○ Week	○ ¼ cup (2 oz)	○ ½ cup (4 oz)	○ ¾ cup (6 oz)	Other _____

Desserts & Snacks

Custard 100249	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Pudding 511001	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Jello 100265	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ ½ cup	Other _____
Ice cream, ice milk, sherbet, frozen yogurt 511002	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 Tbsp	○ ⅛-¼ cup	○ 1 scoop (½ cup)	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Popsicle or Mr. Freezie 511003	○ Yes ○ No	___	○ Day ○ Week	○ ¼	○ ½	○ 1 whole	Other _____
Cake 511004	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 bites	○ ½ slice	○ 1 slice	Other _____
Pop Tarts pastry 100480	○ Yes ○ No	___	○ Day ○ Week	○ ⅛-¼	○ ½	○ ¾	Other _____
Pie 511005	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 bites	○ 1/16 pie	○ ⅛ pie	Other _____
Fruit crisps (eg. apple crisp, berry strudel) 511006	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 bites	○ ⅛ cup	○ ¼ cup	Other _____
Cookies (eg. peanut butter, chocolate chip, raisin, oatmeal) 511007	○ Yes ○ No	___	○ Day ○ Week	○ ½ cookie	○ 1 whole	○ 2	Other _____
Other cookies (eg. arrowroot, digestives, teething biscuits) 511008	○ Yes ○ No	___	○ Day ○ Week	○ ½ cookie	○ 1 whole	○ 2	Other _____
Plain or cheese crackers (eg. Ritz, cheese type, soda crackers) 511009	○ Yes ○ No	___	○ Day ○ Week	○ 1	○ 2	○ 3	Other _____
Wheat crackers (eg. stone wheat thins, Triscuits, wholegrain soda crackers) 511010	○ Yes ○ No	___	○ Day ○ Week	○ 1	○ 2	○ 3	Other _____
Potato chips, cheesies or tortilla chips 511012	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 pieces	○ ¼ small bag	○ ½ small bag	Other _____
Popcorn 100364	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 pieces	○ ¼ cup	○ ½ cup	Other _____

	Has your child eaten this food at least once in the last two weeks?	*How many times per day or per week over the last two weeks?*		*How much does your child usually eat/drink each time?*			
Peanuts, other nuts or seeds 511011	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2 Tbsp	Other _____
Other desserts & snacks: _____ 100218 43504 100481 100201 100145	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

Miscellaneous

Chocolate bar 512001	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ bar	○ ¼ bar	○ ½ bar	Other _____
Granola bar 512002	○ Yes ○ No	___	○ Day ○ Week	○ ⅛ cup	○ ¼ bar	○ ½ bar	Other _____
Fruit Roll-up, fruit leather 512003	○ Yes ○ No	___	○ Day ○ Week	○ 1 square inch	○ 2 square inches	○ 1 whole	Other _____
Candy 512004	○ Yes ○ No	___	○ Day ○ Week	○ taste	○ 1-2 pieces	○ 3-4 pieces	Other _____
Tomato ketchup 23170	○ Yes ○ No	___	○ Day ○ Week	○ 1-2 tsp	○ 1 Tbsp	○ 2-3 Tbsp	Other _____
Other miscellaneous foods: _____ 53106 102717 101556 7604	○ Yes ○ No	___	○ Day ○ Week	usual amount _____			

Sugar, Fats, & Other Condiments

How often does your child eat the following foods?	Prompts:	≤ once per week	2-4 times per week	almost every day 5-7 times/week	2-3 times per day	4-5 times per day	Usual portion
Sugar 513001	✓ cereal ✓ beverage	○	○	○	○	○	_____
Margarine or butter 513002	✓ bread, bagels ✓ crackers ✓ muffins ✓ vegetables	○	○	○	○	○	_____
Cream cheese 100566	✓ bread, bagels ✓ crackers ✓ muffins	○	○	○	○	○	_____
Mayonnaise 513004	✓ bread	○	○	○	○	○	_____
Salad dressing 513005	✓ vegetables	○	○	○	○	○	_____
Gravy 513006	✓ vegetables ✓ meats	○	○	○	○	○	_____
Tartar sauce 100429	✓ fish	○	○	○	○	○	_____
Sour cream 513007	✓ vegetables	○	○	○	○	○	_____
Cheese sauce or cheese whiz 513008	✓ vegetables ✓ noodles	○	○	○	○	○	_____
Soy sauce 101381	✓ rice ✓ noodles ✓ vegetables	○	○	○	○	○	_____
Oyster sauce 53105	✓ rice ✓ noodles ✓ vegetables	○	○	○	○	○	_____
Ketchup 102729	✓ eggs ✓ meats ✓ rice ✓ vegetables	○	○	○	○	○	_____
Sweet spreads, eg. jams, jellies or honey 513009	✓ bread, bagels ✓ crackers ✓ muffins	○	○	○	○	○	_____
Other	please specify _____	○	○	○	○	○	_____

100508 100039
23042 27002
53100

	Has your child eaten this food at least once in the last two weeks?	*What type?*		*How many times per day or week?*	*How much does your child usually eat each time?*			
Purchased Infant, Junior & Toddler Foods								
Cereal (eg. rice, barley, oats or mixed) 514001	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ 3 Tbsp or less dry	○ ¼ cup dry	○ ½ cup dry	Other ___
Cereal mixed with fruit and/ or yogurt 514002	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ 3 Tbsp or less dry	○ ¼ cup dry	○ ½ cup dry	Other ___
Meat or poultry (eg. beef, pork, lamb, veal, ham, chicken or turkey) 514003 - 1 - Str. - 2 - Jr. - 3 - Tod	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Liver 100878	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Meat/poultry and rice/noodle dinner (eg. beef, pork, lamb or chicken) 514004 - 1 - Str. - 2 - Jr. - 3 - Tod	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Vegetable & meat (eg. beef, pork, lamb, chicken or turkey) 514005 - 1 - Str - 2 - Junior - 3 - Tod	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Vegetables 514006 - 1 Str. - 2 - Jr. - 3 - Tod	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more

	Has your child eaten this food at least once in the last two weeks?	*What type?*		*How many times per day or week?*	*How much does your child usually eat each time?*			
Fruits 514007 - 1 str. - 2 Jr.	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Prunes 514008 - 1 - str. 2 - Jr	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Fruit dessert (eg. Tutti Frutti) 514009 - 1 - str. 2 - Jr	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Fruit yogurt dessert 514010 - 1 - str. 2 - Jr	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Custard or pudding 514011 - 1 str. 2 Jr	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more
Other purchased baby foods: _____	○ Yes ○ No	○ strained ○ junior ○ toddler	___	○ Day ○ Week	○ ¼ jar or less	○ ½ jar	○ ¾ jar	○ whole jar or more

514001
220028
220079
514022
240002

24004
514024
210023
60051
60042

310000
210630

Part 2

2.1 **Are you currently breast-feeding?**

○ YES

○ NO

times per day ___ usual time per feeding _____

2.2 **Are you currently giving your child a commercial infant formula?**

○ YES [Please go to Q. 2.2(a)]

○ NO [Please go to Q. 2.3]

2.2(a)

	What brands/types of formula do you usually give your child?	Color of Label	How many times per day or week does your child drink formula?	How much does your child usually drink per feeding?
(1)	_____	_____	___times per ○ day ○ week	_____
(2)	_____	_____	___times per ○ day ○ week	_____
(3)	_____	_____	___times per ○ day ○ week	_____

2.3 **Have you ever given your child a vitamin/mineral supplement?**

○ YES (Please go to Q. 2.4)

○ NO

2.4

	What Brands/Types of supplements?	At what age?	About how much?	
(1)	_____	_____months to	_____mL per	○ day ○ week
	_____	_____months	_____tablet(s)	○ month
(2)	_____	_____months to	_____mL per	○ day ○ week
	_____	_____months	_____tablet(s)	○ month
(3)	_____	_____months to	_____mL per	○ day ○ week
	_____	_____months	_____tablet(s)	○ month

Please indicate the types of milk fed to your baby at the hospital and at each month during the first 26 months.

Type of Milk Feeding	Never	At Hospital	Months											
			1	2	3	4	5	6	7	8	9	10	11	12
Breast-Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Infant Formula														
Regular (low iron)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Formula with iron (fortified)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soya-based formula	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cows Milk														
Whole	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
skim milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goats Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soy Milk (not formula)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Type of Milk Feeding	Months													
	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Breast-Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commercial Infant Formula														
Regular (low iron)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Formula with iron (fortified)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soya-based formula	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cows Milk														
Whole	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1%	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
skim milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goats Milk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soy Milk (not formula)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Thank you for taking the time to complete this questionnaire and for your valuable participation in this study.

Appendix O. FFQ Food Categories used to Catagorize Foods for Data Analysis.

Meat, fish, poultry (MPF)

Mixed dishes with MPF

Meat-based soup

Congee with meat

Iron fortified infant cereal

Other infant cereal

Other cereal

Breads and pasta

Breast milk

Iron fortified formula

Regular formula

Milk and milk products

Soy products

Rice

Fruits and juices

Vegetables

Snack foods

Nuts and legumes

Egg

Caffeine-containing beverages

Rice bevarages

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Tel: (604) 875-
Fax: (604) 875-2226

Aug 1, 1996

Dear

Thank you for participating in the *Infant Nutrition Study*. Your contribution to the study has provided valuable information on the feeding practices and iron status of infants in Vancouver.

We have enclosed a copy of the nutrient analysis of the three day food record of intake which you kept for us. Overall, did great! Chances are that eats a little some days and a lot on other days. That's okay. Continue to offer a variety of types and a textures of tasty, nutritious foods through regular meals and snacks. This is the best way to make sure he has an adequate intake of nutrients and is able to develop healthy eating habits.

Here are some other ideas (information enclosed) which might be helpful to you:

- ○ Offer energy rich foods such as fruit, cheese, and yogurt more often.
- ○ Offer green vegetables such as broccoli, peas and green beans more often.
- ○ Offer yellow and orange vegetables such as carrots, squash and sweet potatoes more often.
- ○ Offer fruit such as bananas, kiwi, and peaches more often.
- ○ Try finger foods such as pieces of toast, cut up soft fruit and dry breakfast cereal more often.
- ○ Offer iron rich foods such as meats, fish, poultry, beans, lentils, and iron-fortified cereal more often.
- ○ Offer protein rich food such as dairy products, meats, poultry and tofu more often.
- ○ Offer calcium rich foods such as dairy products or firm tofu more often.
- ○ _____ _____

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Tel: (604) 875-
Fax: (604) 875-2226

August 1, 1996

Dear

Thank you for participating in the *Infant Nutrition Study*. Your contribution to the study has provided valuable information on the feeding practices and iron status of infants in Vancouver.

As you are aware, haemoglobin was 96.0(normal > 101mg/L) and his serum ferritin was 1.90 (normal > 10μg/L). These test results are consistent with iron deficiency anemia. A letter was sent to your family doctor and we understand the appropriate follow-up has been provided. If you wish to have iron status reassessed, please give us a call at 875-3537. We have enclosed a handout on good food sources of iron for your information.

We have also enclosed a copy of the nutrient analysis of the three day food record of intake which you kept for us. Overall, did great! Chances are that eats a little some days and a lot on other days. That's okay. Continue to offer a variety of types and a textures of tasty, nutritious foods through regular meals and snacks. This is the best way to make sure he has an adequate intake of nutrients and is able to develop healthy eating habits.

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August 1, 1996

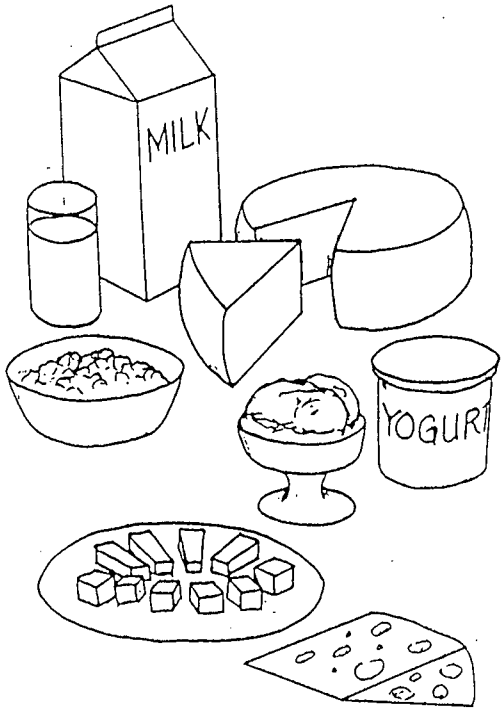
Dear

Thank you for participating in the *Infant Nutrition Study*. Your contribution to the study has provided valuable information on the feeding practices and iron status of infants in Vancouver.

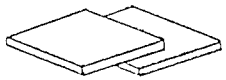
As you are aware, serum ferritin was 8.30 (normal > 10μg/L) which means her iron stores are low. The serum ferritin should increase if has a good intake of iron rich food on a regular basis. We have enclosed a handout on good food sources of iron. If you have any concerns about intake, you can arrange to have her iron status reassessed by giving us a call at 875-3537.

We have also enclosed a copy of the nutrient analysis of the three day food record of intake which you kept for us. Overall, did great! Chances are that eats a little some days and a lot on other days. That's okay. Continue to offer a variety of types and a textures of tasty, nutritious foods through regular meals and snacks. This is the best way to make sure she has an adequate intake of nutrients and is able to develop healthy eating habits.

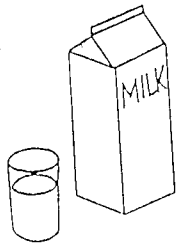
Enjoy Calcium-rich Products
for Strong Bones and Teeth



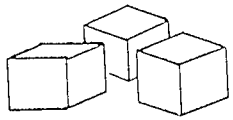
Offer your child 3 - 4 servings of calcium-rich foods daily. Here are examples of one serving of some calcium rich foods.



2 slices cheese

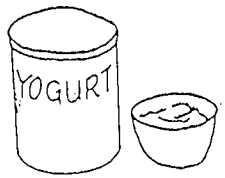


1 cup whole milk



1 ½ oz or 1 ½ x 1 inch cubes of cheese

1⅓ cup cottage cheese



3/4 cup yogurt

Smaller portions can also be provided more frequently throughout the day.

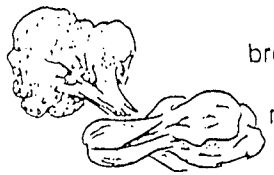
Other good sources of calcium are:

soy formula

canned salmon with bones

ice cream

oxtail or other soups made with bones



broccoli, bok choy, kale, collards, mustard greens, turnip greens

sesame paste or tahini

beans in tomato sauce or molasses

Step 1: Try these ideas to help increase your child's intake of calcium rich foods.

Mark the suggestions you would like to try with your child.

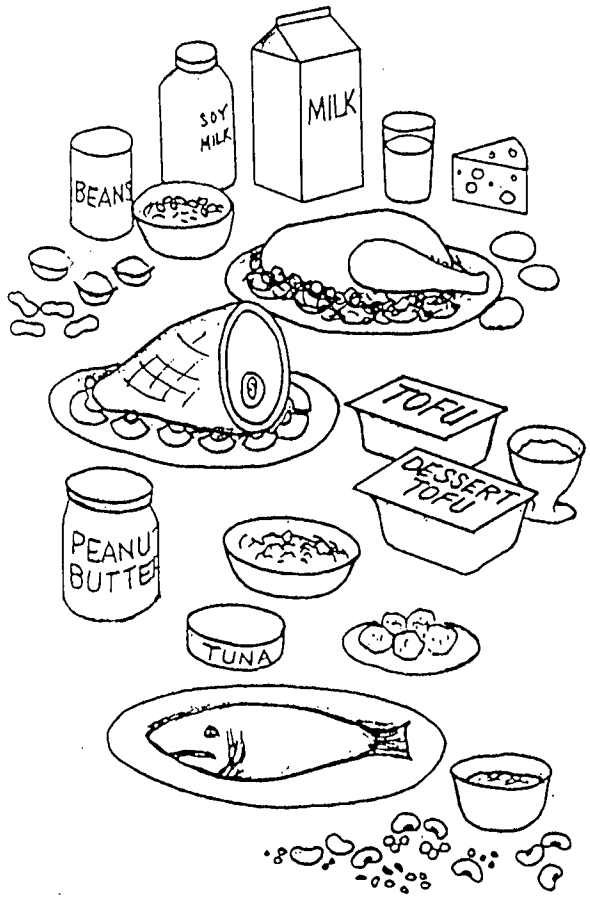
- ☐ *Make milkshakes or milk and fruit smoothies.*
- ☐ *Prepare puddings and custard with milk.*
- ☐ *Make milk based soups.*
- ☐ *Add skim milk powder to milk, milkshakes, mashed potatoes, hot cereal, minced meat, pureed legumes and blended fruit.*
- ☐ *Mix grated cheddar cheese with cream cheese and form into small bite sized balls.*
- ☐ *Use canned salmon or tuna to make sandwiches and casseroles.*
- ☐ *Slice cheese or cut into cubes and serve as a snack.*
- ☐ *Add cheese cubes to salad.*
- ☐ *Sprinkle cheese onto soup or noodles.*
- ☐ *Make cheese sandwiches.*
- ☐ *Spoon yogurt onto cereal.*
- ☐ *Puree broccoli and make into cream of broccoli soup.*
- ☐ *Cook broccoli, kale or bok choy for the noon or evening meal.*

Prepare a plan for your child to eat more dairy products.

Record the foods you usually feed your child in one day. Then using the ideas from the previous page and some of your own, make a plan to add more dairy products for your child's menu.

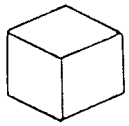
Example: For evening snack my child eats *Cookies and juice*	Dairy products I will add *Replace juice with milk*
In the morning my child usually eats _____	Dairy products I will add _____
For morning snack my child eats _____	Dairy products I will add _____
For lunch my child usually eats _____	Dairy products I will add _____
For afternoon snack my child eats _____	Dairy products I will add _____
At the evening meal my child eats _____	Dairy products I will add _____
For evening snack my child eats _____	Dairy products I will add _____

High Protein Food Choices For Your Child



Offer your child 2 servings of meat and/or alternatives daily. Here are some examples of one serving of high protein foods.

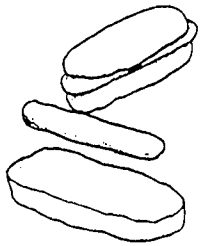
1 - 2 tablespoons peanut butter, tahini or hommous



1 oz cheese or 1 - 2 cheese slices

1 oz (30 g) meat, fish or poultry

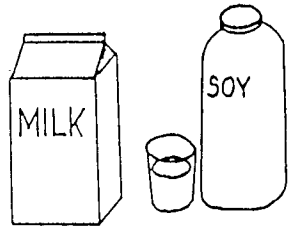
meatballs (2 Tbsp ground meat)



1 small drumstick

1 fishstick or wiener

1 slice chicken or beef steak

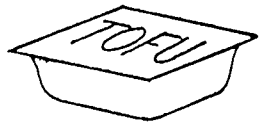


1 cup whole milk or soy milk

1/4 - 1/2 cup dried peas, beans and lentils (cooked, mashed or pureed)

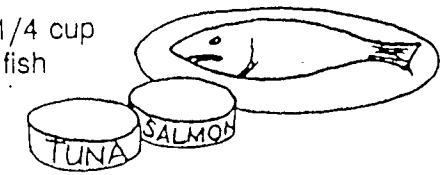
1 egg

1 oz (2-3 Tbsp) tofu



2 - 3 Tbsp cottage cheese

1/4 cup fish

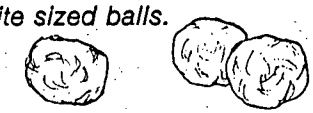


Step 1: Try these ideas to help increase your child's intake of high protein foods.

Mark the suggestions you would like to try with your child.

- ☐ *Mash cooked dry beans and lentils or mince meat, fish or poultry and use as a sandwich filling or spread on crackers.*

- ☐ *Use eggs or tofu to make custard or quiche.*
- ☐ *Use milk or dessert tofu to make milkshakes.*
- ☐ *Mix grated cheddar cheese with cream cheese and form into small bite sized balls.*



- ☐ *Sprinkle grated cheese onto soup or noodles.*
- ☐ *Puree meat, fish or poultry and make into a sauce for pasta.*
- ☐ *Add small pieces of meat, poultry, fish, beans or tofu to rice, congee or pasta.*
- ☐ *Prepare meatloaf with ground beef, chicken or tofu.*
- ☐ *Make meatballs from beef, chicken, turkey, pork or fish.*

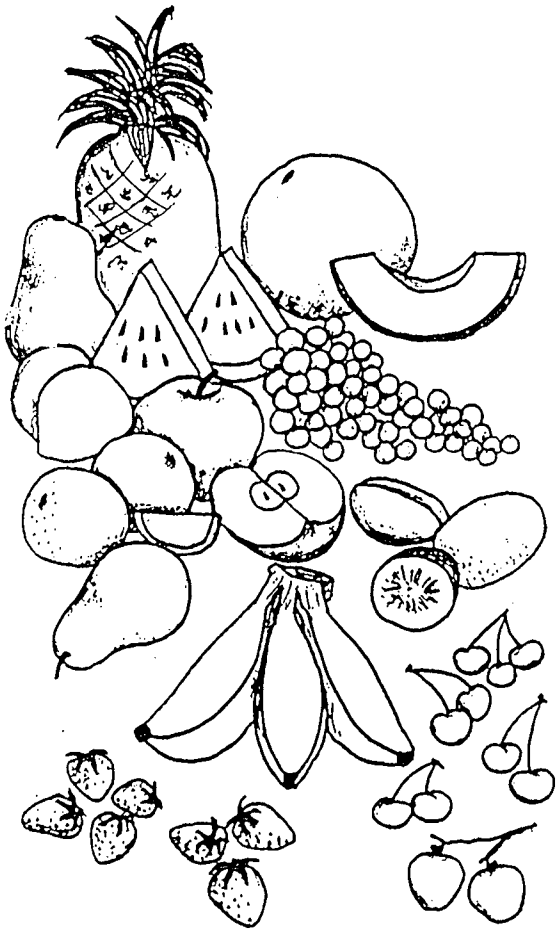
Prepare a plan for your child to eat more protein products.

Record the foods you usually feed your child in one day. Then using the ideas from the previous page and some of your own, make a plan to add more high protein foods to your child's menu.

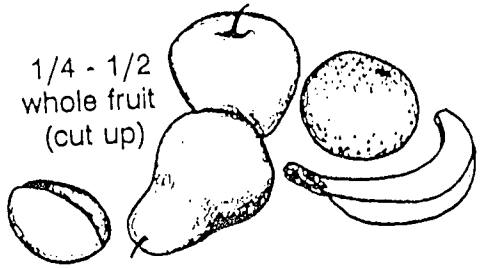
Example: For morning snack my child eats	High protein foods I will add
Sliced fruit and water	*Cheddar and cream cheese balls*

In the morning my child usually eats _____ _____	*High protein foods I will add* _____ _____
For morning snack my child eats _____ _____	*High protein foods I will add* _____ _____
For lunch my child usually eats _____ _____	*High protein foods I will add* _____ _____
For afternoon snack my child eats _____ _____	*High protein foods I will add* _____ _____
At the evening meal my child eats _____ _____	*High protein foods I will add* _____ _____
For evening snack my child eats _____ _____	*High protein foods I will add* _____ _____

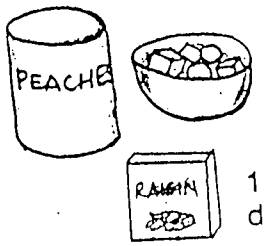
Enjoy Fruits More Often



Offer your child 2-3 servings of fruit each day. Here are some examples of one serving of fruit.



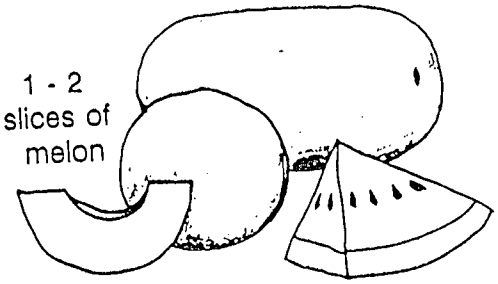
1/4 - 1/2 whole fruit (cut up)



1/4 - 1/2 cup fruit; fresh or canned

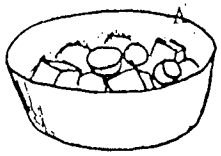
or

1 - 2 Tbsp dried fruit

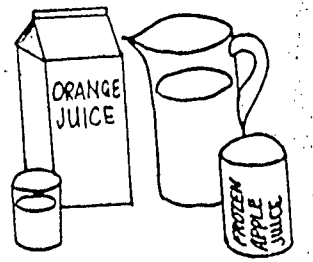


1 - 2 slices of melon

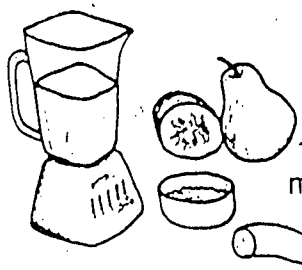
Remember: Cut fruit into small pieces to prevent choking.



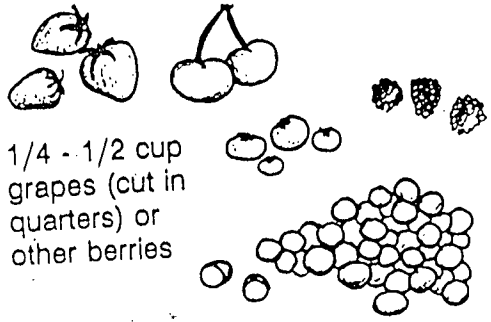
1/3 - 1/2 cup fruit salad



1/3 - 1/2 cup fruit juice



1/4 - 1/2 cup mashed or pureed fruit



1/4 - 1/2 cup grapes (cut in quarters) or other berries

Ideas to try:

These ideas will help you think about and plan ways for your child to eat more fruits.

Mark suggestions you would try.

- ☐ *Bake fruit crisp.*
- ☐ *Make fruit frost:*
  Mix together 1/2 cup each of milk, fresh fruit, orange juice, and ice cream in a blender at low speed for 30 seconds.
- ☐ *Use juice or berries to make popsicles.*
  Berry Popsicles:
  Toss 2 cups berries with 1/4 cup sugar and 1 Tbsp lemon juice. Let stand 45 minutes. Transfer to blender or food processor; add 1 cup skim vanilla yogurt. Process until smooth. Pour into popsicle molds and freeze.
- ☐ *Make fruit and cheese sandwich: core and slice apple or peach, layer with cheese in between.*
- ☐ *Slice or mash fruit and add to cereal.*
- ☐ *Make fruit salad.*

Prepare a plan for your child to eat more fruits.

☺ ☺ ☺ ☺ ☺ ☺

Example:

For afternoon snack my child eats

Cheese on crackers, water

Fruits I will add

Grapes, cut in half

In the morning my child eats

_____

_____

Fruits I will add

_____

_____

For morning snack my child eats

_____

_____

Fruits I will add

_____

_____

For lunch my child ususally eats

_____

_____

Fruits I will add

_____

_____

For afternoon snack my child eats

_____

_____

Fruits I will add

_____

_____

At the evening meal my child eats

_____

_____

Fruits I will add

_____

_____

For evening snack my child eats

_____

_____

Fruits I will add

_____

_____

Record the foods you usually feed your child in one day. Then using the ideas from the previous page and some of your own, make a plan to add more breads and cereals to your child's menu.

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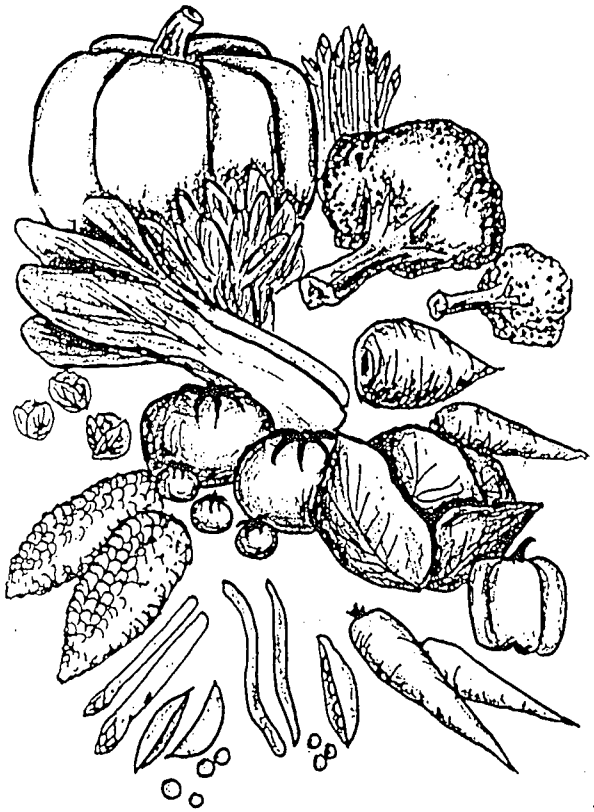
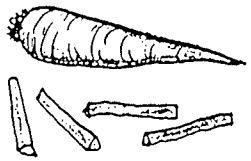
Enjoy a Variety of Vegetables



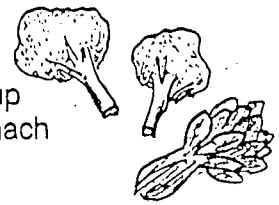
Offer your child at least 2 servings of vegetables each day. Try a variety of both yellow and green vegetables. Here are examples of one serving of vegetables.

1/2 tomato

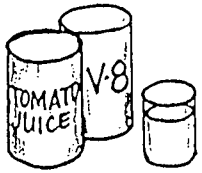
1/2 - 1 carrot (cooked and sliced)



2 - 3 Brussel sprouts (cooked and cut)

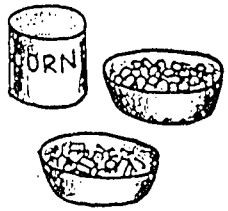


1/4 - 1/3 cup cooked spinach or broccoli



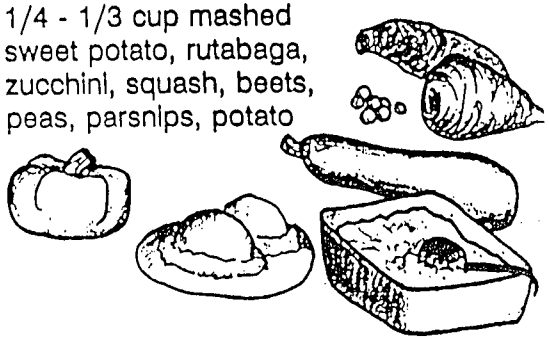
1/2 - 1 cup V8 or tomato juice

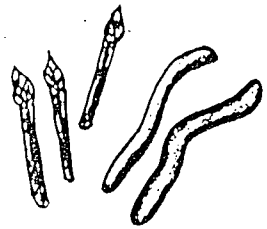
1/2 cup salad vegetables



1/4 - 1/2 cup peas or mixed vegetables

1/4 - 1/3 cup mashed sweet potato, rutabaga, zucchini, squash, beets, peas, parsnips, potato





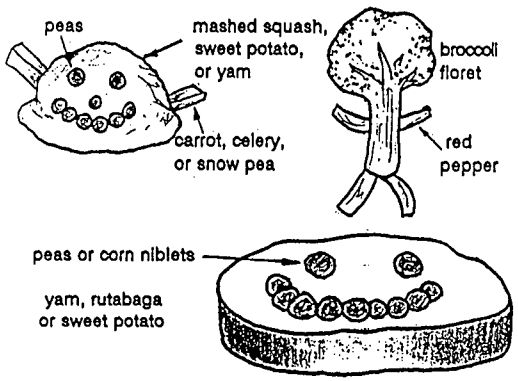
3 - 4 green or yellow beans or asparagus spears

Remember:
Steam vegetables or cook until soft to prevent choking.

Step 1: *Try these ideas to help increase your child's intake of vegetables.*

Mark the suggestions you would like to try with your child.

- ☐ Puree vegetables, dilute with water or milk. Use for juice, soup or sauce for meats, pasta or rice.
- ☐ Make a vegetable broth.
- ☐ Partly cook vegetables until tender and serve with dip.
- ☐ Grate raw vegetables and serve raw or cooked.
- ☐ Steam vegetables and use as finger foods.
- ☐ Mash sweet potatoes or squash.
- ☐ Make cooked vegetable characters together with your child. If they can help, they are more likely to give vegetables a try.



Step 2: *Is your child eating enough vegetables?*

Record the foods your child usually eats throughout the day.

Step 3: *Prepare a plan to offer your child more vegetables.*

Using the ideas from the previous page and some of your own, make a plan to add vegetables to your child's menu.

Example:

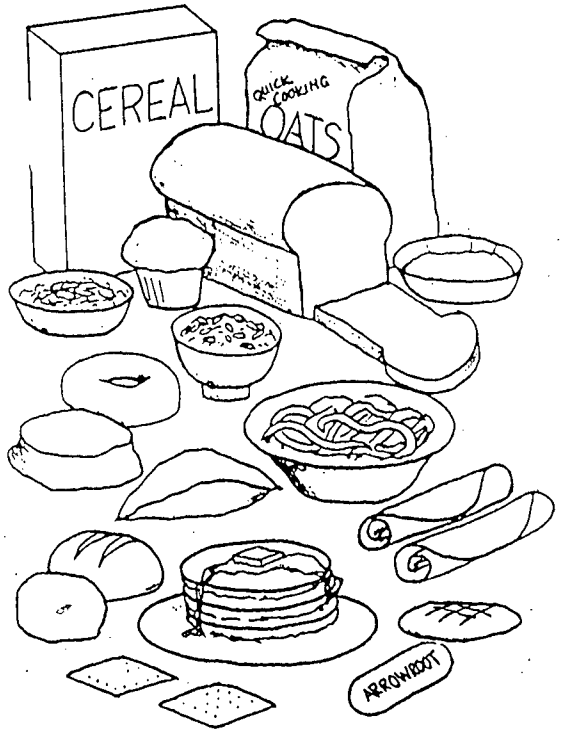
For lunch my child usually eats:	Vegetables I will add
1/2 Ham sandwich	*Tomato and lettuce in the sandwich*
Milk	*Carrot sticks, cooked until tender*

Foods my child usually eats:	**Vegetables I will add**
For breakfast	
For morning snack	
At lunch	
For afternoon snack	
At supper	
For evening snack	

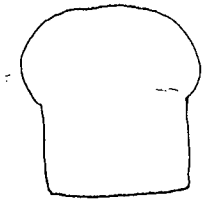
Total the number of servings of vegetables _____

Does your child eat/drink at least

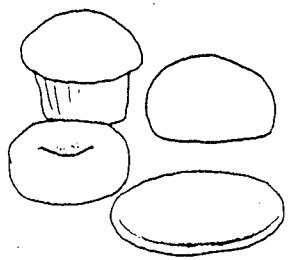
Enjoy a Variety of Grain Products



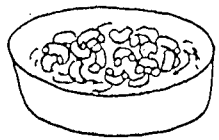
Offer your child 4 - 5 servings of grain products each day. Here are some examples of one serving of grain products.

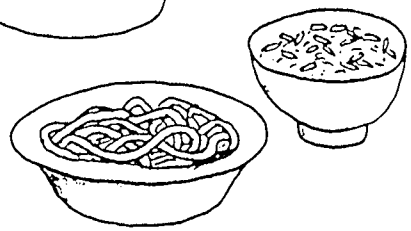


1/2 - 1 slice whole wheat bread

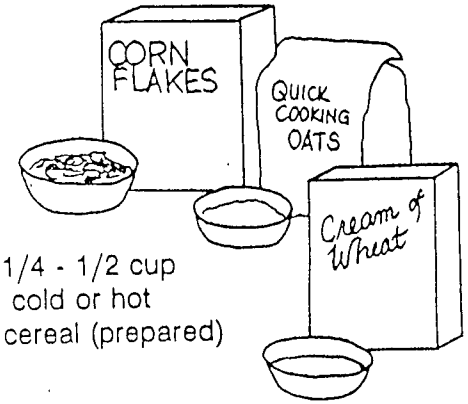


1/4 - 1/2 bun, muffin, roll, bagel, tortilla, roti or pancake

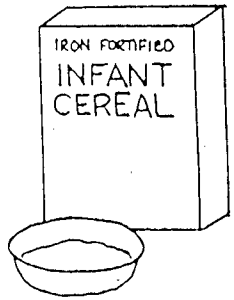




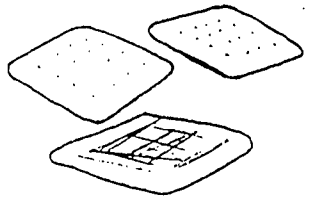
1/4 - 3/4 cup pasta, noodles, or rice



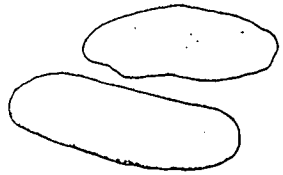
1/4 - 1/2 cup cold or hot cereal (prepared)



infants up to 12 months should eat 4 - 8 Tbsp (1/4 - 1/2 cup) iron fortified infant cereal (prepared)



2 - 4 crackers (wholegrain, saltines, graham)

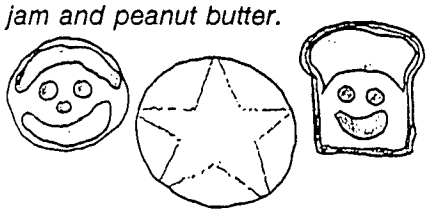


1/2 - 1 cookie (plain, oatmeal, arrowroot)

Step 1: *Try these ideas to help increase your child's intake of grain products.*

Mark the suggestions you would like to try with your child.

- ☐ *Cut toast or pita bread into sticks.*
- ☐ *Cut pancake, bread, tortilla into shapes and decorate with berries, jam and peanut butter.*



- ☐ *Spread pancakes or bread with peanut butter, tahini, or jam and roll into a log, then cut into slices.*

- ☐ *Sprinkle cereal into yogurt and fruit.*
- ☐ *Add pasta or rice to vegetables or meat to pasta or rice.*
- ☐ *Provide dry ready to eat cereals (eg. Cheerios) in a cup or bowl for a snack.*
- ☐ *Using an English muffin, make a mini pizza.*

Prepare a plan for your child to eat more grain products.

Record the foods you usually feed your child in one day. Then using the ideas from the previous page and some of your own, make a plan to add more breads and cereals to your child's menu.

Example: For breakfast my child usually eats	Grain products I will add
1/2 slice bread, peanut butter, juice	*Cereal with yogurt and fruit*
In the morning my child usually eats	Grain products I will add
For morning snack my child eats	Grain products I will add
For lunch my child usually eats	Grain products I will add
For afternoon snack my child eats	Grain products I will add
At the evening meal my child eats	Grain products I will add
For evening snack my child eats	Grain products I will add

Table A.1 Hematological and biochemical indices of iron status among infants participating in the study.

	8-12 mths (n=61)	13-17 mths (n=35)	18-26mths (n=52)
Hemoglobin (g/L)	116.4 ± 9.5	121.2 ± 7.0*	123.3 ± 7.3+
	118.0 (92 - 133)	121.0 (108 - 135)	124.0 (105 - 139)
No. (%) below cutoff	10	2	1
	(16.4)	(5.7)	(1.9)
Mean corpuscular volume (fL)	76.7 ± 5.3	78.2 ± 3.5	78.1 ± 5.1
	77.3 (55.5 - 87.2)	78.4 (68.9 - 84.5)	78.8 (56.8 - 87.6)
No. (%) below cutoff	3	0	2
	(4.9)	-	(3.8)
Serum ferritin (μg/L)	20.8 ± 16.2	20.2 ± 16.7	21.2 ± 18.0
	18.2 (1.0 - 93.3)	17.2 (3.4 - 69.2)	15.1 (2.5 - 104.9)
No. (%)below cutoff	15	15	17
	(24.6)	(42.9)	(32.7)
Soluble transferrin receptor (sTfR) (nmol/L)	23.4 ± 10.5	19.8 ± 5.2δ	20.1 ± 6.0δ
	21.5 (11.4 - 67.1)	20.8 (9.7 - 32.7)	19.7 (9.8 - 31.3)
No. (%) below cutoff[1]	23	8	14
	(37.7)	(22.9)	(26.9)
sTfR:ferritin (nmol/nmol)	3.2 ± 9.1	1.8 ± 1.5	1.9 ± 2.4
	1.1 (0.2 - 67.1)	0.9 (0.3 - 5.6)	1.2 (0.15 - 12.5)
No. (%) below cutoff[1]	19	15	12
	(31.1)	(42.9)	(23.1)

Values shown are mean ± SD, median (range) unless otherwise indicated; data not available for 2 infants at 8-12 mths of age and 2 at 18-26 mths of age.

Normal cut-off criteria based on 5th percentile values from the Second National Health and Nutrition Examination Survey after excluding persons with a higher likelihood of iron deficiency: Hgb, ≥110 g/L; MCV, ≥67 fL; Ferritin >12 μg/L.

[1]Normal cut-offs have not been established; however, for the purpose of classifying infants, a sTfR of <24 nmol/L and sTfR:ferritin <2, respectively, were considered normal.

General linear Model for Univariate analysis showed significant differences from value for 8-12 mths by *, $p<0.01$; +, $p<0.001$; δ, $p<0.05$.

No significant differences were found between infants at 13-17 and 18-26 mths of age.

Table A.2. Infants with iron deficiency anemia, low iron stores, normal iron status, and low hemoglobin grouped by gender.

	All (n=145)	Males (n=79)	Females (n=69)
Iron deficiency anemia[1]	9 (6)	5 (6)	4 (6)
Low iron stores[2]	38 (26)	19 (24)	19 (27)
Normal iron status[3]	94 (65)	53 (67)	41 (59)
Low hemoglobin[4]	4 (3)	1 (1)	3 (4)

Values shown are the number of infants and in brackets, the % of infants by gender within a given iron class assignment.
[1]Iron deficiency anemia, Hgb <110 g/L + ferritin ≤12 μg/L.
[2]Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L;
[3]Normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC≤18 $X10^9$; 11 (3 at 8-12 mths, 3 at 13-17 mths and 5 at 18-26 mths) had a Hgb >110 g/L + ferritin >35μg/L.
[4]Low hemoglobin, Hgb 102-109 g/L + ferritin >12 μg/L.

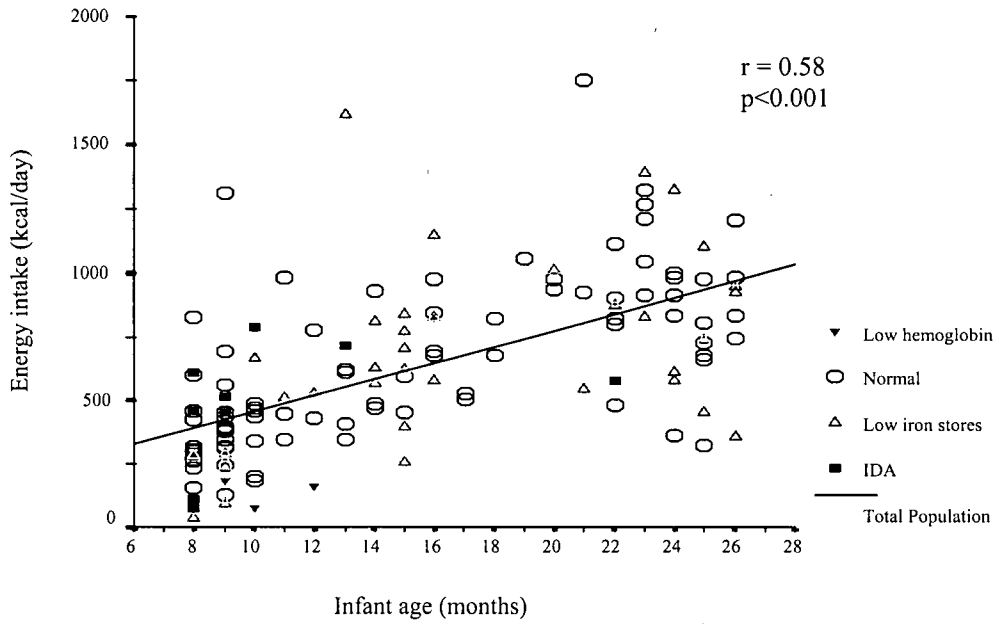


Figure A.1. Scatterplot of energy intake from non-milk food (kcal/day) as estimated from a 3d-FR versus age among infants 8-26 months of age, n = 146.
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

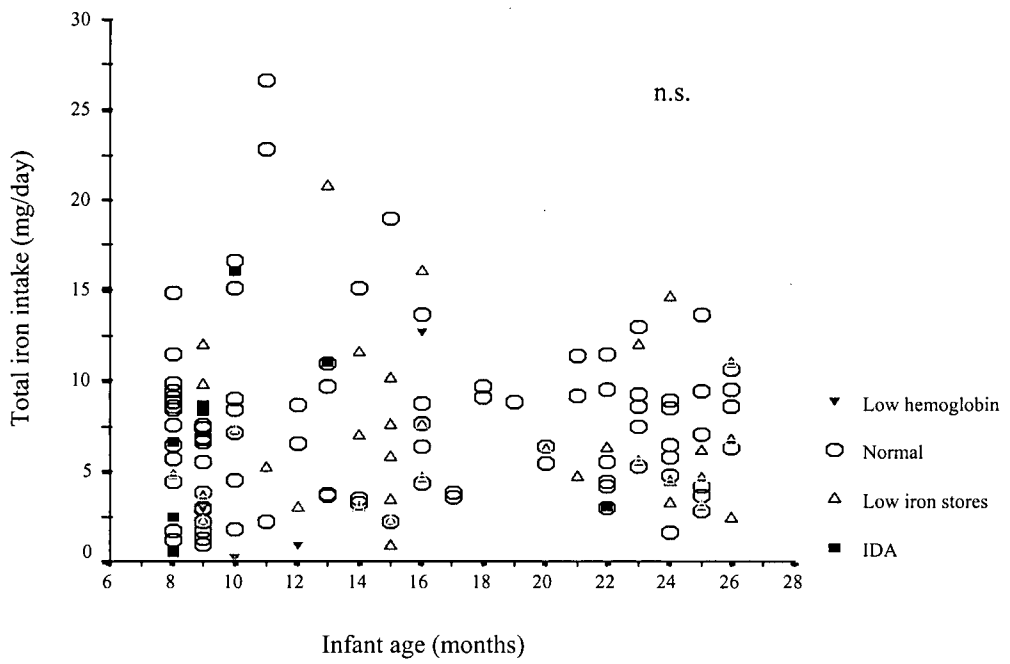


Figure A.2. Scatter plot of total iron intake from non-milk food sources (mg/day) as estimated from a 3d-FR versus age among infants grouped by iron status (n = 146. No significant relation was found between total iron intake and infant age.
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

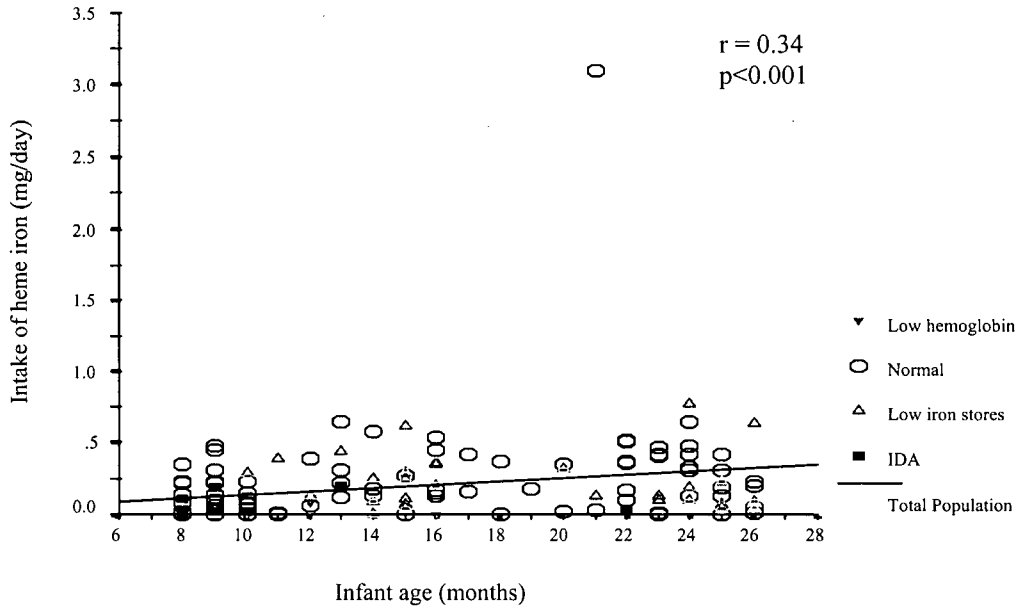


Figure A.3. Scatterplot of heme iron intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants aged 8-26 months, n = 146.
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

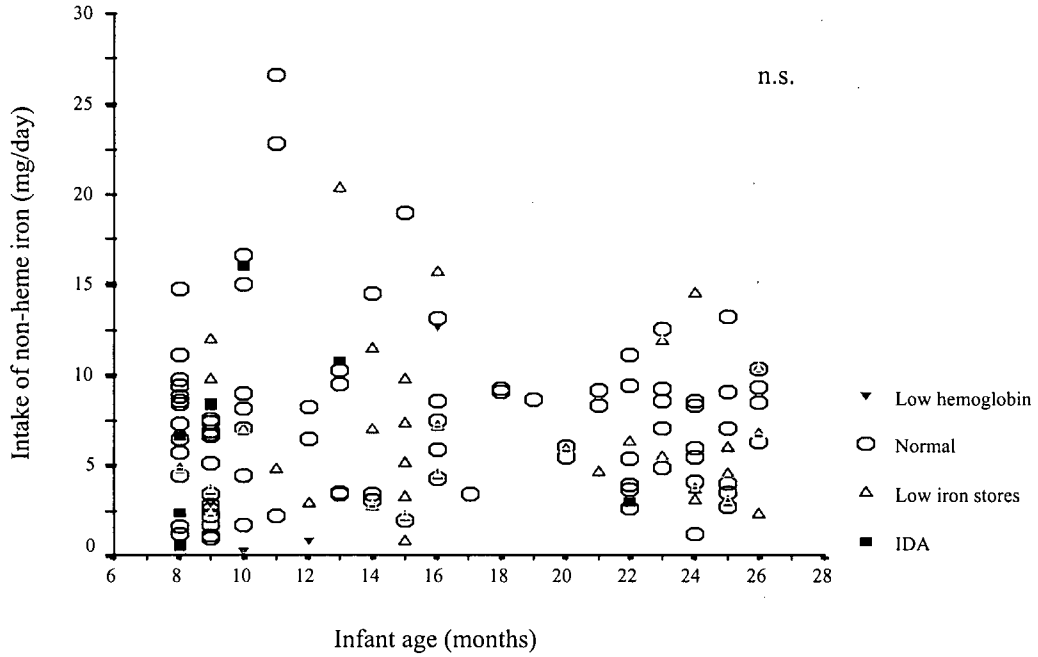


Figure A.4. Scatter plot of non-heme iron intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants aged 8-26 months, n = 146. No significant relation was found between total iron intake and infant age.
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

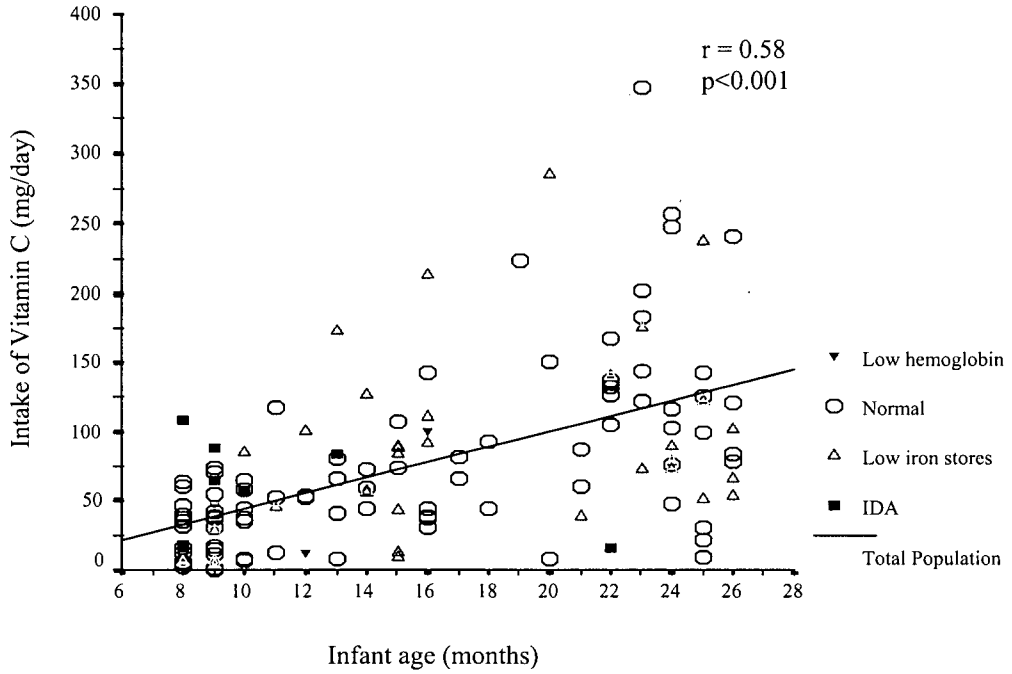


Figure A.5. Scatterplot of vitamin C intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants aged 8-26 months (n = 146, r = 0.58, p<0.001).
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

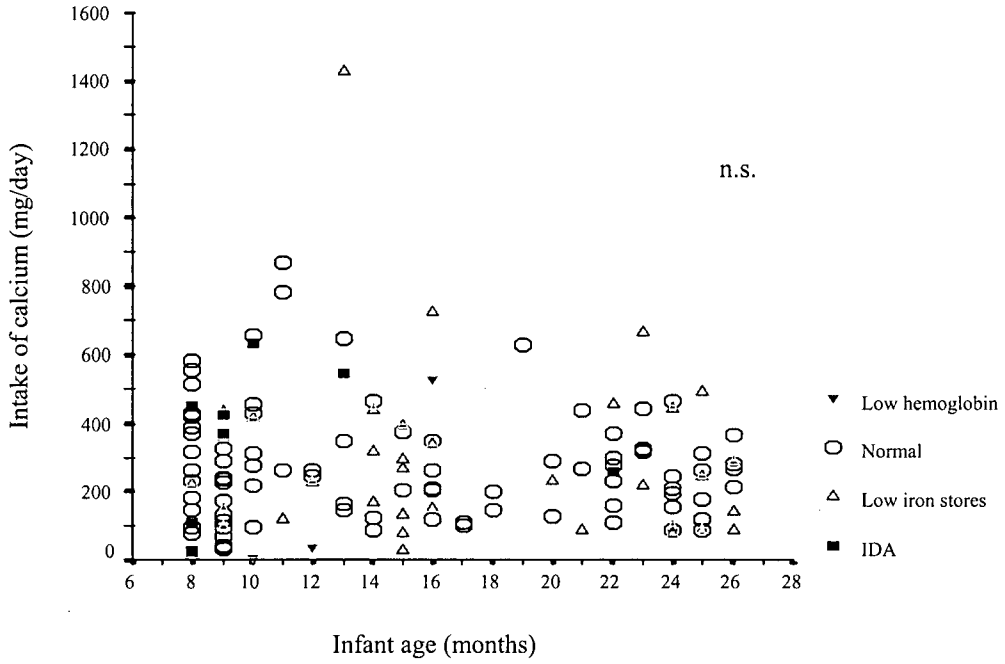


Figure A.6. Scatterplot of calcium intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants aged 8-26 months, n = 146. No significant relation was found between calcium and infant age.
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

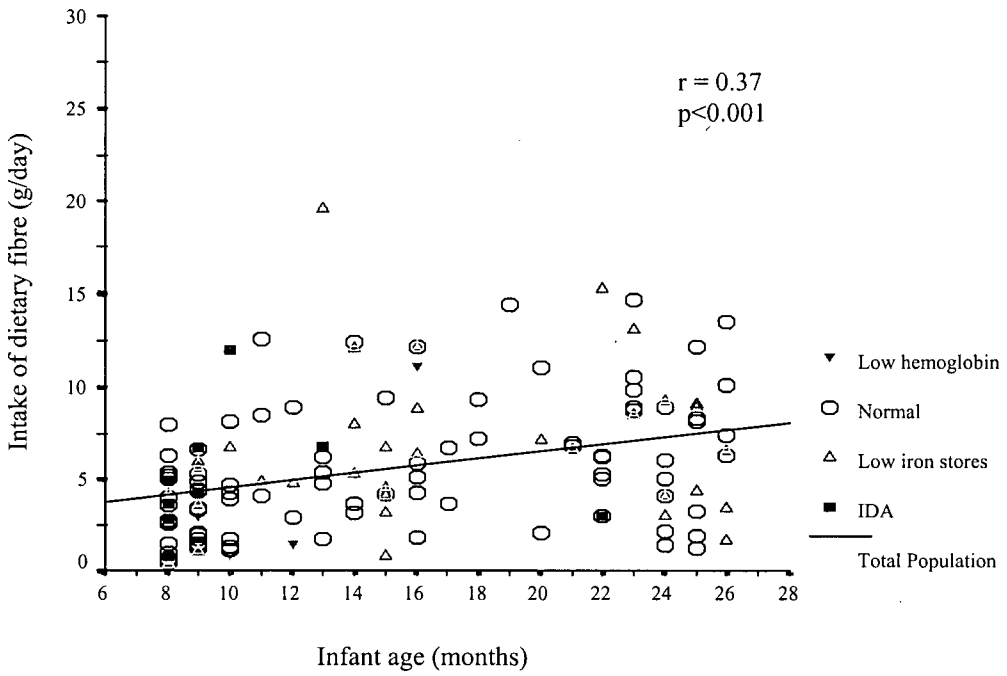


Figure A.7. Scatterplot of dietary fibre intake from non-milk foods (g/day) as estimated from a 3d-FR versus age among infants aged 8-26 months, n = 146.
Infants are designated by iron status as: ■, IDA, Iron deficiency anemia; △, Low iron stores; ○, Normal, Normal iron status; ▼, Low hemoglobin.

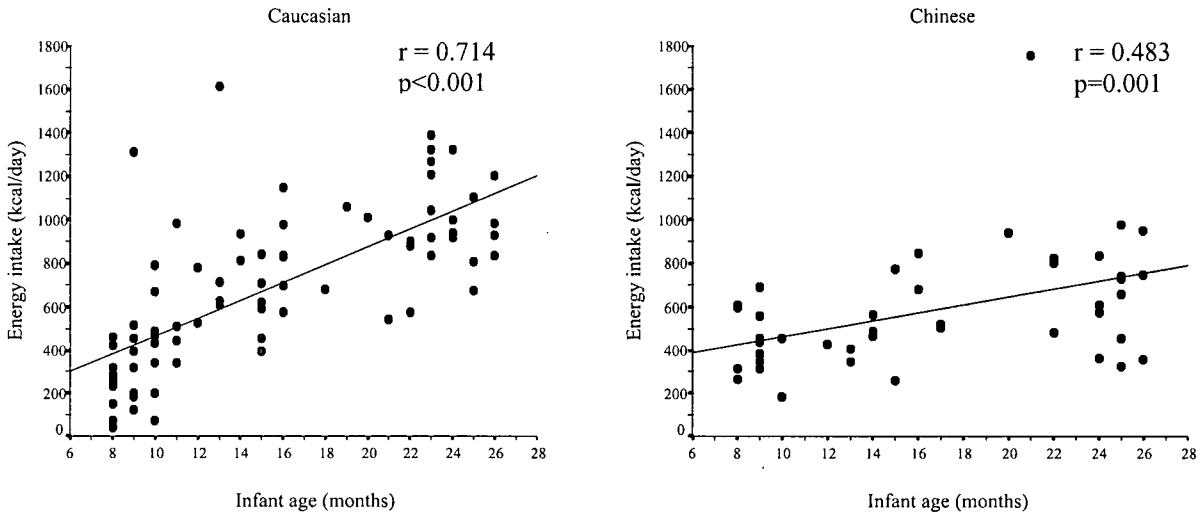


Figure A.8. Scatterplots of energy intake from non-milk foods (kcal/day) as estimated from a 3d-FR versus age among infants of Caucasian (n =78) and Chinese (n =47) ancestry.

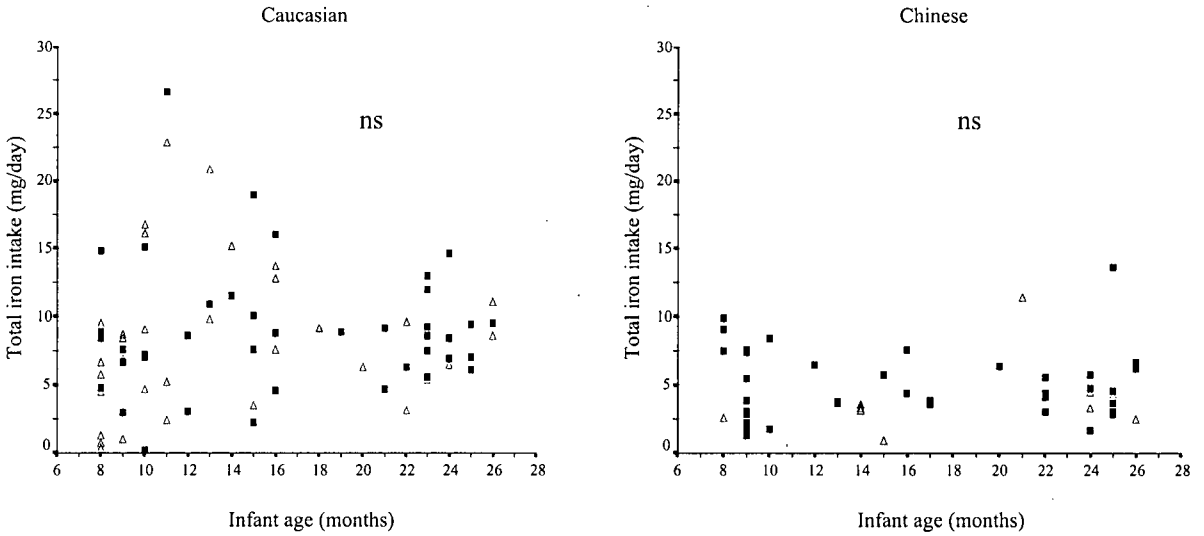


Figure A.9. Scatterplots of total iron intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants of Caucasian (n = 78) and Chinese (n = 47) ancestry△non-iron supplemented, ■ iron supplemented.[1]

[1]Supplemented group includes infants having been fed an iron fortified formula for one mth prior to the study and/or with a history of having been fed an iron fortified formula for 3 or more mths or an iron supplement including iron drops or a multivitamin supplement for ≥1 mth.

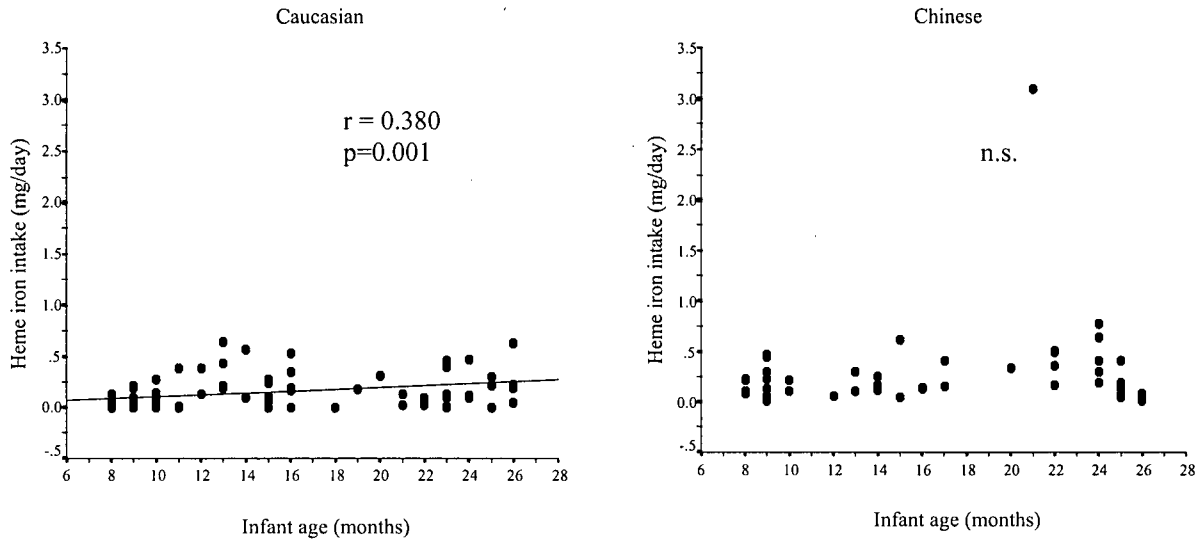


Figure A.10. Scatterplots of heme iron intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants of Caucasian (n = 78) and Chinese (n = 47) ancestry.

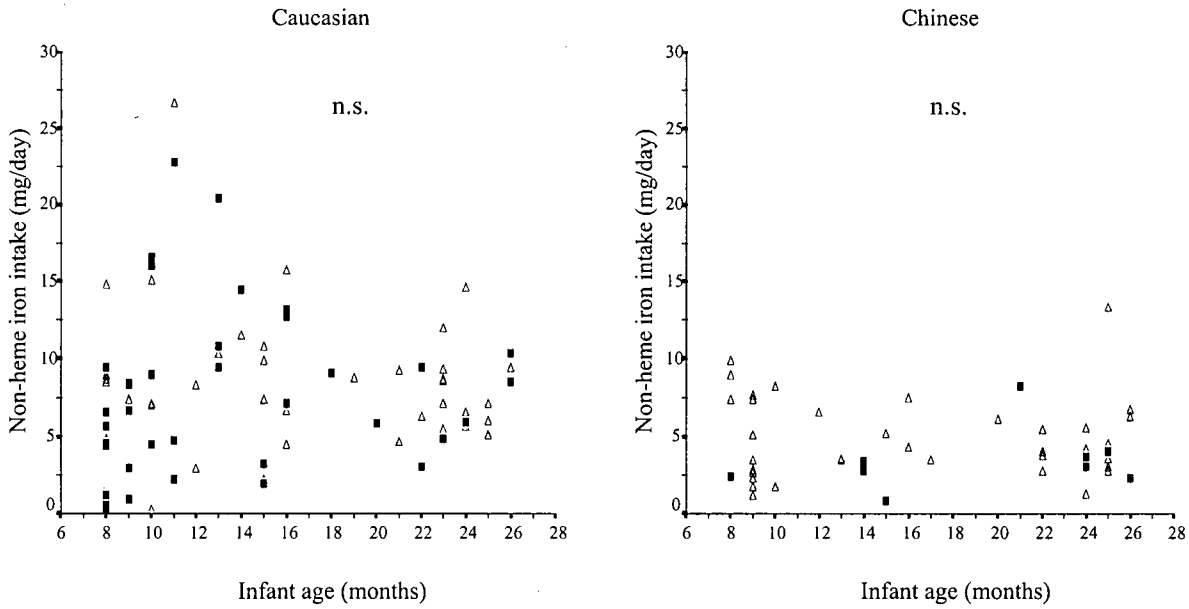


Figure A.11. Scatterplots of non-heme iron intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants of Caucasian (n = 78) and Chinese (n = 47) ancestry, △non-iron supplemented, ■ iron supplemented.

[1]Supplemented group includes infants having been fed an iron fortified formula for one mth prior to the study and/or with a history of having been fed an iron fortified formula for 3 or more mths or an iron supplement including iron drops or a multivitamin supplement for ≥1 mth.

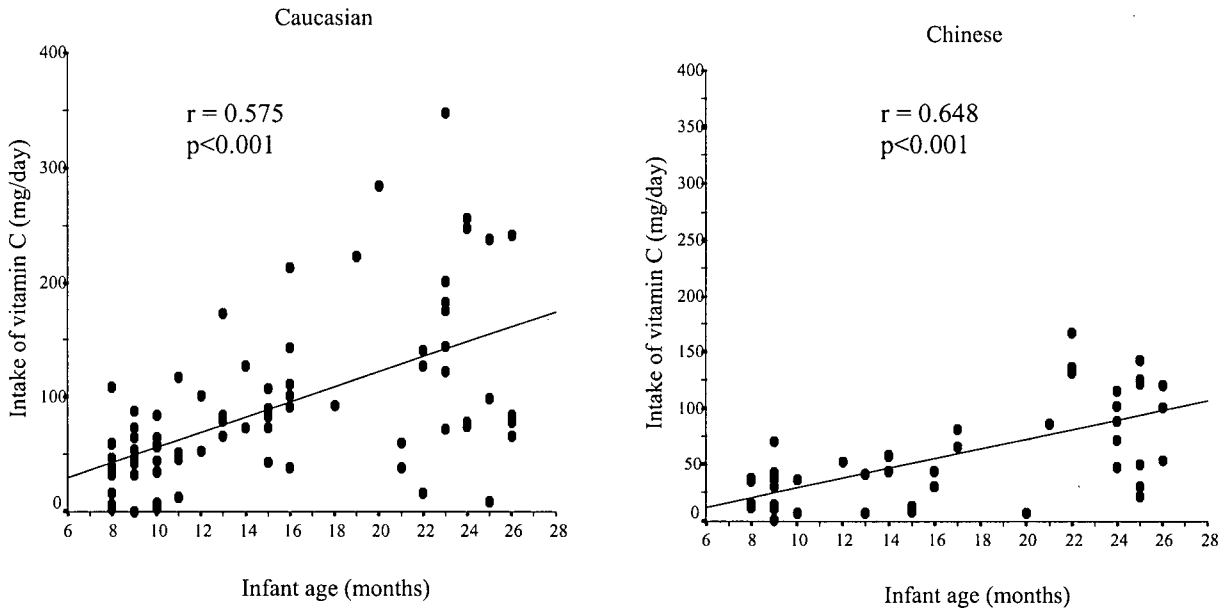


Figure A.12. Scatterplots of vitamin C intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants of Caucasian (n = 78) and Chinese (n = 47) ancestry.

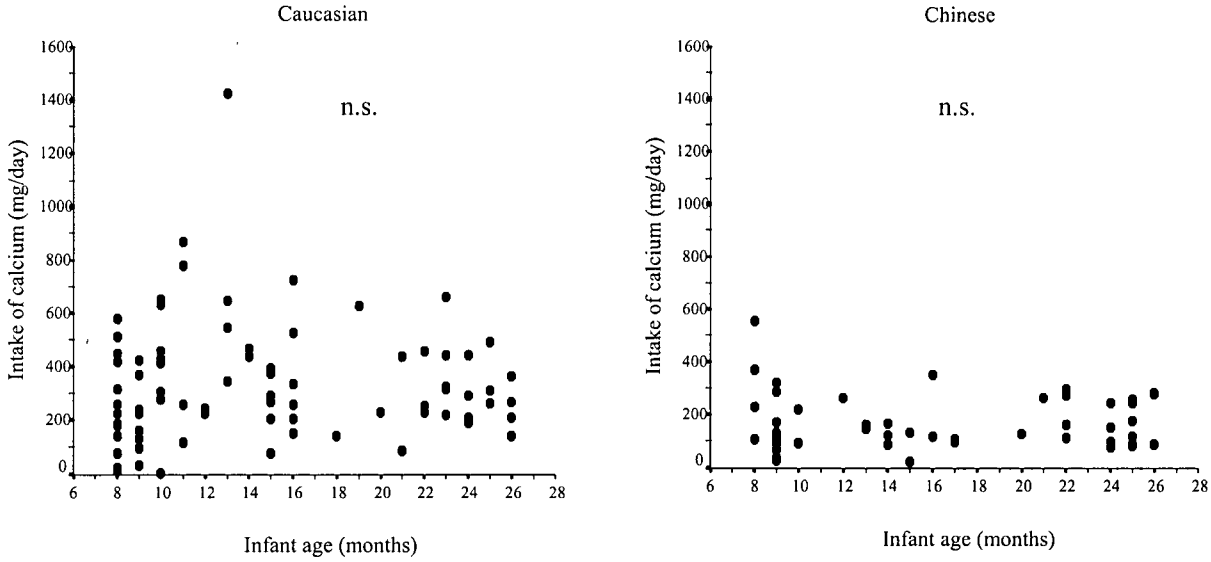


Figure A.13. Scatterplots of calcium intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants of Caucasian (n = 78) and Chinese (n = 47) ancestry.

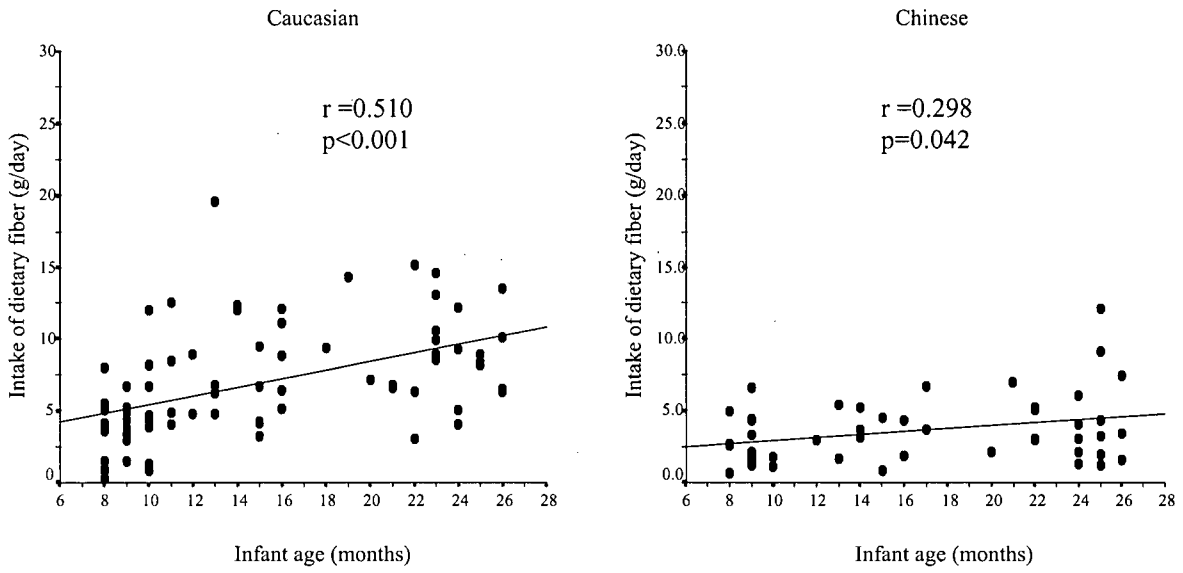


Figure A.14. Scatterplots of fibre intake from non-milk foods (mg/day) as estimated from a 3d-FR versus age among infants of Caucasian (n = 78) and Chinese (n = 47) ancestry.

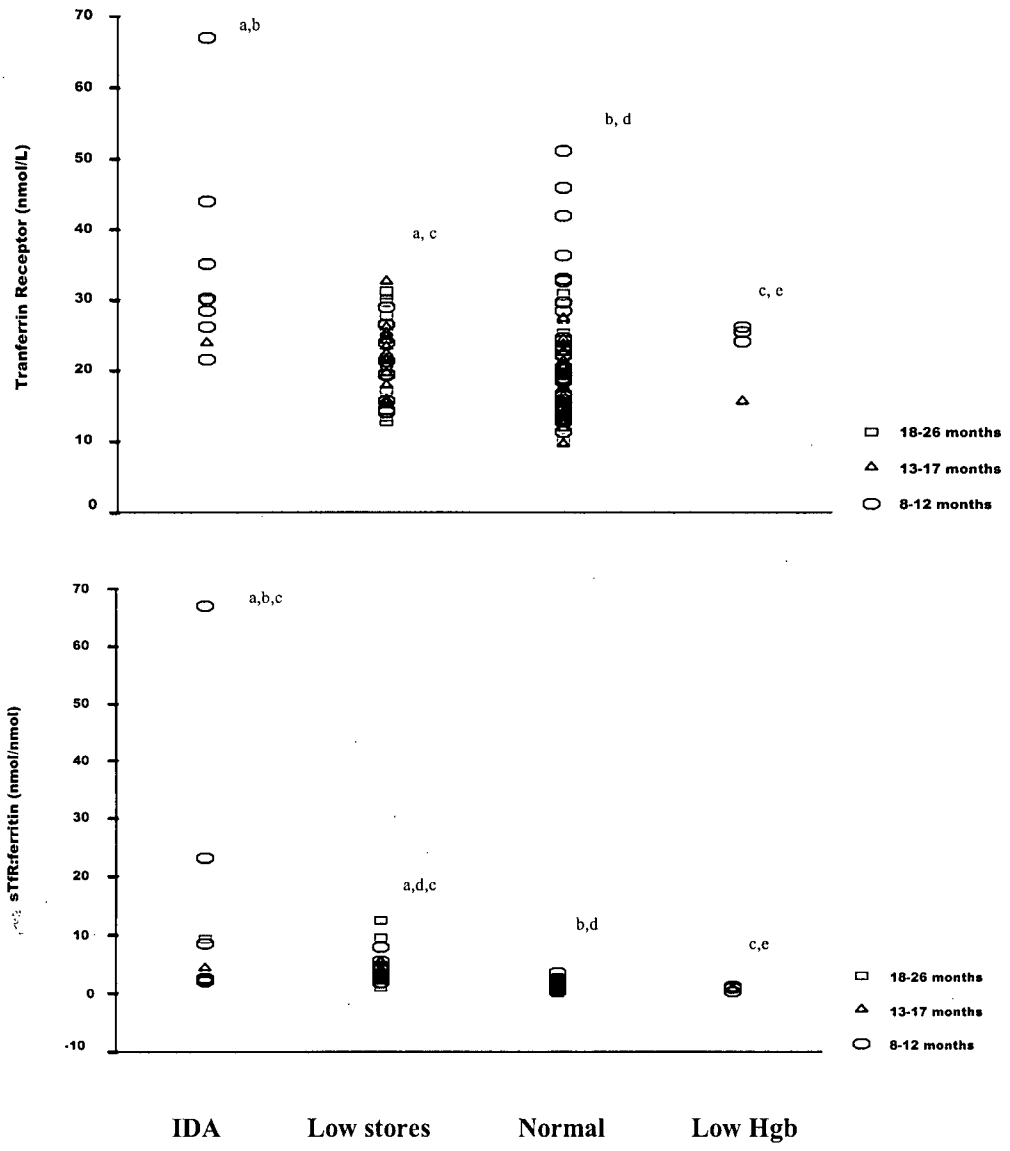


Figure A.15. Scatterplots of infants aged 8-26 months grouped by transferrin receptor (sTfR) concentrations and sTfR:ferritin ratio according to assignment of iron status in 148 healthy infants.

Mean ± SD sTfR in infants with iron deficiency anemia, 34.1 ± 14.0 nmol/L, n = 9, low iron stores, 22.1 ± 5.3 nmol/L, n = 38, normal iron status, 19.8 ± 7.4 nmol/L, n=94, and low hemoglobin, 22.9 ± 4.9, n=4; Analysis of variance: $^{a}p=0.013$, $^{b}p<0.0001$, $^{c}p=0.061$. Mean±SD sTfR:ferritin in infants with iron deficiency anemia, 13.6 ± 21.2, n = 9, low iron stores, 3.6 ± 2.3, n = 38, normal iron status, 0.9 ± 0.6, n=94, and low hemoglobin, 0.8 ± 0.3, n=4. Analysis of variance: $^{a}p=0.047$, $^{b}p<0.0001$, $^{c}p<0.0001$, $^{d}p<0.0001$, $^{e}p<0.0001$.

Iron deficiency anemia, Hgb ≤101 g/L or Hgb <110 g/L + ferritin ≤12 μg/L; Low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L; Normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^9$; low hemoglobin, Hgb 102-109 g/L + ferritin >12 μg/L.

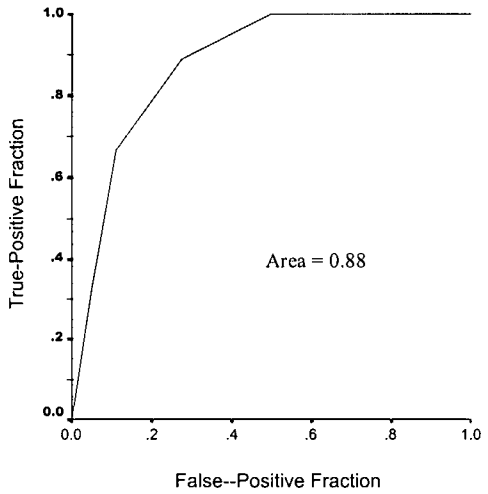
Normal cutoffs have not been established; however, for the purpose of this study, a sTfR of <24 nmol/L and sTfR:ferritin <2, respectively, was considered normal.

Table A.3. Laboratory indices used to define iron status among study participants with normal iron status, low iron stores, and iron deficiency anemia.

	Iron deficiency anemia (n = 9)	Low iron stores (n = 38)	Normal iron status (n = 94)
Hemoglobin (g/L)	99 ± 6^{a} 96 (92 – 108)	122 ± 6^{b} 122 (110 – 135)	122 ± 7^{b} 122 (110 – 139)
Mean corpuscular volume (fL)	71.6 ± 9.9^{a} 75.3 (55.5 – 81.7)	78 ± 4.8^{b} 78.2 (61 – 87.6)	78 ± 3.9^{b} 78.5 (56.8 – 87.3)
Ferritin (μg/L)	6.7 ± 4.5^{a} 5.4 (1.0 – 13.1)	7.4 ± 2.7a 7.8 (2.5 – 11.9)	27.0 ± 16.5^{b} 22.5 (12 – 104.9)

Values are mean ± SD, median (range).
Iron deficient anemia, Hgb <110 g/L + ferritin ≤12 μg/L; low iron stores, Hgb ≥110 g/L + ferritin ≤12 μg/L; normal iron status, Hgb ≥110 g/L + ferritin >12 μg/L + WBCC ≤18 $X10^{9}$.
Values in the same row with different superscripts are significantly different, $P<0.05$.

Iron deficiency anemia



Low iron stores

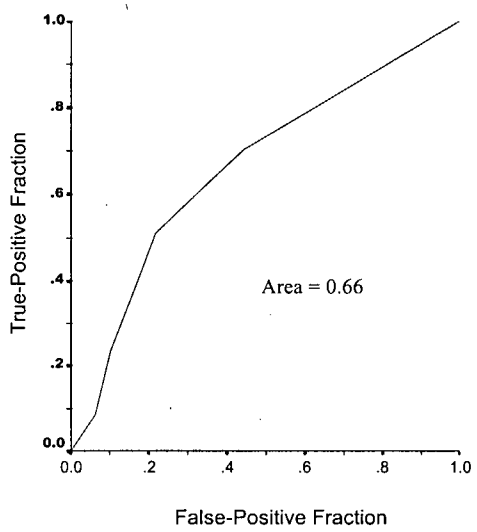


Figure A.16. Receiver Operating Characteristic (ROC) Curves for sTfR as an indicator of iron deficiency anemia and low iron stores.

Table A.4. Maternal socio-cultural background of study participants.

	Caucasian (n = 84)	Chinese (n = 48)	Other (n = 13)
Mother born in Canada			
Yes	70 (83)	3 (6)	-
No	14 (17)	45 (94)	12 (100)
Country of birth for mothers not born in Canada			
Hong Kong	-	21 (47)	1 (8)
China	-	13 (27)	-
Southeast Asia	-	6 (13)	-
Europe	11 (78)	-	1 (8)
U.S.	3 (21)	-	-
Other[1]	1 (7)	-	10 (77)
Number of years immigrant mothers had lived in Canada			
≤2	1 (7)	7 (16)	4 (33)
3-5	-	12 (27)	1 (8)
6-10	3 (21)	19 (42)	2 (16)
>10	8 (57)	7 (16)	5 (38)
Language spoken at home by immigrant mothers			
English	11 (78)	5 (11)	5 (42)
English and Chinese	2 (14)	4 (9)	1 (8)
English and Other	1 (7)	-	2 (16)
Chinese	-	36 (80)	1 (8)
Other[2]	-		3 (25)

Results shown are the number of infants, and in brackets the % of all infants within a given category.
Information on whether the mother was born in Canada or not was not given for 1 infant of Other ancestry; Country of birth of immigrant mother was not given for 5 infants of Chinese ancestry.
[1]South Africa (n=1) for Caucasian, and India (n=3), Philippines (n=3), Japan (n=2), Mexico (n=1), and Nicaragua (n=1) for Other.
[2]Punjabi (n=2) and Spanish (n=1).