FOOD SECURITY AND NUTRITIONAL STATUS AMONG VANCOUVER
PRESCHOOL CHILDREN

By

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Abstract

Objectives: The purpose of this study was to measure the prevalence of household food insecurity and to determine the association of household food insecurity with covariates related to the physical and social environments as well as the relationship of household food insecurity to preschool children's body mass index and nutritional status indicators.

Study Design: Household food insecurity was measured using the USDA Core Food Security Module in a convenience sample of 142 households with children aged 2-5 years in Vancouver in March 2004. Univariate analyses utilized two-sample t-tests, Wilcoxon signed-rank test and Spearman rank correlation. Multivariate logistic regression was used to examine associations among socio-demographic variables, physical and social environmental predictors, children's body mass index, children's serum ferritin, serum zinc and household food insecurity.

Results: Half of households were categorized as food secure, 16.2% were categorized as food insecure with anxiety about their food supply, 21.0% as food insecure with few or no hunger indications, 11.9% as moderately food insecure with indications of adult hunger and 0.7% as severely food insecure with high risk of child hunger. After controlling for socio-demographic variables, parents with less access to food of reasonable quality, lower self-rated food preparation skills, fewer cooking appliances, and lower levels of social inclusion were more likely to experience household food insecurity. Children in food insecure households were over twice as likely to have a body mass index over the 85th percentile compared to those in food secure households OR 2.6 (95%CI: 1.02, 6.5). Spearman rank correlation showed a significant association between increasing household food insecurity and increasing body mass index z-score ($\rho = 0.18$, $p = 0.04$). Median serum zinc levels were significantly lower among children from food insecure households. Study results did not show a correlation between household food insecurity and serum ferritin depletion.

Conclusions and Implications: The prevalence of household food insecurity in the present study indicates a need for monitoring of food insecurity among households with children in Canada. The results suggest that the physical and social environments as well as personal/household attributes are associated with household food insecurity. The study provides evidence that food insecurity is associated with sub-optimal nutritional status in young children.

Table of Contents

ABSTRACT.....	ii
TABLE OF CONTENTS.....	iii
LIST OF TABLES.....	ix
LIST OF FIGURES.....	xi
LIST OF ABBREVIATIONS.....	xii
ACKNOWLEDGEMENTS.....	xiii
CHAPTER 1 INTRODUCTION.....	1
1.1 BACKGROUND.....	1
1.2 PURPOSE.....	1
1.3 OBJECTIVES.....	1
1.4 HYPOTHESES.....	2
CHAPTER 2 LITERATURE REVIEW.....	3
2.1 INTRODUCTION.....	3
2.2 RISK FACTORS FOR HOUSEHOLD FOOD INSECURITY.....	4
2.3 CONSEQUENCES OF HOUSEHOLD FOOD INSECURITY.....	4
2.4 PREVALENCE AND SEVERITY OF FOOD INSECURITY AMONG CHILDREN AND FAMILIES.....	5
2.4.1 <i>Prevalence of Food Insecurity Among Adults</i>	5
2.4.2 <i>Prevalence of Food Insecurity Among Children</i>	6
2.5 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF FOOD INSECURE CANADIANS.....	7
2.5.1 <i>Low Income</i>	7
2.5.2 <i>Age and Lone Parent Status</i>	7
2.5.3 <i>Other Factors</i>	7
2.6 FOOD INSECURITY AND HEALTH.....	8
2.6.1 <i>Relationship between Household Food Security and Child Health</i>	8
2.6.1.1 Physical Health Status.....	8
2.6.1.2 Emotional and Behavioural Functioning.....	9
2.6.1.3 Academic Outcomes.....	9
2.7 RELATIONSHIP BETWEEN PROXIMAL RISK FACTORS: SOCIAL AND PHYSICAL ENVIRONMENTS AND PERSONAL ATTRIBUTES.....	9
2.7.1 <i>Access to Food Correlates</i>	10
2.7.2 <i>Social Ecological Framework</i>	10

2.7.2.1	Social Environment	11
2.7.2.2	Personal/Household Attributes.....	11
2.7.2.3	Physical Environment.....	12
2.8	RELATIONSHIP BETWEEN FOOD SECURITY AND BIOCHEMICAL NUTRITIONAL STATUS.....	13
2.8.1	<i>Food Security and Biochemical Markers of Nutritional Status</i>	13
2.8.2	<i>Food Security and Dietary Intake</i>	14
2.9	THE RELATIONSHIP BETWEEN IRON NUTRITION AND HEALTH.....	15
2.9.1	<i>Biochemical Correlates</i>	15
2.9.2	<i>Role of Iron</i>	15
2.9.3	<i>Consequences of Deficiency</i>	15
2.9.3.1	Storage Iron Depletion.....	16
2.9.3.2	Iron Deficiency	16
2.9.3.3	Iron deficiency anemia	16
2.9.4	<i>Prevalence of Biochemical Nutrient Deficiency</i>	17
2.9.5	<i>Pathway to Nutrient Deficiency Risk: Adequacy of Dietary Intake</i>	18
2.10	ASSESSMENT OF IRON STATUS	18
2.10.1	<i>Serum Ferritin</i>	19
2.10.2	<i>Zinc protoporphyrin: erythrocyte ratio</i>	19
2.10.3	<i>Transferrin saturation</i>	19
2.10.4	<i>Hemoglobin</i>	20
2.10.5	<i>Case Definitions</i>	21
2.10.5.1	Iron Deficiency Anemia	21
2.10.5.2	Iron Deficiency	22
2.11	THE RELATIONSHIP BETWEEN ZINC NUTRITION AND HEALTH.....	22
2.11.1	<i>Role of Zinc</i>	22
2.11.2	<i>Consequence of deficiency</i>	22
2.11.3	<i>Prevalence of Zinc Deficiency</i>	23
2.11.4	<i>Pathway to Risk: Adequacy of Dietary Intakes of Zinc in Preschoolers</i>	23
2.12	ASSESSMENT OF ZINC STATUS	24
2.12.1	<i>Case Definition</i>	24
2.13	RELATIONSHIP BETWEEN FOOD SECURITY AND ANTHROPOMETRICS.....	25
2.13.1	<i>The Relationship Between Weight and Health</i>	25
2.13.2	<i>Consequences of Overweight</i>	26
2.13.3	<i>Prevalence of risk</i>	26
2.13.4	<i>Pathway to Risk: Socio-demographic Factors and Overweight</i>	27
2.13.5	<i>Pathway to Risk: Food Security and BMI</i>	28

2.13.6	<i>Pathway to Risk: Mechanisms Relating Food Insecurity, Diet and Overweight</i>	28
2.14	SIGNIFICANCE OF THE RESEARCH.....	29
2.15	REFERENCES.....	31

CHAPTER 3 CORRELATES OF FOOD INSECURITY AMONG PRESCHOOLERS: A CROSS-SECTIONAL STUDY39

3.1	METHODS.....	39
3.1.1	<i>Study Design</i>	39
3.1.2	<i>Sampling Criteria, Recruitment and Consent</i>	39
3.1.3	<i>Measurement of Outcome: Food Insecurity</i>	40
3.1.4	<i>Measurement of Covariates of Interest and Socio-demographic Variables</i>	41
3.1.5	<i>Statistics</i>	43
3.2	RESULTS.....	45
3.2.1	<i>Description of Covariates and Socio-demographic Characteristics</i>	45
3.2.2	<i>Description of Food Security Status</i>	46
3.2.3	<i>Indications of Severity of Food Insecurity</i>	46
3.2.4	<i>Relationship between Food Insecurity and Socio-demographic Characteristics</i>	47
3.2.4	<i>Relationship Between Food Insecurity and Factors Related to the Physical and Social Environments as well as Personal Attributes</i>	47
3.2.5	<i>Multivariate Analysis</i>	49
3.3	DISCUSSION.....	51
3.3.1	<i>Main results</i>	51
3.3.1.1	<i>Indications of Extent of Food Insecurity</i>	51
3.3.1.2	<i>Indications of Severity of Food Insecurity for Children</i>	51
3.3.2	<i>Comparison to the Literature</i>	51
3.3.3	<i>Socio-demographic characteristics associated with food insecurity</i>	53
3.3.4	<i>Exposures of Interest</i>	55
3.3.6	<i>Assessment of the Outcome Measurement Survey Tool</i>	58
3.4.6.1	<i>Content validity</i>	58
3.4.6.2	<i>Criterion validity</i>	60
3.3.7	<i>Other Limitations</i>	61
3.3.7.1	<i>Selection bias</i>	61
3.3.7.2	<i>Information bias</i>	61
3.3.7.3	<i>Confounding</i>	61
3.3.7.4	<i>Other Limitations</i>	62
3.4	SUMMARY.....	62

3.5	FIGURES AND TABLES.....	64
3.6	REFERENCES.....	71
CHAPTER 4 PRESCHOOL CHILDREN'S NUTRITIONAL STATUS AND HOUSEHOLD FOOD SECURITY: A CROSS-SECTIONAL STUDY		74
4.1	METHODS.....	74
4.1.1	<i>Study design</i>	74
4.1.2	<i>Sampling, recruitment and consent</i>	74
4.1.3	<i>Protocol</i>	75
4.1.3.1	Determination of blood iron and zinc indicators	75
4.1.4	<i>Covariates</i>	76
4.1.4.1	Measurement of Socio-demographic Characteristics	76
4.1.4.2	Measurement of Covariate of Interest: Food Security.....	77
4.1.4.3	Measurement of Outcome: Blood Iron and Zinc Indicators.....	77
4.1.4.4	Measurement of Outcome: Anthropometric Indicators.....	78
4.1.4.5	Statistics	78
4.1.4.6	Anthropometric Analysis.....	80
4.2	RESULTS.....	82
4.2.1	<i>General</i>	82
4.2.2	<i>Level of Food Insecurity</i>	82
4.2.3	<i>Description of the children</i>	82
4.2.4	<i>Hematological and Serum Nutrient Indicators</i>	83
4.2.4.1	Overall Results: Iron.....	83
4.2.4.2	Zinc.....	83
4.2.5	<i>Comparison to population data</i>	84
4.2.6	<i>Relationship Between Food Security and Nutritional Status</i>	84
4.2.6.1	Comparison of continuous values for nutritional indicators	84
4.2.6.2	Comparison by categorical measures for nutritional indicators.....	84
4.2.6.3	Secondary Analyses.....	85
4.2.7	<i>Children's Anthropometric Indicators</i>	86
4.2.7.1	Overall results	86
4.2.7.2	Height-for-age.....	86
4.2.7.3	Weight-for-age.....	86
4.2.8	<i>Anthropometric Measures of Children Compared to Reference Population</i>	86
4.2.9	<i>Relationship Between Food Security and Anthropometric Status</i>	87

4.2.9.1	Comparison of continuous values for body mass index and level of household food security	87
4.2.9.2	Multiple Logistic Regression Analysis: Comparison of categories of body mass index and household food security	87
4.3	DISCUSSION.....	88
4.3.1	<i>Discussion of Overall Results</i>	88
4.3.1.1	Body Mass Index	88
4.3.1.2	Iron Nutrition	89
4.3.1.3	Zinc Nutrition.....	90
4.3.2	<i>Food insecurity and Biochemical Markers of Nutritional Status</i>	90
4.3.2.1	Food Security and Iron Nutrition	90
4.3.2.2	Food Security and Zinc Nutrition.....	91
4.3.2.3	Food Security and Body Mass Index	93
4.3.3	<i>Family Adaptations to Household Food Insecurity</i>	94
4.3.4	<i>Limitations</i>	94
4.3.4.1	Information bias.....	95
4.3.4.2	Selection bias	95
4.3.4.3	Confounding	95
4.4	FIGURES AND TABLES	97
4.4	REFERENCES.....	106

CHAPTER 5	SUMMARY OF RESULTS AND IMPLICATIONS FOR MEASUREMENT, POLICY AND PRACTICE.....	110
5.1	PREVALENCE AND SEVERITY OF FOOD INSECURITY	110
5.1.1	<i>Implications</i>	110
5.2	UTILITY OF THE CORE FOOD SECURITY MODULE AS A DIRECT MEASURE OF HOUSEHOLD FOOD INSECURITY IN A CANADIAN SAMPLE.....	111
5.2.1	<i>Implications</i>	111
5.3	FACTORS ASSOCIATED WITH FOOD INSECURITY	112
5.3.1	<i>Socio-demographic factors</i>	112
5.3.2	<i>Implications</i>	113
5.3.3	<i>Environmental correlates of food insecurity</i>	113
5.3.4	<i>Implications</i>	113
5.3	HOUSEHOLD FOOD INSECURITY IN RELATIONSHIP TO OVERWEIGHT IN CHILDREN	114
5.3.1	<i>Implications</i>	114
5.4	HOUSEHOLD FOOD INSECURITY IN RELATIONSHIP TO PRESCHOOLER'S IRON STATUS	114

5.4.1	<i>Implications</i>	114
5.5	HOUSEHOLD FOOD INSECURITY IN RELATIONSHIP TO PRESCHOOLER'S ZINC STATUS	115
5.5.1	<i>Implications</i>	115
5.6	REFERENCES.....	116
6.0	APPENDICES.....	117
	<i>Appendix A. An Ecological Model of Food Security Promotion</i>	117
	<i>Appendix B. Food Groups Developed for Description of Canadian Preschoolers' Diets and Percentage Contribution of the Food Groups to Mean Intakes of Iron and Zinc.</i>	118
	<i>Appendix C. P values Associated with Correlations Between Categorical Variables.</i>	119
	<i>Appendix D. P values Associated with Correlations Between Categorical Variables.</i>	122
	<i>Appendix E. P values Associated with Correlations Between Categorical Variables.</i>	124
	<i>Appendix F. Table of Adjusted Odds Ratios for Food Insecurity</i>	125
	<i>Appendix G. Effect of logistic regression modeling between nutritional indicators and food insecurity with food insecurity as the outcome.</i>	126
	<i>Appendix H. Effect of logistic regression modelling between BMI and food insecurity with food insecurity as the outcome.</i>	127

List of Tables

Table 2.1. Laboratory measurements commonly used in the evaluation of iron status.	19
Table 2.2. Case definition for iron deficiency anemia from the U.S. CDC.....	21
Table 2.3. Case definition for iron deficiency anemia for the current study.	21
Table 2.4. U. S. CDC Case definition for iron deficiency.	22
Table 2.5. Case definition for iron deficiency for the current study.	22
Table 2.6. Cut off values for deficiency set for serum zinc for children under 10 years old....	24
Table 2.7. Prevalence of overweight among American preschoolers 1971 – 2000.	27
Table 3.1. Item Calibration Values: 1998 US National Benchmark Levels*	64
Table 3.2. Socio-demographic characteristics of a sample of households in East Vancouver, 2004.....	65
Table 3.3. Total number of affirmative answers, categories of food insecurity, and Core Food Security Module scale values for the sample.....	66
Table 3.4. Households categorized by official Core Food Security Module categories and categories based on all risk factors.....	67
Table 3.5. Number of affirmative responses to each questionnaire item by food insecure households (n=71).	67
Table 3.7. Odds ratios for food insecurity for variables associated with physical and social environments as well as personal/household attributes.....	69
Table 3.8. Multivariate analysis of risk factors for food insecurity.	70
Table 4.1. Socio-demographic characteristics of a sample of preschoolers and their families in East Vancouver, 2004 (n = 142).	97
Table 4.2. Socio-demographic and individual characteristics of preschoolers from food secure and food insecure households (n=142).	98
Table 4.3. Study sample nutritional indicators compared at selected percentiles to NHANES population data.	99
Table 4.4. Comparison of median nutritional indicators by food security group.	99
Table 4.5. Correlation between continuous values of nutritional indicators and food security score.....	100
Table 4.6. Prevalence of iron and zinc depletion or deficiency conditions by food security status.....	100
Table 4.7. Prevalence of at least mild iron depletion by income category.....	101
Table 4.8. Proportion of iron replete and iron depleted children by household food security status and household income group.	102
Table 4.9. Distribution of anthropometric measures in the sample of preschoolers.....	102
Table 4.10. Study sample body mass index distribution compared at selected percentiles to the CDC population reference.	102
Table 4.11. Study sample height-for-age distribution compared at selected percentiles to the CDC population reference.....	103
Table 4.12. Study sample weight-for-age distribution compared at selected percentiles to the CDC population reference.....	103
Table 4.13. Comparison of preschoolers mean BMI, weight-for-age and height-for-age z- scores.	103
Table 4.14. Comparison of median of z-score values within food security categories.....	104
Table 4.15. Correlation between anthropometric z-score values and household food security scale score.	104

Table 4.16. Odds of children in food insecure homes having a body mass index indicating underweight, healthy weight, at-risk of overweight, or overweight.....	105
Appendices	
Table 3.9. P values Associated with Correlations Between Categorical Variables: Primary Outcome Food Security Status. (Chi-square or Fisher's exact test).....	119
Table 3.10. P values Associated with Correlations Between Categorical Variables: Food Secure Comparison Group.....	120
Table 3.11. P values Associated with Correlations Between Categorical Variables: Food Insecure Comparison Group	121
Table 4.17. Entire Sample Group P values Associated with Correlations Between Categorical Variables. Primary Outcome: at Least Mildly Depleted Serum Ferritin (Chi-square or Fisher's exact test).	122
Table 4.18. Normal Serum Ferritin Value Group (serum ferritin >24 ug/L) P values Associated with Correlations Between Categorical Variables.....	122
Table 4.19. At Least Mildly Depleted Serum Ferritin Group (serum ferritin $\leq$ 24 ug/L) P values Associated with Correlations Between Categorical Variables.....	123
Table 4.20. P values Associated with Correlations Between Categorical Variables. Entire Sample Group. Primary Outcome BMI >85 th percentile. (Chi-square or Fisher's exact test).....	124
Table 4.21. P values Associated with Correlations Between Categorical Variables. Body Mass Index >85 th Percentile Group.....	124
Table 4.22. P values Associated with Correlations Between Categorical Variables. Body Mass Index < 85 th Percentile Group.....	124
Table 4.23. Odds of children in food insecure homes having a body mass index indicating underweight, healthy weight, at-risk of overweight, or overweight (showing all adjustments).	125
Table 4.24. Crude and adjusted odds ratios of food insecurity for indicators of nutritional status.....	126
Table 4.25. Odds ratios and 95 percent confidence intervals for food insecurity for body mass index classifications.....	127

List of Figures

Figure 2.1. Conceptual framework of food insecurity, its risk factors and consequences.....5

List of Abbreviations

BMI	Body mass index
CCHIP	Community Childhood Hunger Identification Project
CCHS	Canadian Community Health Survey
CI	Confidence interval
CFSM	Core Food Security Module
CSFII	Continuing Survey of Food Intakes by Individuals
LICO	Low income cut off
NHANES	National Health and Nutrition Examination Survey
NLSCY	National Longitudinal Survey of Children and Youth
NPHS	National Population Health Survey
OR	Odds ratio
ZPP	Zinc protoporphyrin

In Appendices

Clinic	Data collection clinic
Educ	Education level
Fsec	Food Insecure
Inc	Household income
Lang	Language spoken at home
MPF	Meat Poultry Fish
SP	Single parent
VS	Vitamin Supplement use
Yr Can	Years in Canada

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Chapter 1 Introduction

1.1 Background

Household food insecurity is recognized by some as a public health problem in Canada and other industrialized countries (1-4). There have been calls to assess the scope of the food insecurity and evaluate where interventions may alleviate individual suffering as well as the associated economic, health and social disadvantages, which are unnecessary in a food-rich country such as Canada (5, 6). Food insecurity is hypothesized to be detrimental to individuals yet we have little information on its impact on the nutritional health of children. There is a need to describe the links between household food insecurity and nutritional health in order for national and provincial ministries of health and local health authorities to recognize it as a public health issue within their mandate. Further, there is a need to begin describing risk factors for household food insecurity that may be influenced directly through public health policy, programs or practice in addition to factors that relate to social or municipal policy, which may be influenced through advocacy.

1.2 Purpose

This study aims to accomplish a number of purposes. The first is to assess the prevalence and level of severity of food insecurity within a Canadian sample thought to be at high risk. The assessment will be accomplished, for the first time in Canada, using a tool that directly measures a wide variation in the experience of food insecurity. The application of the survey, which was developed in the United States, will assist with confirming its suitability for use in this country and help establish what categorical measures of household food insecurity are more relevant to monitor here. The study examines novel risk factors related to the physical and social environments as well as personal/household attributes and their association with household food insecurity. This study provides a rare opportunity to assess Canadian preschool children's biochemical nutritional status, particularly serum iron and zinc as well as measured weights and heights. These variables will be examined for their relationship to level of household food insecurity.

1.3 Objectives

This cross-sectional research study will examine potential risk factors related to the physical and social environments as well as personal/household attributes and their association to level of

household food security. Secondly, it will evaluate the relationship between household food security and biochemical/anthropometric measures of nutritional status among Vancouver children 2 - 5 years of age.

1.4 Hypotheses

1. Parents who report food insecure households within the past year are more likely to rate themselves as having
 - Inadequate community access to a variety of quality food
 - Lower ratings of social inclusion.
 - Less skill in food preparation for children
 - A home kitchen with 4 or fewer cooking appliances.
2. Children aged 2 - 5 years who live in households that have experienced food insecurity in the past year are more likely to have lower levels of the serum nutrients ferritin and zinc.
3. Children aged 2 - 5 years who live in households that have experienced food insecurity in the past year are more likely to have a BMI above the 85% percentile according to the Centre for Disease Control Growth Charts (7).

Chapter 2 Literature Review

2.1 Introduction

Food security is a multi-dimensional and evolving concept. The term food security connotes the ideas of availability of adequate food for populations, affordability of food, food safety, food as a right, accessibility of food that promotes optimal health, sustainable agricultural systems, and use of agricultural biotechnology (8). Food security or insecurity is a characteristic of nations, communities, households or individuals and can be analyzed at each of these levels. *Canada's Action Plan for Food Security* (1998) adopts the definition of food security that emerged from the World Food Summit which states that "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life" (6).

This study adopts the World Food Summit definition of food security and uses a conceptual framework of food insecurity that is centered on risk factors for and consequences of inadequate physical and economic access to food for individuals and households (Figure 2.1) (9). At this level, food security exists when, for each household member, the ability to acquire food is assured; food is obtained in a manner that maintains human dignity; food is safe, nutritionally adequate, personally and culturally acceptable; and food is sufficient in quality and quantity to promote optimal growth and development or maintain health (10). Food insecurity is a continuum, progressing from uncertainty or anxiety about a household's food supply, to reduced quality and then quantity of food consumed (11). Hunger, the painful sensation caused by a lack of food, is now recognized as the extreme form of food insecurity experienced among adults or children in the household. The term food insufficient refers to those who report sometimes or often not having enough food to eat.

The theoretical framework presented outlines both predictor and outcome variables related to household food security. Relationships between the variables can be tested for their utility in explaining and describing the impact of food insecurity. A key aspect of any framework is its predictive value as this enables health promotion planners to hypothesize how a problem, such as food insecurity can be addressed (12).

2.2 Risk Factors for Household Food Insecurity

Food security occurs in a context in which social, economic and political factors affect access to food. These factors and related policy have a significant impact on household food security but they are beyond the scope of this work. Proximal risk factors for food insecurity can be divided into influences of the social environment, such as household income and social connectedness; the physical environment, such as location of community food markets, the type, quality and quantity of food available; and personal and household attributes, including the physical ability to shop and cook, knowledge and food preparation skill as well as storage and cooking facilities (9, 13).

Poverty and low socioeconomic status are known to be associated with poor diet, nutritional status and overall health (14). Although a strong relationship exists between low income and food insecurity, poverty is not a perfectly sensitive or specific predictor as not all low income households are food insecure and very few experience hunger while some households above an income-based poverty line experience food insecurity (15). For this reason, a more direct measure of food security is needed.

2.3 Consequences of Household Food Insecurity

The framework indicates two sets of potential consequences of individual food insecurity (see figure 2.1). These include 1) the physical and biochemical symptoms of suboptimal nutritional status, mediated through dietary intake, and 2) effects on social, physical and mental wellbeing related to quality of life (9). In industrialized countries, malnutrition includes both over and under-nutrition. For example, individuals can be overweight and at the same time undernourished in terms of micronutrients. Food insecurity can affect health and quality of life either directly or indirectly through nutritional status. For example, hunger without malnutrition may affect a child's ability to learn. This framework proposes that the association of food insecurity with nutritional status is in addition to the association between poverty and health. Associations between immediate risk factors and consequences of food insecurity are the focus of this study.

Figure 2.1. Conceptual framework of food insecurity, its risk factors and consequences.
(Adapted from Campbell, 1991).

2.4 Prevalence and Severity of Food Insecurity Among Children and Families

Indications of the extent of food insecurity among children and families have emerged from recent surveys.

2.4.1 Prevalence of Food Insecurity Among Adults

The 1998-1999 National Population Health Survey (NPHS) indicated 3,015,000 (10.2%) of Canadians fell on the continuum of food insecurity. Most food insecure households were anxious about not having enough food to eat or not eating the quality or variety of foods they wanted at least once in that year. The proportion living in a food insecure household experiencing the most extreme food insecurity, where they did not always have enough to eat, was 4.1%. A similar percentage of Canadians (4.5%) indicated in the 1996-1997 NPHS not always having enough food to eat (14).

In the 2000-2001 Canadian Community Health Survey (CCHS), 14.6% of British Columbians reported not eating the quality or variety of food they wanted, 11.6% reported worrying about sufficient food, and 8.2% indicated they 'sometimes' or 'often' did not have enough to eat due to lack of money. Among a representative sample of Vancouver residents aged 12 and over, the

prevalence of food insecurity was slightly higher with 13.4% not eating the quality or variety of foods they wanted to eat because of a lack of money, 10.4% of households “often” or “sometimes” worrying there would not be enough to eat because of a lack of money, and 9.2% indicating they or someone else in their household often or sometimes did not have enough food to eat because of a lack of money (16).

2.4.2 Prevalence of Food Insecurity Among Children

Nationally, the 1998-1999 NPHS indicated food insecurity was more prevalent among young adults (12.5% of respondents aged 18-34 years) but still more common among children. Among the 924,000 (13.4%) children 0-17 years of age in a food insecure household, 678,000 (9.8%) had compromised diets and 338,000 (4.9%) experienced hunger (11, 14). Further indicators of child hunger are available from the 1994 and 1996 National Longitudinal Survey of Children and Youth (NLSCY) surveys in which households were asked if their child had ever experienced hunger because there was no food in the house or money to buy food. In the 1994 survey, 1.2% of families with children under 11 years of age reported child hunger, which equates to about 57,000 children (17). The 1996 prevalence rate of 1.6% of NLSCY families (representing 75,615 children) reporting hunger is about one quarter of the prevalence rate found in the United States. The Longitudinal Study of Child Development in Quebec revealed 3.8% of families of a representative sample of infants 1.5 years of age experienced a lack of food at least once since the child’s birth. Prevalence rates across decreasing income quintiles were 0.4% in the highest quintile, 1.0%, 1.5%, 6.8% and 9.2% of families in the lowest income quintile (18).

Among American children, the Third National Health and Nutrition Examination Survey (NHANES III) data, gathered between 1988 and 1994, estimated the prevalence of food insufficiency, sometimes or often not getting enough food to eat, among children aged 2 months to 5 years at 6.8% overall, 16.5% among the low income population, and 3.4% among the low-middle-income population (19). The Community Childhood Hunger Identification Project (CCHIP) categorized families with children as hungry based on positive parental responses to questions on the experience of not having enough to eat. Data from nine U.S. states revealed that 8% of children under the age of 12 experienced hunger and an additional 21% were at-risk for hunger (20).

2.5 Socio-demographic Characteristics of Food Insecure Canadians

The socio-demographic characteristics of food insecure families are consistent among studies with low income and single parent status as primary risk factors (11, 17, 21). The 1998-1999 NPHS data provides the following indicators of risk among Canadians (14). It is important to note that this survey does not capture data from transient families, families in the Canadian military or those living on-reserve.

2.5.1 Low Income

Not all low income households were food insecure, but among those who were, the main source of income, whether employment or income assistance, did not matter. The estimated adjusted odds ratio (OR) indicated that households were more likely to be food insecure if their income was in the lowest third of the range (OR =10.2, 95% confidence interval (CI): 8.01, 12.98), or the middle third (OR=3.07, 95% CI: 2.37, 3.98), compared to the highest third.

2.5.2 Age and Lone Parent Status

The prevalence of food insecurity was higher for families with at least one child less than five or twelve years old (13.6% and 12.8%, respectively) than for all Canadians. A high proportion of single parent families were food insecure (26.6%) compared to two-parent families with children (8.1%). Single parent families with a child less than thirteen years old were four times (OR=4.28, 95% CI: 3.45, 5.31) more at risk and couples with a child less than thirteen years old were two times (OR=1.99, 95%CI: 1.66, 2.38) more at risk than couples with no children.

2.5.3 Other Factors

Likelihood of food insecurity was significantly higher for respondents with a restriction of activity (OR=1.86, 95%CI: 1.63, 2.12), a chronic medical condition (OR=1.13, 95% CI: 1.00, 1.28) and for Aboriginal respondents (OR=1.95, 95%CI: 1.42, 2.68). Living in a dwelling owned by a member of the household was a protective factor, with a 61% lower risk compared to that of renters (OR=0.39, 95%CI: 0.35, 0.44). Compared to those who lived in Canada for more than 10 years, immigrants who had lived in Canada for less time were not significantly more likely to be food insecure (OR=0.77, 95% CI: 0.59, 1.28).

Data from the NLSCY comparing families that reported frequent hunger (at least every few months) to families that reported occasional hunger provides other risk factors for families. Independent predictors of frequent hunger included a higher total number of siblings in the household (OR=1.32, 95% CI: 1.08, 1.62) and mother's education level less than high school (OR=4.47, 95% CI: 2.27, 8.80) (17).

2.6 Food Insecurity and Health

In addition to noting poor functional health, particular attention has been given to the psychological and social health consequences those in food insecure households suffer. Lower levels of social support and social inclusion are correlated with food insecurity as those affected adopt food acquisition strategies and food choices that depart from socially accepted patterns (22, 23). Qualitative research with food insecure parents indicated that the core characteristics of the experience involved feelings of “alienation, shame, embarrassment, exclusion from society, powerlessness and fear of judgment”(24). Families experienced disrupted social interactions such as having friends to dinner and loss of food-related rituals for special occasions (25).

2.6.1 Relationship between Household Food Security and Child Health

The association between poverty and ill health is well documented and food insecurity occurs in the context of financial resource constraints; however, recent research identifies health consequences that are specific to food insecurity. Among children, evidence is available on the impact of food insecurity on physical health, emotional and behavioural functioning, as well as academic achievement.

2.6.1.1 Physical Health Status

In the 1996 NLSCY, children of families experiencing hunger were reported to have significantly poorer health than other children. Among children from hungry families, 70.3% were reported to have very good or excellent health while 88.1% of children in families not reporting hunger had the same health status. The finding is similar to that from NHANES III data, which showed food insufficient preschool children were more likely to experience frequent stomachaches, headaches and colds compared to children in food sufficient families, after controlling for family income,

race/ethnicity and other socio-demographic characteristics. Food insufficient middle-income families were equally likely to report children in poor health as food insufficient low income families (OR middle income = 3.53, 95% CI: 2.10, 5.93; OR low income = 3.32, 95% CI: 2.39, 4.57). Both groups of food insufficient children had higher odds of poor health than children from food sufficient households in either the middle-income group (OR = 1.60, 95%CI: 1.31, 1.97) or the low income group (OR = 2.23, 95%CI: 1.63, 3.03) (26). In this study, low income was defined as <130% of an established poverty line and middle income as 130% - 350% of the poverty line.

2.6.1.2 Emotional and Behavioural Functioning

In school aged inner city children in Baltimore and Philadelphia, a relationship between hunger or being at-risk for hunger and psychosocial problems was demonstrated (27, 28). Results indicated a positive relationship between increasing psychosocial dysfunction (such aggression, poor attention or anxiety) and increasing severity of food insecurity, which remained after controlling for household socioeconomic status. Data from NHANES III found that in families reporting not always having enough to eat, children 6-11 years old were almost twice as likely to have seen a psychologist and adolescents had almost twice the odds of having seen a psychologist, being suspended or have had difficulty getting along with others (29).

2.6.1.3 Academic Outcomes

The NHANES III study also found insufficient food intake among school-aged children was associated with poor academic outcomes. After adjusting for confounding variables, including family income and poor health, 6-11 year old food insecure children had significantly lower arithmetic scores and were more likely to have repeated a grade. No differences between food secure and food insecure children were found on tests of reading or cognitive ability (29). Data from the U.S. Early Childhood Longitudinal Study – Kindergarten Cohort indicated children from homes rating even marginally food insecure scored lower on math scores and had smaller increases in learning over a year compared with food secure children (30).

2.7 Relationship Between Proximal Risk Factors: Social and Physical Environments and Personal Attributes

2.7.1 Access to Food Correlates

Little is known about the pathway to food insecurity apart from inadequate money for food. One model in the literature was proposed by the developers of the NPHS Food Security Supplement and includes non-financial determinants of household food security including the variables: income management, food acquisition and food management (14). The framework proposes that food security is promoted by increasing disposable income through budgeting or multiple jobs. The food acquisition variable influences food security through access to transportation, choice of shopping possibilities, and ability to purchase economy size packages. Food management in the home includes maintaining staples, proper storage and meal planning. When asked about particular problems related to food acquisition on the 1998-1999 NPHS, respondent's issues included lack of money for transport (21%), health problems (15%), lack of transport available (12%), long-term disability (11%), and stores too far away (8%). Other unspecified problems were reported by 22% of food insecure respondents (14). Other variables of the framework were not explored in the NPHS Food Security Supplement.

2.7.2 Social Ecological Framework

The various dimensions of food security may be explored by examining them through a theoretical framework. The social ecological framework is a useful guide for proposing factors affecting household food security. Ecological models, which correspond to the society and health epidemiological lens, are based on systems theory and define health as a product of the interdependence between the individual and subsystems of the ecosystem, which include the individual, family, community, culture, physical and social environments (31, 32).

Three core principles guide the theory of social ecological models. First, health is influenced by the interaction among the physical environment (geography, agriculture, and technology), the social environment (culture, economics, politics) and personal attributes (physical, psychological and behavioural). Secondly, the degree of agreement between people's biological, behavioural, and socio-cultural needs and the environmental resources available to them is a key determinant of health. Thirdly, patterns of behaviour, roles or community settings exert a primary influence on health making them leverage points to be targeted in programs (33).

The framework suggests household food security is affected by factors influencing access to food

within the household and community. This framework will be used as a rubric to assess study variables related to physical environment, the social environment and personal/household attributes.

This section discusses how relevant variables (social environment, personal/household attributes, and physical environment) and their interaction may affect food security status. See Appendix A *An Ecological Model of Food Security Promotion* for a diagrammatic description of the model.

2.7.2.1 *Social Environment*

Community characteristics are important intervening variables in the experience of food insecurity. For example, persons with low income may be unable to shop around for low food prices without a car or adequate public transportation to reach large suburban supermarkets. Inner city areas may lack large parcels of land for grocery stores, instead zoning promotes the location of convenience stores and fast food outlets.

Pricing has a strong influence on food choices (34). Fresh produce may cost as much as 22% more in a low income neighbourhood area compared with a higher-income area and is often of lower quality and variety (32). As a result, people living in low income areas are much less able to meet their needs for health promoting foods in their own neighbourhood.

Initiatives to combat lack of economic access to food include changes to social safety nets, aimed at ensuring a minimum family income through setting minimum wages, pensions, unemployment benefits, and social assistance rates for vulnerable groups such as the unemployed and single-parent families (35). Individuals and households may turn to community resources such as food banks, community kitchen programs or meal programs sponsored by church or social organizations to cope with food shortage; however, these programs are known as short-term solutions that do not solve food insecurity (36).

2.7.2.2 *Personal/Household Attributes*

Personal attributes such as health status, metabolism and physiology influence the specific foods required by any one person to be food secure. Food choices considered acceptable depend on tradition and culture. The knowledge and skills needed to utilize food to the fullest depend on the

household member's (primarily women's) time, skills and abilities to shop for and prepare food. Food preparation skills are usually learned within the family of origin and are based on culture and values (13). Knowledge about nutrition increases as education level increases, but little variation has been found across income levels (37). Food insecure low income Canadian mothers given a test on label reading, nutrient needs of children and sources of various nutrients averaged scores of 70% (38) indicating some knowledge of nutrition.

Adequate home facilities including a refrigerator and stove are required for safe food storage and preparation. Appliances such as freezers allow some households to buy larger quantities of food, often at lower prices. Microwaves, blenders, slow cookers and bread makers speed preparation of food from unprocessed ingredients and allow the use of less expensive foods such as beans, lentils and cheaper cuts of meat.

2.7.2.3 *Physical Environment*

Since most households do not grow a substantial amount of their own food, due to a lack of access to land, information about gardening, time, or physical ability to labour, the accessibility and quality of grocery stores is key. In American cities, food stores located in lower income neighbourhoods were less likely to carry an adequate variety of fresh food for a healthy diet (32). Another study found the types of food stores and food service establishments differed between poor and wealthy neighbourhoods with 3 times as many full supermarkets in wealthy neighbourhoods compared to the poorest areas which had more small grocery stores and convenience stores (39).

Rural areas in the United States provided a limited number of supermarkets, limited availability of food items, and a higher relative cost of a standard market basket of foods compared to urban areas (40). There were 3.8 supermarkets per county in the rural areas versus 29 in urban centres. Supplies of fresh fruits, vegetables, and meats were limited in the small and medium-size grocery stores that were more common in rural areas. Among rural food stores, the average cost a standard market basket was \$102 in small and medium stores versus \$81 in full-sized supermarkets.

Comparing census tracts with and without full service supermarkets, Black Americans reported

an increased intake of fruits and vegetables with the presence of one supermarket in the census tract (relative risk (RR) = 1.32, 95%CI: 1.08, 1.60) and an increase of 32% for each additional local supermarket (41). The same trend was apparent among White Americans but weaker and not statistically significant (RR = 1.11, 95%CI: 0.93, 1.32).

2.8 Relationship between Food Security and Biochemical Nutritional Status

Compromised nutritional status, measured through dietary, anthropometric or biochemical assessments, is a potential, but not an inevitable consequence of food insecurity. The relationship between household food insecurity and individual-level indicators of nutritional status depends on the nature and duration of inadequate intake. Any observed relationship also depends on how both food security and nutritional status variables are measured (5).

Study findings indicate that current measures of household food security correspond to conventional assessments of dietary adequacy among adults. A number of studies document significantly poorer food and nutrient intakes among individuals in food insecure households compared to those in food secure settings. This section reviews studies comparing the nutritional status of food secure and food insecure household members, particularly mothers and children. It then outlines the biochemical measures chosen for this study and the rationale for considering their relationship to food security in children.

2.8.1 Food Security and Biochemical Markers of Nutritional Status

Little data exists on the relationship between food insecurity and biochemical or clinical measures of nutritional status among adults. Serum nutrient levels often reflect longer-term nutritional status and are less prone to measurement error than reported nutrient intakes from dietary recall instruments (42). In NHANES III, measurements of serum concentrations of nutrients indicated that adults 20-59 years of age from food-insufficient families had lower serum concentrations of total cholesterol, vitamin A, serum albumin and carotenoids (43). No data is available comparing serum nutrient concentrations of children with differing household food security status.

2.8.2 Food Security and Dietary Intake

Corresponding to the biochemical inadequacies found among food-insufficient adults in the NHANES III study, adults from food-insufficient families reported lower frequency of intake of milk/milk products, fruits/fruit juices and vegetables compared with food-sufficient adults.

Among a small sample of Canadian mothers receiving emergency food supplies, those women in food insecure households with moderate or severe hunger had lower overall nutrient intakes, including significantly lower intakes of energy, protein, fat, carbohydrate, vitamin A, vitamin C, folate, calcium, iron, magnesium, and zinc compared to food secure women (44).

Because the distribution of food within a household may not be equal, the association between household level food insecurity and various household members' dietary intakes differs. Mother's dietary intakes show strong systematic variation according to the severity of household food insecurity but children's do not show the same variation (45). Households involved in the 1989-1991 Continuing Survey of Food Intakes by Individuals (CSFII) in which a preschooler lived showed significant differences in nutrient intake between food sufficient and food insufficient mothers. While food insufficient mothers had lower intakes of energy, protein, thiamine, calcium, phosphorus and magnesium, their preschool children's intakes were not significantly different from the children of food sufficient mothers (46).

More recently, the 1994-1996 CSFII, a nationally representative sample of American households and children 0-17 years of age examined children's nutritional status and food security. Children of low income families, whether food-sufficient or food-insufficient, had similar macronutrient and micronutrient intakes (47). However, when compared with the higher income food sufficient households, children in the low income food insufficient households consumed fewer calories, more carbohydrate, fewer fruits and vegetables and more dry beans and lentils.

In a small sample of Hispanic children in grade 5, intakes of most foods, energy and percentage of energy from fat were not significantly associated with the level of household food security. Meat intake was significantly lower in children from food insecure households than in children in food secure households. This study highlighted the possible periodicity of hunger and potentially extreme variability in food insecure children's food intake. In the days prior to the parent's payday, there were significant decreases in at-home energy and meat intakes in children from

food insecure households (48).

2.9 *The Relationship Between Iron Nutrition and Health*

2.9.1 Biochemical Correlates

For this study, measures of iron and zinc were chosen as the primary indicators of children's nutritional status. These nutrients were selected because of their known role in human nutrition and for practical reasons including amount of blood required for analysis and cost of analysis.

For each nutrient, first the relationship between the nutrient and children's health is described including the role of the nutrient as well as consequences and prevalence of deficiency. Secondly, the pathway to risk is described in terms of dietary factors related to inadequate intake. Finally, literature on biochemical assessment for the nutrient is discussed.

2.9.2 Role of Iron

In human nutrition, iron primarily functions as a component of enzymes and hemoglobin. Hemoglobin is essential for the transport of oxygen to body tissues for metabolism. Iron-containing proteins are divided into 4 categories: functional iron-containing heme proteins such as hemoglobin, iron-sulphur enzymes, iron storage and transport proteins such as transferrin and ferritin and other iron-containing enzymes (49). Hemoglobin circulating in blood accounts for 65% of iron in the body while other types of functional iron account for less than 1% of body iron content (50). Iron that is not immediately needed for functional iron compounds is stored in the form of ferritin in all cells but particularly the liver, spleen, and bone marrow with small quantities also circulating in the blood. The concentration of ferritin in blood serum is proportional to stores elsewhere in the body. For children, 1 µg/L of serum ferritin indicates 0.14mg/kg stored iron (51). The iron transport protein transferrin accounts for less than 1% of body iron. Its primary role is the movement of iron from storage in cells, liver, spleen, or bone marrow to functional iron compounds (52).

2.9.3 Consequences of Deficiency

Several stages of iron depletion lead to an incremental involvement of different systems in the body. This section outlines the effects of increasing severity of iron depletion.

2.9.3.1 *Storage Iron Depletion*

Most literature indicates storage iron depletion, defined as a serum ferritin concentration less than 12 µg/L, has no immediate health impact but jeopardizes the supply of iron to the functional compartment, particularly heme molecules in erythrocytes (49). Mild iron depletion is defined as serum ferritin concentration less than 24 µg/L (53). Contrary to the generally accepted idea of the inconsequence of iron depletion, one recent randomized, placebo controlled study found oral iron therapy improved perceived level of fatigue more than placebo in adult women with serum ferritin concentrations less than 50µg/L (54). This study indicates potential health effects of inadequate iron supply beyond depleted heme levels.

2.9.3.2 *Iron Deficiency*

Iron deficiency is defined by a reduction in tissue iron supply but hemoglobin concentrations are unaffected. While evidence supports that functional consequences of deficiency occur when tissue iron deficiency is severe enough to reduce hemoglobin levels, growing evidence indicates that iron deficiency, without anemia, is related to changes in behaviour and lower scores on infant development tests (55-57). This evidence is promoting the recognition that identifying persons having iron deficiency is as important as identifying those with iron-deficiency anemia (58). For example, in one trial among adolescents, iron supplementation of non-anemic iron-deficient girls was shown to improve some aspects of cognitive functioning, including measures of verbal learning and memory (59). Mechanisms for the effects of tissue iron deficiency suggested by animal models involve reduced iron content and altered distribution in the brain, resulting in decreased activity in nutrient-dependent enzymes or changes in neurotransmitter function. (57, 60, 61).

2.9.3.3 *Iron deficiency anemia*

In iron deficiency anemia, there is a measurable deficit in erythrocyte hemoglobin, the most easily measured functional iron-containing compartment. At this stage, delivery of oxygen to tissues is impaired in addition to a deficiency of tissue iron.

2.9.3.3.a Effect on mental and motor development

Iron deficiency anemia during the first 2 years of life, despite treatment, has been associated with later poor performance on tests of intelligence or specific cognitive processes at or near school age in children in Israel, Costa Rica, and Chile (62). Recent work with children suggests decreased neural myelination in infancy, associated with iron deficiency anemia, affects visual and auditory signal conduction later in childhood despite treatment of the condition (61). Anemic infants demonstrate behavioural differences compared to non-anemic children including wariness, hesitancy, less interaction with others, and less exploratory behaviour, which may negatively influence development (63). While iron deficiency anemia is associated with lower scores on developmental tests, even after adjusting for factors related to birth, nutrition, family background, lead exposure, parental IQ, and home environment, many biological and environmental factors are associated with both anemia and poor cognitive development and a causal relationship is not certain (64). Anemic children over 2 years of age score lower on tests of cognition and measures of school achievement than nonanemic children (64). Evidence indicates they usually catch up in cognition upon treatment but not in school achievement. Iron deficiency anemia is associated with other health problems including impaired growth, decreased exercise capacity, fatigue, and decreased appetite (63).

2.9.4 Prevalence of Biochemical Nutrient Deficiency

The only national study on the prevalence of nutritional deficiency in Canada was the Nutrition Canada survey of the early 1970s, which identified about 40% of children 1-4 yrs of age with low serum ferritin values, reflecting storage iron depletion (65). The prevalence of iron deficiency anemia was not assessed. More recently, among a low-risk sample in Ottawa-Carleton, iron deficiency anemia was found in 10.5% of 3-year-old children (66). Among 19-36 month old children of first generation immigrants from China and Southeast Asia to Montreal, 16.5% had iron deficiency anemia (67).

More recent data from the American NHANES estimated the prevalence of iron deficiency to be much lower than the rates found in the Canadian subgroups. For children 3-5 years of age, the prevalence was 3% (95% CI: 2-4%) in the 1988-1994 survey and 5% (95% CI: 2-7%) in the

1999-2000 survey. The prevalence of iron deficiency anemia from the same surveys was less than 1% in both 1988-1994 and 1999-2000 (58, 68).

2.9.5 Pathway to Nutrient Deficiency Risk: Adequacy of Dietary Intake

The iron requirement of infants, toddlers and preschoolers is high compared with the volume of food consumed. In order to meet nutritional needs, the recommended dietary allowance (RDA) for iron is set at 11mg for infants 7-12 months of age, 7 mg for children 1-3 years of age and 10 mg for those 4-8 years of age. In comparison, the RDA for an adult man is 8 mg and for an adult woman, 18 mg (49).

Evidence from the Continuing Survey of Food Intakes by Individuals (CSFII), conducted in 1994–1996, suggests that most preschoolers meet the recommended dietary allowance (RDA) for iron through diet (58). However, data from the same survey, collected in 1989-1991, found iron intake of preschoolers from food sufficient households averaged 104.3% of the RDA while those from food insufficient households averaged 86.6% of the RDA, a significantly lower intake (46). In Canada, among a sample of 325 Ontario children aged 4 and 5 years assessed for dietary intake, median iron intakes met 100% of the Canadian recommended nutrient intakes (69).

Primary food sources of iron for a sample of Canadian preschoolers primarily living in households below the Statistics Canada low income cut off were hot and cold cereals (contributing 25.3% of iron), breads (contributing 17.8% of iron), meats (contributing 8.5% of iron), and mixed dishes such as canned pasta with sauce, fast foods, and soup (contributing 9.0% of iron) (Appendix B) (70).

Because iron metabolism is complex, with both biological and nutritional factors enhancing and inhibiting absorption from food, the correlation between intake and measures of blood iron is typically low. For example, in a study of 123 men, the Spearman correlation coefficient between plasma ferritin level and heme iron intake (iron from meat, fish or poultry) was 0.16 ($p = 0.07$) while the correlation between plasma ferritin and total iron intake was -0.15 ($p = 0.08$) (71).

2.10 Assessment of Iron Status

Iron status can be assessed through several laboratory tests. Because each test assesses a different aspect of iron metabolism, results of one test may not always agree with results of other tests and no single test is accepted for diagnosing iron deficiency. As stated by the U.S. Centres for Disease Control “detecting iron deficiency in a clinical or field setting is more complex than is generally believed” (58, p. 10). Available laboratory tests can be used in combination to identify depleted iron stores, iron deficiency and iron deficiency anemia and a partial list is found in table 2.1.

Table 2.1. Laboratory measurements commonly used in the evaluation of iron status.

Stage of Iron Deficiency	Indicator	Diagnostic Range
Depleted iron stores	Serum ferritin concentration	<12µg/L
Early functional iron deficiency	Transferrin saturation	<16%
	Zinc protoporphyrin	>70 µg/dL erythrocytes
Iron deficiency anemia	Hemoglobin concentration	<110 g/L

From: Ferguson et al., 1992. (49).

2.10.1 Serum Ferritin

Serum ferritin concentration is the most specific indicator available of depleted iron stores. Among women of childbearing age, the sensitivity of low serum ferritin (<12 µg/L) for iron deficiency was 61% and the specificity was 100% (72). However, ferritin concentrations are increased in the presence of acute or chronic infection or inflammation so ferritin concentrations may be in the normal range yet iron stores are depleted (58).

2.10.2 Zinc protoporphyrin: erythrocyte ratio

Erythrocyte protoporphyrin is the immediate precursor of hemoglobin. When iron is lacking, zinc can be incorporated into the protoporphyrin ring resulting in the formation of zinc protoporphyrin (ZPP). A concentration of zinc protoporphyrin >70 µg/dL erythrocytes indicates iron deficiency. The sensitivity of the zinc protoporphyrin:erythrocyte ratio for iron deficiency in children aged 6 months – 17 years is 42% and the estimated specificity is 61% (73). Infection, inflammation and lead poisoning can also elevate ZPP levels (58).

2.10.3 Transferrin saturation

Transferrin saturation indicates the extent to which the transport protein transferrin has vacant

iron-binding sites (lower values indicate a higher proportion of vacant sites). A transferrin saturation cut off of <16% is standard among adults. Saturation levels typically increase from a low point at 4 months of age until adulthood. Several factors influence the test results. Each meal increases saturation levels, diurnal variations result in higher saturation in the morning than at night and infection or inflammation can decrease saturation (58). Among a group of adult women, the sensitivity of low transferrin saturation (<16%) for iron deficiency was 20% and specificity was 93% compared to a gold standard of iron content in bone marrow (72).

2.10.4 Hemoglobin

Low hemoglobin (<110 g/dL) in children aged 2-5 indicates anemia but the measure has low sensitivity and specificity for iron deficiency, as it is a rare condition. A diagnosis of iron-deficiency anemia can be made if hemoglobin concentration increases after a course of therapeutic iron supplementation. Alternatively, other laboratory tests, discussed above, can be used to differentiate iron deficiency anemia from anemia due to other causes such as folate or vitamin B12 deficiency, thalassemia major or sickle cell disease (58).

2.10.5 Case Definitions

2.10.5.1 Iron Deficiency Anemia

The case definition for anemia from the United States Centres for Disease Control and Prevention used the following criteria.

Table 2.2. Case definition for iron deficiency anemia from the U.S. CDC.

Hemoglobin	<5 th population percentile (specific to age and sex) 111g/dL
And 2 of the following	
Transferrin saturation	<16%
Zinc protoporphyrin	>70 µg/dL erythrocytes
Mean cell volume	>79fL

From: Centres for Disease Control and Prevention, 1998.

This definition was shown to correctly identify 25% of children aged 1–5 years who were iron deficient (sensitivity) and to correctly classify 92% of children aged 1–5 years as not having iron deficiency (specificity) (74).

The case definition for iron deficiency anemia for this study used the following criteria. This definition is currently used at the British Columbia Children's Hospital Nutrition Research Program.

Table 2.3. Case definition for iron deficiency anemia for the current study.

Hemoglobin	<110 g/dL
And 2 of the following	
Transferrin saturation	<7%
Zinc protoporphyrin	>70 µg/dL erythrocytes
Serum ferritin	<12 µg/L

Lowering the hemoglobin concentration cut off results in identifying slightly fewer children who have anemia due to causes other than iron deficiency (false positives) and the lower transferrin saturation criteria results in identifying fewer children with iron deficiency and iron deficiency anemia (74). The conservative transferrin saturation cutoff used for this study is based on the 2.5th percentile found in a healthy sample of Canadian children 1-5 years of age (75).

2.10.5.2 Iron Deficiency

The case definition for iron deficiency from a recent publication by researchers at the Centers for Disease Control and Prevention used the following criteria for preschoolers.

Table 2.4. U. S. CDC Case definition for iron deficiency.

At least 2 of the following	
Mean cell volume (fL)	<76 (<77 for 5 year olds)
Transferrin saturation (%)	<12
Serum ferritin (µg/L)	<10

From: Mei Z, Parvanta I, Cogswell ME, 2003. (76)

The case definition for iron deficiency used in this study is used by the Nutrition Research Program at the British Columbia Research Institute for Women's and Children's Health.

Table 2.5. Case definition for iron deficiency for the current study.

Serum ferritin	<12 µg/L
And 1 of the following	
Transferrin saturation	<7%
Zinc protoporphyrin	>70 µg/dL erythrocytes

2.11 The Relationship Between Zinc Nutrition and Health

2.11.1 Role of Zinc

Zinc is an essential trace mineral for health. Biologically, zinc has roles in humans as a component of enzymes, particularly those involved with synthesis of ribonucleic acid and deoxyribonucleic acid; synthesis of structural proteins and as a regulator of gene expression (49). With its involvement in these specific processes, zinc is important in the development of the central nervous system in childhood through brain growth, neurotransmission, and memory (77). Zinc is stored mainly in bones, teeth, liver, and muscle. Small amounts, about 0.1% of total zinc, circulate in plasma attached to albumin or globulins (78).

2.11.2 Consequence of deficiency

Numerous less specific roles of zinc have become apparent through observations of the clinical signs of deficiency. The first signs of zinc deficiency in marginally nourished children are suboptimal growth, anorexia and impaired taste (78). Even mild to moderate zinc deficiency can affect growth (79). There is evidence associating zinc deficiency with deficits in activity, attention, and motor development, which interfere with children's cognitive development,

independently of other socio-demographic and nutritional factors (77). However, the mechanism through which these effects occur is unclear. Since other nutrients, such as iron, are important in the development of cognitive function, the combined effects of micronutrient deficiencies may be important (80).

2.11.3 Prevalence of Zinc Deficiency

Information on the serum zinc concentration that will result in clinical deficiency is not available. Serum zinc was assessed in the 1976–1980 NHANES but not included in NHANES III as in 1985 it was not deemed a useful laboratory indicator for zinc status by the Federation of American Societies for Experimental Biology (81). Data from NHANES II found a mean serum zinc concentration of 12.61 mmol/L in children aged 3-9 years (82). This data was recently reanalyzed to develop reference cutoffs for population assessment based on the 2.5th percentile, adjusted for age, fasting status and time of day of sample collection (82).

2.11.4 Pathway to Risk: Adequacy of Dietary Intakes of Zinc in Preschoolers

The recommended dietary allowance for zinc is set at 3 mg/day for children aged 1-3 years and 5 mg/day for 4-8 year old children (49). In comparison, the RDA for men is 11 mg/day and for women, 8 mg/day. Data from NHANES III for 1988-1994 indicates only 18.9% of American children 1-3 years of age and 51.5% of children 4-6 years of age had “adequate” intakes of zinc (>77% of the RDA) (81). Evidence from the 1989-1991 Continuing Survey of Food Intakes by Individuals found zinc intakes of children 1-5 years of age from food sufficient households averaged 71.4% of the RDA while those from food insufficient households averaged 63.0% of the RDA (46). Although the difference was not significant, children from food insecure households were 1.54 times more likely to have a low zinc intake (95% CI: 0.85, 2.87). For Mexican preschool children, data from the 1999 Mexican National Nutrition Survey shows the prevalence of inadequate zinc intake increased as socioeconomic status decreased: 9%, 18%, and 37% of children were identified with inadequate intakes across income tertiles (83). Of particular note, the prevalence of serum zinc below a cut off of 9.94 mmol/L followed a similar pattern in a subsample of 124 children (approximately 20%, 25%, and 47% of children from high, medium and low socioeconomic groups).

Zinc is widespread in the food supply. The best food sources of zinc include oysters, beef, liver,

pork and baked beans (49). Primary food sources of zinc for a sample of Canadian preschoolers primarily living in households below the Statistics Canada low income cut off were meat (24.2%); fluid milk (22.4%) and grains, breads, and cereals (15.8%) (Appendix B) (70). As with iron, zinc metabolism is complex and numerous factors affect the amount of zinc absorbed into the body from food (49).

2.12 Assessment of Zinc Status

No single measure of zinc is a sensitive and specific measure of nutritional status. Concentrations of zinc in blood tend to be maintained within a narrow range through different levels of intake and clinical deficiency can coexist with normal serum levels (49). However, serum or plasma zinc is the only biochemical indicator of zinc status for which reference data are available and it is a useful indicator of zinc status at the population level (82). Studies consistently show that zinc supplementation is positively correlated with plasma zinc (84). Other researchers question the utility of serum zinc in the evaluation of zinc status (81). Serum zinc measurements are confounded in children by factors including recent meals, time of day, infection, serum albumin level and current diarrhea (84). Serum zinc blood samples may also be liable to contamination from erythrocyte zinc.

2.12.1 Case Definition

The typical cut off for morning fasting is 10.7mmol/L (49). For this study, a conservative case definition is used and none of the children were assumed to be fasting. The definition of zinc deficiency used the cut off set at the 2.5th percentile from the NHANES II study. For children 3-9 years old, the cutoffs are as follows.

Table 2.6. Cut off values for deficiency set for serum zinc for children under 10 years old.

Sample Collection Time	Cut off
Morning nonfasting	9.94 mmol/L
Afternoon	8.72 mmol/L

From: Hotz C., American Journal of Clinical Nutrition, 2003. (82)

2.13 Relationship between Food Security and Anthropometrics

Body mass index is an indicator of nutritional status. First, this section reviews the literature on the relationship between weight and health, including the consequences and prevalence of overweight. Secondly, it discusses the pathway to risk in terms of the relationship between food security and BMI as well as that between food insecurity and diet. Finally, it outlines the assessment of anthropometric status.

2.13.1 The Relationship Between Weight and Health

Weight and stature are commonly used to assess size and growth. Body mass index is an anthropometric index, calculated as weight (kg) /height (m²) and is the recommended assessment method for children (85). The U.S. Centre for Disease Control's Body Mass Index (BMI)-for-age charts provide a reference set of BMI values for children, based on measurements from a large American population of boys and girls. BMI is the most easily calculated yet reliable marker of fatness found in epidemiological studies of children. BMI is strongly associated with total body fat (kg) ($R^2 = 0.85$ and 0.89 for boys and girls, respectively) and with percentage body fat ($R^2 = 0.63$ and 0.69 for boys and girls, respectively) (86).

Increasing BMI in children is associated with the adverse biochemical and physiological effects of excessive adiposity, such as elevated serum insulin and blood pressure. In children between 10 and 15 years of age, a significant positive correlation between BMI and serum insulin levels ($r = 0.63$, $p < 0.0001$) was observed (87). A significant positive correlation between BMI and systolic ($r = 0.5$, $p < 0.0001$) and diastolic ($r = 0.46$, $p < 0.0001$) blood pressures in a cohort of 440 children between 6 and 18 years of age supports the utility of the measure (88).

Overweight refers to increased body weight in relation to height, when compared to a standard of acceptable or desirable weight. The following are the cutoffs recommended by the U.S. Centres for Disease Control and Prevention for assessment of under and overweight in children aged 2 years and up:

Underweight - BMI-for-age < 5 th percentile

At risk of overweight - BMI-for-age 85th percentile to < 95 th percentile

Overweight - BMI-for-age > 95th percentile

It should be noted that individual children may have differences in total body fat and percentage body fat despite similar BMI values as excess weight may be due either to fat or to lean muscle (85). In other words, BMI has a high specificity (correctly identifying those not overweight) but a variable sensitivity (correctly identifying those over fat).

Obesity is defined as an excessively high amount of body fat or adipose tissue in relation to lean body mass (89). The amount of body fat includes concern about both the distribution of fat throughout the body and the size of the fatty tissue deposits. Experts recommend not labeling children as "obese" to reduce the potential for stigmatization. However, in the literature the term obese is used to classify children with BMI's greater than the 95th percentile.

2.13.2 Consequences of Overweight

Medically, hyperlipidemia, hypertension, abnormal liver enzymes and abnormal glucose tolerance are more frequent in overweight children (90). Weight gain may be an accelerating factor for the onset of type 2 diabetes and contribute to the increased incidence of diabetes in youth seen in some populations (91). One longitudinal study found being overweight in childhood correlated with a higher likelihood of obesity as an adult. For example, in children 3 to 6 years old, only 12% of those with BMI-for-age less than the 85th percentile were obese at age 25, while 36% of those with a BMI-for-age greater than the 85th percentile and 52% of those with a BMI-for-age greater than the 95th percentile were obese at age 25 (92). Overweight children also commonly suffer from psychosocial consequences of obesity such as exclusion, teasing, and discrimination (90).

2.13.3 Prevalence of risk

Obesity is called the most prevalent nutritional disease of children in North America (90). Nationally representative Canadian data for children aged 7-13 years, combined from studies at several time points from 1981 to 1996, indicate an increase in BMI of almost 0.1 kg/m² per year for both sexes at most ages (93). Among 7 year old boys, the prevalence of BMI greater than the 85th percentile increased from 15% in 1981 to 44% in 1996; the prevalence of obesity was 4% in 1981 and 30% in 1996. Among 7 year old girls, the prevalence of BMI greater than the 85th

percentile was 15% in 1981 and 34% in 1996; the proportion greater than the 95th percentile increased from 5% in 1981 to 16% in 1996. In Quebec, among a large sample of inner-city children aged 9-12 years, 35.2% of boys and 33.0% of girls had a BMI >85th percentile and 15.1% of boys and 13.3% of girls had a BMI >95th percentile (94).

In a small sample of Canadian preschoolers in 1996, 15% of children had a BMI between the 75th and 85th percentiles and 18% had a BMI over the 85th percentile (69). Longitudinal data from the United States on the proportion of children 2-5 years old with a BMI over the 95th percentile indicates rates of obesity increased two fold between 1971 and 2000 (table 2).

Table 2.7. Prevalence of overweight among American preschoolers 1971 – 2000.

	NHANES I (1971-1974)	NHANES II (1976-1980)	NHANES III (1988-1994)	NHANES 1999-2000
	% (SE)	% (SE)	% (SE)	% (SE)
Total	5.0% (0.6)	5.0% (0.6)	7.2% (0.7)	10.4% (1.7)

From: Ogden C, Flegal K, Carroll M, Johnson C, 2002. (95)

2.13.4 Pathway to Risk: Socio-demographic Factors and Overweight

Biologically, overweight and obesity both result from an energy imbalance. This involves consuming more energy than the amount of energy expended through normal metabolism and physical activity. However, food intake and activity levels are influenced by numerous environmental, cultural and social factors. To date, the bulk of evidence supports that lower income women are more likely to be overweight (96). In contrast, American population-based studies of children find a weak and inconsistent relationship between socioeconomic status or parental education level and overweight children (97). Clearer relationships are evident across racial/ethnic groups with the greatest increase in overweight occurring among Hispanic and African-American children compared to Caucasian children (97).

In Canada, data from the 1994 NLSCY indicated that among children aged 7-11 years, the prevalence of overweight increased significantly with decreasing tertiles of income (98). Children from single parent families were also more likely to be overweight. Data from the 1996 NLSCY indicates, in British Columbia, the prevalence of overweight increased from 5.1% in

1981 to 26.6% in 1996 (99) among children 7-13 years of age. Geographically, rates of overweight increase from west to east across provinces with 36% of children 7-13 years old in Newfoundland with a BMI >85th percentile (99). The same study found socio-demographic variables were inversely associated with overweight but the risk of overweight was more strongly associated with province. Odds of overweight were reduced by 3% with an increase of \$10,000 family income, 4% by an increase of 1 year in father's education level and by 11% for each additional sibling.

2.13.5 Pathway to Risk: Food Security and BMI

Recent studies that examined the relationship between household food insufficiency and risk of overweight in children have not provided consistent results. In the American Continuing Survey of Food Intake by Individuals (1994-1996), children of low income families, whether food-sufficient or food-insufficient, had a similar percentage of over and underweight (47). However, when compared with the higher-income food-sufficient households, a greater number of children in the low income food-insufficient households were overweight. A comparison with NHANES III data found a higher prevalence of overweight only among white girls aged 8-16 years from low income, food insufficient households compared to low income, food sufficient households (96). A third study found, among low income households, a greater proportion of children 5-12 years old in food secure households were at-risk of overweight compared to the proportion in food insecure households (40.7% vs. 34.2%) (100). In this study, participation in federal food assistance programs (meal programs and food stamp programs) decreased the likelihood of overweight in girls but not boys.

2.13.6 Pathway to Risk: Mechanisms Relating Food Insecurity, Diet and Overweight

Several theories on the mechanism by which food insecurity may cause obesity have been proposed in the literature and are summarized here (96). The first suggests those in food insecure households consume cheaper foods, which tend to be more processed and either high in fat or carbohydrate, resulting in excess energy consumption. Secondly, some propose food insecure individuals overeat when money and food are available, in preparation for the days when less food is available with overall energy intake exceeding requirements. Thirdly, wide fluctuations

in energy intake may result in the body conserving energy so the individual's weight increases without excess energy consumption.

Some support for the first model, the energy-density theory, comes from economic analysis. Advances in food processing technology have made foods with added sugars and fats the cheapest sources of energy (101). Retail prices for sweets and fats have increased by half as much as those for fruits and vegetables over the past 20 years. Households concerned with the risk of food insecurity or hunger may choose the foods that provide the most energy per dollar spent (102).

2.14 Significance of the Research

This study will assess the prevalence and variation in severity of food insecurity within a Canadian sample thought to be at high risk. It uses a methodology that directly measures a wide variation in household food insecurity, allowing detection of factors influencing food security in addition to household income and other well documented socio-demographic characteristics. The research examines household food insecurity within a framework outlining potential predictor and outcome variables at the individual and household levels. Novel risk factors related to the physical and social environments as well as personal/household attributes are explored for their association with household food insecurity.

This study provides a rare opportunity to assess Canadian preschool children's biochemical nutritional status, particularly serum iron and zinc as well as measured weights and heights. The outcome measures of nutritional status used in this study, iron and zinc nutrition as well as body mass index, are linked to adverse health or learning outcomes for children.

The results of this study will be useful to health professionals and researchers. Should household food insecurity prove to correlate with children's nutritional status, primary health professionals may use the survey to screen for household food insecurity with an awareness of related nutritional issues. Public health authorities may use the tool to measure household food insecurity in a similar population in their jurisdiction, make inferences on the nutritional status of children and take appropriate action such as creating food related programs or policies or advocating for changes to social policies. The food security research agenda is furthered through this initial

application of the survey tool. This research will assist with confirming the survey's suitability for use in Canada as a research tool to assess the variation in food insecurity with segments of the population and as a monitoring tool at the population level.

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Chapter 3 Correlates of Food Insecurity Among Preschoolers: a Cross-Sectional Study

3.1 Methods

3.1.1 Study Design

We conducted a cross-sectional study on a convenience sample of parents of children aged 2-5 years in which factors related to access to food and socio-demographic characteristics were compared between categories of household food security. The data was collected as part of a larger study on children's nutrition conducted in March 2004 (Dr. S. Innis, March 2004, Department of Pediatrics, University of British Columbia, unpublished).

3.1.2 Sampling Criteria, Recruitment and Consent

Parents or primary caregivers were eligible if their children were 2-5 years of age and the family lived in the City of Vancouver and the parent was fluent in English, Cantonese or Mandarin. Parents of children with chronic medical problems or fever within the previous 3 days were excluded.

Informed written consent was obtained for all participants. The consent form was verbally reviewed with participants in English, Cantonese or Mandarin but the form was written only in English. Registration forms were translated into Chinese script by a librarian working in translation and checked by two nutrition students fluent in Chinese for accuracy. Interviews were conducted in English, Cantonese and Mandarin. The investigator gave Chinese-speaking interviewers the survey in advance and discussed the content and intent with them. In addition, they observed a number of English interviews before conducting interviews. Ethics approval for the study protocol was obtained from the University of British Columbia Clinical Research Ethics Review Board, Children's & Women's Health Centre of British Columbia Research Review Committee and the Vancouver School Board.

Data collection clinics occurred in East Vancouver, a multi-cultural area where at least 34% of family incomes fell below the Statistics Canada Low income Cut Off (LICO) in 2001 (1). The neighbourhoods were chosen to increase the probability of recruiting enough children from food

insecure households to allow statistical comparison. Parents were invited to attend 1 of 6 nutrition research clinic days held by the Nutrition Research Program of the BC Research Institute for Children's and Women's Health at 1 of 4 community facilities. Within each of the four areas, parents were recruited from community centres, neighbourhood houses, libraries, daycares, and preschools. Advertisements were posted in English and Chinese on community bulletin boards. Appointments were made with parents recruited in advance but drop-ins were accepted. Parents with appointments were telephoned to confirm or change their appointments if necessary.

The desired sample size of 49 children in each of the food secure and food insecure comparison groups was based on the assumption of a 20% difference (10% vs. 30%) in the proportions of children with a mean serum nutrient level below a cut off, providing an 80% chance of detecting a significant difference at the 0.05 significance level (2 tailed). Data on the preschoolers' nutritional status is presented in the next chapter.

3.1.3 Measurement of Outcome: Food Insecurity

Food insecurity was measured using the 18-item United States Department of Agriculture's Core Food Security Module Questionnaire (CFSM) and analyzed according to the *Guide to Measuring Household Food Security* (2). The recommended wording of the questions, response categories and skip patterns were used. An initial screening question, which does not contribute to the scale score, was omitted from this study protocol. All respondents were asked at least questions 2 through 6. If all responses to this first level of screening were negative, further questions about more severe levels of food insecurity were omitted to reduce respondent burden.

The CFSM scale was developed using a probabilistic log-linear measurement model called the Rasch measurement model to calibrate the questions (2). Rasch modeling produced an interval scale in which the item calibration values represent the position of the item along the scale. The calibration measurements are provided for information in table 3.1. The 18 CFSM items were the best-fitting items from 58 food security questions in the 1998 Food Security Supplement of the U.S. Current Population Survey. Research findings indicated that the module is a uni-dimensional food security scale that demonstrated adequate fit and dispersion of items to assess the spectrum of food insecurity experienced in the United States (3). The scale has demonstrated stability

across various ethnic groups, household types, and geographic regions in the United States (4, 5). The Core Food Security Module has not been calibrated in Canada. This study does not propose to validate the tool in the Canadian context.

The Core Food Security Module does not distinguish among the ways food insecurity might be experienced, for example, chronic or cyclical, or among the strategies households use to cope with their situation (2). Other dimensions of the broad concept of food security not measured include food safety, nutritional quality of diets or sustainable food supplies.

Summing affirmative responses to questionnaire items scores the CFSM. Questions Q2 to Q7 are scored affirmatively if the response is “often” or “sometimes” true and negatively otherwise. Questions Q8a, Q12a and Q14a are follow-up questions and coded affirmatively when the response is “almost every month” or “some months but not every month” and negatively for “only one or two months”. Response categories are yes and no for other questions. All questions a household was not asked because it was screened out are coded as negative responses. For the final score, responses were coded as 0 = negative response and 1 = affirmative response.

The scale allows categorization households into four levels: food secure, food insecure without hunger, food insecure with moderate hunger, and food insecure with severe hunger. According to the *Guide to Measuring Household Food Security*, households may answer up to two questions affirmatively and still fall in the food secure category. Due to the small sample size in this study, anyone answering at least one question affirmatively was considered food insecure. Further, the study objective is to examine correlates of any concern about food supply. Others have suggested the Core Food Security Module criteria are too stringent as households with one affirmative response to the CFSM were more likely to have other indications of food insecurity, such as obtaining supplementary food, compared to those with no affirmative responses (6).

3.1.4 Measurement of Covariates of Interest and Socio-demographic Variables

Covariates were chosen based on a social ecological framework, which suggests household food security is affected by factors influencing access to food within the household and community. Measured factors relate to the physical environment, the social environment and

personal/household attributes (7) and are as follows.

1. Respondents rated their agreement with 3 separate statements on physical access to foods of reasonable price, quality, and variety within their community with the response categories strongly disagree, disagree, neutral (neither agree nor disagree), agree and strongly agree.
2. Personal and household attributes were assessed with 2 questions. Respondents were asked to rate their own cooking skills with the categories: I don't cook, I have basic skills, I have average skills, I am quite skilled and I am extremely skilled. Number of household cooking appliances was assessed as fewer than 2 appliances, 2 full sized appliances, 3-4 appliances, 5-6 appliances, or 7 or more appliances.
3. Social environment was assessed through 2 questions. The first asked the how often the respondent met with parents, friends or people he/she knew with response categories as more than once per week, once per week, at least once per month, about once a year and never. The second question asked the respondent to rate their social life with response categories set as very satisfying, mostly satisfying, somewhat satisfying, and very dissatisfying.

Socio-demographic characteristics collected included years of family residence in Canada, language spoken at home, participation in a program providing supplementary food (such as a food bank) in the past year, age of respondent, single parent status, household income category as a percentage of the Statistics Canada low income cut off (LICO) and respondent education level.

As description of response categories is as follows.

1. Number of years of family residence in Canada was categorized as all the respondent's life, more than 5 years, 1-5 years, and less than one year.
2. Response categories for language spoken at home were English, Cantonese/Mandarin, and other.
3. Participation in a supplementary food program was categorized as any or none.
4. Age of respondent was categorized as 25 years and under or over 25.
5. Before tax household income was categorized as <50%, 50-100%, 100-150% or >150% of the LICO. The LICOs are gross income levels below which households spend 54.7% or more on the basic necessities of food, shelter, and clothing. The LICOs are set for seven categories of household size and five community sizes (based on the population)

(8).

6. Education levels were categorized as less than high school completion, high school graduate, some college or university (including trade school) and college or university graduate.

3.1.5 Statistics

The primary analyses in this research examined the association between factors associated with the physical and social environments as well as personal/household attributes and household food security status and between socio-demographic characteristics of parents and their household food security status. Statistical analyses were performed using SPLUS Version 6.1 (9).

Descriptive statistics were calculated for each socio-demographic variable: age category of the respondent, single parent status, language spoken at home, household income group, and respondent's highest level of education and number of children in the household. Descriptive statistics were calculated for each covariate: assessment of access to food of reasonable price, quality and variety; number of cooking appliances; rating of food preparation skill; frequency of meeting with others and rating of social life. Household food security score was calculated according to the *Guide to Measuring Household Food Security* (2).

Bivariate associations were examined. Chi-square or Fisher's exact statistics were calculated between explanatory variables to assess associations. To examine relationships between each factor of interest and the outcome (household food insecurity), boxplots were prepared using the continuous food security score versus each categorical variable. Secondly, a dichotomous variable was constructed from the continuous food security score scale to differentiate between households reporting any food insecurity (coded as 1) or none (coded as 0). Bivariate associations were examined between the categorical food security variable and each covariate using chi-square or Fisher's exact statistics to assess the potential association. The results of the bivariate analysis are presented in Appendices 3a, 3b, and 3c showing the p value resulting from each statistic.

Univariate logistic regression (10) modeled the association between each categorical variable and the likelihood of household food insecurity with the odds ratio as the measure of this association. Age group, marital status, years of residence in Canada, language spoken at home, participation

in a supplementary food program, household income category, and education level were entered as independent socio-demographic variables. The covariates, related to physical and social environment as well as personal/household attributes, were each entered as independent variables.

Multivariate logistic regression modeled the association between categorical variables and the likelihood of household food insecurity with the odds ratio as the measure of this association. Variables were entered into the model based on the significance of chi-square tests between each variable and the dichotomous food security variable as well as the significance of univariate regression coefficients. To ensure precision of regression coefficients the literature recommends no more than 10 events per variable, which amounts to 7 variables in this study (10). Addition of more than 2 variables changed the regression coefficient for food insecurity by more than 10%, an indication that other variables were influential (10). However, in this sample the socio-demographic variables were correlated in many cases (see tables 3.9, 3.10 and 3.11 in Appendices 3a, 3b, and 3c), which contributed to increased variance and imprecision in the model.

To address this issue two types of models were constructed. In the first type of model, all variables are adjusted for only the most important confounder, income, as adding more than one increased the standard error and inflated confidence intervals excessively, a result of associations among socio-demographic variables. Income was shown in the univariate analysis to be the best predictor of food insecurity and is known from the literature to be the primary determinant of food insecurity. The second type of multivariate model examined how types of study factors may work together to influence household food security status by including all the socio-demographic variables in each model and selected covariates. Despite wide confidence intervals, the utility of variables can be examined. The components of each model were as follows:

Model 1 - socio-demographic variables

Model 2 – model 1 plus 3 environmental variables related to food access

Model 3 – model 1 plus the personal and household attribute variable related to self-rated food preparation skill and number of household cooking appliances

Model 4 – model 1 plus social environment variables related to social inclusion

Model 5 – model 1 plus all covariates (physical and social environments as well as personal attributes). This model is not reported as it did not produce a stable model.

3.2 Results

3.2.1 Description of Covariates and Socio-demographic Characteristics

A total of 151 parents enrolled in the study and nine subsequently withdrew. Reasons for withdrawing included insufficient time to complete the clinic surveys and reversing the decision to allow a blood draw on the parent's preschool child, a component of the clinic. Therefore, the final sample included 142 households. Seventy-nine parents registered for the study did not show up to the clinic and 39 dropped-in and were accepted without pre-registering. Five participants who completed a registration form did not meet study inclusion criteria and were not enrolled. One third of the interviews were conducted in Cantonese or Mandarin and the remainder in English.

After preliminary assessment of the frequency of responses to questions in the access to food section, covariates of interest were recategorized. Responses to the questions on access to food of reasonable price, quality, and variety were grouped as strongly disagree/disagree, neutral, agree, and strongly agree (reference category). Number of cooking appliances was grouped as fewer than 2/2 full size, 3-4, 5-6, or 7 or more (reference category). Rating of cooking skill categories were I don't cook/I have basic skills, I have average skills, I am quite skilled, and I am extremely skilled (reference category). Categories for the number of times the respondent met with parents, friends or people he/she knew were collapsed to more than once per week (reference), once per week, at least once per month, about once a year/never.

Languages spoken at home were categorized as English (reference), Cantonese/Mandarin, or Other, which included 11 languages: Arabic, Vietnamese, Japanese, Spanish, French, Hungarian, Korean, Polish, Burmese, Philipino, and Bengali.

Approximately one quarter of the participants had lived in Canada for less than 5 years (Table 3.2). Two-thirds of the families were living at or below the Statistics Canada low income cut off and a similar number spoke languages other than English at home. Only 16 (11.3%) of parents were under age 25 and one quarter were single parent families. Education level was rated as less than high school completion by 27 (13.4%), high school graduate by 32 (22.7%), some college or university 28 (19.9%) and college or university graduate by 54 or 38.3% of parents.

3.2.2 Description of Food Security Status

Seventy-one households (50%) answered at least one question affirmatively and were considered food insecure. Table 3.3 shows the total number out of 18 questions respondents indicated applied to their household, which is used to categorize households into levels of food security and assign a value on an interval scale between 0 and 10. For comparison, the official classification of households according to the *Guide to Measuring Household Food Security* is provided (table 3.4) and indicates that 66% of households would be considered food secure, rather than 50% according to the classification used for this study. The effect of each method of categorization on the results was analyzed in a multivariate analysis (not shown). Standard errors and confidence intervals were smaller by classifying only those households with a score of 0 as food secure.

Among this sample, 71 (50%) of households were categorized as food secure and 71 (50%) were experiencing various degrees of food insecurity. In the sample, 23 (16.2%) agreed with 1-2 questions, 30 (21.0%) confirmed 3-7 items and scored 2.4-4.3 out of 10 on the scale, 17 (11.9%) agreed with 8-12 questions, scoring 4.7-6.3 out of 10 on the scale and 1 (0.7%) agreed with 13 questions and scored 6.6 on the scale. None of the households in the sample scored above 6.6 out of 10.

3.2.3 Indications of Severity of Food Insecurity

Table 3.5 indicates the number of respondents who indicated a survey item applied to their household. The items in the table are ordered from lowest to highest severity calibration of questionnaire items described earlier. The frequency of response generally follows the order predicted by the Rasch model. Three quarters of food insecure households answered they sometimes or often worried their food would run out before getting money to buy more. Thirty four (47.9%) of parents said they could not afford to feed children balanced meals and 24 (33.8%) of parents felt children were not eating enough, an item calibrated as indicating a more severe level of food insecurity in the model. Two other items indicating child hunger were each agreed to by 6 (8.5%) of respondents: *children hungry but could not afford more food* and *children skipped meals in 3 or more months* of the past year. One family reported a child who had gone hungry for at least one day in the past year because of a lack of money for food.

3.2.4 Relationship between Food Insecurity and Socio-demographic

Characteristics

In a univariate logistic regression analysis, respondents more likely to report household food insecurity included parents under age 25 OR 3.4 (95% CI: 1.04, 11.1) and single parents OR 4.0 (95%CI: 1.7, 9.3) (Table 3.6). Those speaking languages other than English or Cantonese/Mandarin at home were more likely to report food insecurity compared to English speaking families OR 5.3 (95% CI:1.8, 15.2). The odds of Chinese speaking parents reporting food insecurity was 0.5 (95% CI: 0.3, 1.1) compared to English speaking families but not statistically significant. A household income lower than the Statistics Canada low income cut off strongly predicted food insecurity and this was statistically significant. Risk increased across decreasing income categories compared to those households with incomes greater than 150% of the LICO: for households with an income 100-150% of the LICO odds of food insecurity were 1.7 times higher (95%CI: 0.3, 8.5), for households with an income 50-100% of the LICO odds were 7.7 times higher (95%CI: 2.1, 28.7) and at incomes less than 50% of the LICO, odds were 27.3 times higher (95% CI: 7.1, 105.3). Households in which the responding parent had less than a completed college or university education were at higher risk for food insecurity. Compared with families in which the respondent was a college or university graduate, food insecurity was 6.7 times (95% CI: 2.4, 18.3) more likely among households in which the respondent had an incomplete college or university education, 4.6 times (95% CI: 1.8, 11.8) more likely among those with a respondent who graduated from high school, and 7.5 times (95% CI: 2.7, 21.1) more likely among households with a respondent who did not complete high school. Newcomers to Canada may be at increasing risk of food insecurity the more recently they arrived; however, none of the confidence intervals for categories of length of residence excluded one. Users of supplementary food programs such as breakfast programs or food banks were 2.1 times more likely to report food insecurity (95%CI: 1.05, 4.3).

3.2.4 Relationship Between Food Insecurity and Factors Related to the Physical and Social Environments as well as Personal Attributes.

A greater number of respondents in the food secure group agreed or strongly agreed that the food where they shop was reasonably priced compared to those in the food insecure group, 58 (82.9%) and 46 (65.7%) of parents, respectively (table 3.7). Fifteen (22.1%) food insecure householders

were neutral, disagreed, or strongly disagreed that the quality of the food available to them was reasonable, twice as many as in the food secure group, which included 7 (10.1%) of respondents. Ratings of access to a variety of food were similar with 86% of food insecure and 89% of food secure respondents rating variety as reasonable. Twice as many food secure households had 7 or more cooking appliances (38% vs. 19.7%). Three times as many food insecure households contained only 3-4 appliances (39.4% vs. 12.7%) compared to food secure households. There was variability in the self-rated food preparation skill levels between the two groups with 6 (8.5%) of food secure householders rating themselves with basic skills or as doing no cooking compared to 21 (29.6%) of food insecure householders. The ratings regarding social inclusion were significantly different between comparison groups. Among food secure householders, 54 (76.1%) met with friends at least weekly compared to 39 (54.9%) of food insecure respondents. Twelve (16.9%) food insecure householders indicated they met with friends and family once per year or less compared to similar responses from 3 (4.2%) from food secure householders. The majority of parents in food secure households rated their social lives as very satisfying or satisfying 62 (88.6%) while only 41 (57.8%) of food insecure householders gave similar ratings. Thirty (42.3%) of food insecure householders were somewhat or very dissatisfied with their social lives.

The results of logistic regression analysis, with and without adjustment for income, on the factors affecting access to food indicate a significantly higher likelihood of food insecurity among those who did not find their food to be reasonably priced or of reasonable quality (table 3.7). Those with 3-4 cooking appliances were 3.5 times more likely to be categorized as food insecure compared to those with 7 or more appliances (95%CI: 1.1, 11.1). Parents with basic cooking skills were 7.6 times more likely to be in a food insecure household (95% CI: 1.4, 41.8) compared to those rating themselves as extremely skilled at food preparation. Lack of social inclusion was strongly associated with food insecurity. Those meeting once per year or less with friends and family were 7 times more likely to be in food insecure households. Rating social life as somewhat dissatisfying increased the likelihood of household food insecurity (OR 4.0 95%CI: 1.0, 15.6) and a rating of very dissatisfying increased odds by 19.5 times (95%CI: 1.3, 282.2).

3.2.5 Multivariate Analysis

To examine how types of study factors may work together to influence household food security status, a multivariate analysis was performed. A number of models were assessed for their utility in predicting food insecurity. The components of each model were as follows:

Model 1 – all socio-demographic variables

Model 2 – model 1 plus 3 environmental variables related to food access

Model 3 – model 1 plus the personal and household attribute variable related to self-rated food preparation skill and number of household cooking appliances

Model 4 – model 1 plus social environment variables related to social inclusion

Model 5 – model 1 plus all covariates (physical and social environments as well as personal/household attributes).

Socio-demographic characteristics of respondents at greater risk for household food insecurity are noted first, followed by a discussion of the utility of other variables in models 2 through 5 (Table 8). Across models, those who spoke Cantonese or Mandarin at home were 86-100% less likely to indicate food insecurity. Households in which respondents had either an incomplete college/university or high school level education were both at significantly greater risk for food insecurity in all models. Household income below the low income cut off was a statistically significant predictor of food insecurity in all models. Younger parents were at increased risk for food insecurity except in the model with social environment variables added; however, the confidence intervals cross 1 in each case so the inference is not definitive. Single parents and newcomers to Canada were not more likely to be food insecure in any of the models.

Model 2

Of the 3 environmental variables related to food access, perceived lack of access to food of reasonable quality was predictive of household food insecurity. Variables assessing access to food of reasonable price and variety showed no relationship to household food security status.

Model 3

Households with fewer resources available in terms of cooking skill and cooking appliances, food insecurity was more likely compared to households with the greatest resources. Compared to households with 7 or more cooking appliances, those the fewer appliances appeared more likely

to be food insecure. Respondents rating themselves with either average or basic skills at cooking were more likely to be in food insecure households.

Model 4

Parent's rating of their social environment indicated increasing likelihood of food insecurity with decreasing satisfaction with social inclusion.

Model 5

The regression coefficients are not presented as the model was unstable, likely due to associations among variables.

3.3 Discussion

This study provided an initial Canadian trial of a measurement tool that captures a wide variation in the experience of food insecurity. In this sample of predominantly low income inner city households, food insecurity was prevalent and experienced by 50% of the sample group. While food security was strongly related with household income, other factors were predictive of food insecurity.

3.3.1 Main results

3.3.1.1 Indications of Extent of Food Insecurity

Among this sample, half of households were categorized as food secure and half were experiencing various degrees of food insecurity. In the sample, 16.2% were food insecure with anxiety about their food supply, 21.0% were classified as food insecure with few or no hunger indications, 11.9% were classified as moderately food insecure with indications of adult hunger and 0.7% were classified as severely food insecure with higher risk of child hunger.

3.3.1.2 Indications of Severity of Food Insecurity for Children

While the number of children classified as at high risk of hunger was low, parent's concern about the quality and quantity of children's food intakes occurred at less extreme levels of food insecurity. The quality of food consumed may be affected for half of the children in food insecure households as parents indicated they relied on a few kinds of low cost food for children and one third of parents indicated they could not feed children balanced meals. The quantity of food available within the home may be limited for almost 10% of children in food insecure households as parents indicated children were hungry but they could not afford more food or children skipped meals due to a lack of food.

3.3.2 Comparison to the Literature

This is one of the first studies to use the Core Food Security Module in Canada and provides an indication of the variation of severity of food insecurity within an inner city sample. In this country, one study used a modified version of the CFSM to assess food security in the previous 30 days (11). In that sample of mothers receiving emergency food assistance, 35.3% of households were classified as food insecure with moderate hunger (higher risk of adult hunger) and 21.6% as food insecure with severe hunger evident (higher risk of child hunger). The 30-day

scale does not measure the less severe spectrum of food insecurity and focuses on reductions of food intake and related indicators of hunger, providing little information on progressive states of food insecurity. Our findings are consistent with a survey that used the full 18-item CFSM to categorize 124 predominantly Hispanic low income households with children in California, which found 24.4% were food insecure without hunger, 8.9% were food insecure with indications of adult hunger, and 1.6% were food insecure with higher risk of child hunger (12).

Population level surveys of food insecurity in Canada and the United States have typically measured extreme food insecurity (hunger or food insufficiency) using 1-3 questionnaire items designed to indicate the prevalence of these states but not characterize the broader scope of food insecurity with respect to compromises in quality and quantity of food selection. The 1996 - 1997 NPHS measured food insufficiency: a household sometimes or often not having enough food to eat; in addition, it asked about running out of money to buy food. In the 1998-1999 NPHS, food insecurity measurement was broadened with the use of 3 questions indicating worry about not having enough to eat, compromising the variety or quality of food consumed, and not having enough to eat. These 3 questions were repeated in the 2000 Canadian Community Health Survey. The measurement of the impact of food insecurity on children has similarly been limited to the extreme: in the 1994 and 1996 NLSCY studies measured hunger related to lack food in the house or money to buy food. Little data exists on the prevalence of a wider range of food insecure states, the qualitative or quantitative changes that compose these states and their impact on children's food intakes.

Differences in methodology between the prevalence indicator questions used in population-based studies described above and the score-based scale used in this study do not allow direct comparison. However, 12.6% of households surveyed in the Canadian Community Health Survey experienced food insecurity of a severity that placed adults or children at high risk of hunger, and indicates a slightly higher prevalence of severe food insecurity in our sample compared to the population. In comparison, among a representative sample of Vancouver residents aged 12 and over in the CCHS, 9.2% indicated they or someone else in their household often or sometimes did not have enough food to eat because of a lack of money (13).

The prevalence of less extreme levels of food insecurity is far higher in the current sample

compared to the population: 37.5% of the sample indicated anxiety about depleting food supplies before having money to buy more in comparison to 10.4% of Vancouver households (13). While 13.4% of Vancouver residents 12 and over were unable to consume the variety or quality of foods desired due to financial constraints, 23.5% of the current sample indicated their diet was qualitatively unsatisfactory, relying on a few kinds of low cost foods for their children and unbalanced meals.

3.3.3 Socio-demographic characteristics associated with food insecurity

In the univariate analysis, the associations between demographic variables and food insecurity were consistent with earlier research findings. Those households whose respondents were parents under age 25, single parents or whose education level was less than a completed college or university education were more likely to be food insecure.

The primary socio-demographic risk factor for household food insecurity, consistent with the hypothesis and other studies, was household income level. Households with incomes <50% of the Statistics Canada low income cut off were at high risk for food insecurity; however, risk was not limited to the lowest income category but showed a gradient across levels. Households with incomes in the second highest category were still 1.7 times more likely to report food insecurity than those with incomes above 150% of the LICO. The risk was not statistically significant so the inference is not definitive. The study was not designed to provide statistical power to assess this variable.

Users of supplementary food programs were more likely to be food insecure but it was not a powerful predictor. Other studies find that as food insecurity worsens, there is increased utilization of resource augmentation strategies but use of supplementary food programs is a weak indicator of food insecurity (3). This study did not measure the number or type of supplementary food programs used by participants, limiting our ability to compare results on the relationship between the number of supplementary food programs used and severity of food insecurity. Most community programs are universally available without a means test. If there is no stigma attached to use of meal programs, such as breakfast or lunch programs, those who are food secure may use the programs for reasons such as socializing or convenience. For those at risk of food insecurity, use of these programs may provide a resource that prevents households from developing

characteristics of food insecurity, such as anxiety about food supply. Supplementary food programs may also diminish the severity of existing food insecurity.

Newcomers to Canada were not significantly more likely to be food insecure although there was a trend toward increasing food insecurity with fewer years in Canada, with those residing here less than 1 year 1.7 times more likely to be food insecure. However, the strength of the inference is weak as the confidence interval crossed 1 and the wide confidence interval indicates that new immigrants are a heterogeneous group. At the population level, the 1998-1999 NPHS found immigrants who had lived in Canada for less than 10 years were not significantly more likely to be food insecure (14).

Food security scores unexpectedly varied by language group as those who spoke Cantonese or Mandarin were half as likely as those speaking English to be food insecure. In contrast, those speaking other languages were 5.3 times more likely to report food insecurity compared to English speaking homes. Given that 80.6% of Chinese speaking participants had household incomes below the LICO and food insecurity is strongly associated with household income, this result is of note. In contrast, 46.5% of English speaking and 85.7% of those speaking other languages at home had incomes below the LICO.

Larger numbers of household members may explain the finding as 55.7% of Chinese speaking households had 5-9 members. In contrast, 18.6% of English speaking and 9.5% of households primarily speaking other languages were large. Of Chinese speaking households, 38.7% had 3 – 5 adults while only 16.9% of English speaking and 9.5% of other households had 3 – 5 adults present. Having a greater proportion of adults in Chinese speaking households may reduce perceived risk for food insecurity, perhaps due to more varied sources of income. Culturally, food may be a higher priority with a family choosing to forgo other items than food. If mothers in this group have greater skill at food preparation due to learning that occurred in their family of origin, they may be more resourceful at preparing meals from inexpensive ingredients. However, in the sample 19% of parents in Chinese speaking households rated their skill level as basic compared to 15% and 29% of those speaking English and other languages at home. The proximity of inexpensive China town grocery markets may also have contributed to a lower risk of food insecurity. The possibility of culture or geographic location as influential factors is indicated as

6.6% of Chinese speaking, 16.9% English speaking and 28.6% of other respondents reported a lack of access to reasonably priced food.

Related to internal validity of the study, social desirability bias, related to a cultural desire to present a positive image of the family, may have affected responses. Secondly, most of the respondents from Chinese speaking households did not speak any English and were interviewed by members of their own community, perhaps promoting a desire for a positive image. Lastly, some parents may have feared consequences to their families if an inability to provide for their children was detected, despite assurances of confidentiality.

3.3.4 Exposures of Interest

Variables were chosen using the social ecological model as a rubric. The framework suggests household food security is affected by factors in the physical environment (geography, agriculture, and technology), the social environment (culture, economics, politics) and by personal attributes (physical, psychological and behavioural). This section assesses whether measures of these factors varied in relation to the food security measure in a manner consistent with the theoretically derived hypotheses after adjustment for household income.

The first hypothesis, related to the physical environment, said that respondents who rated themselves as having inadequate community access to a variety of quality food at reasonable prices would be at greater risk of household food insecurity. The results indicate a significantly higher odds of food insecurity among respondents who did not find the food where they shop to be reasonably priced or of reasonable quality. Ratings of access to a variety of food were similar and high in both groups. These results suggest there are barriers preventing some respondents from shopping at a store with better prices and food quality. The nature of possible barriers was not assessed in this study but based on the literature, may involve community characteristics. For example, inner city areas often lack large grocery stores, instead zoning promotes the location of convenience stores and fast food outlets. Public transportation to reach large suburban supermarkets may be unavailable or unfeasible for a parent with several children who cannot be left at home while the parent shops. Without a car, these parents with low income may be unable to shop around for quality food at reasonable prices. Further research on the physical environment could involve mapping both food insecurity and food outlets by postal code to look for

geographical patterns.

These results are consistent with data from the United States indicating produce may cost as much as 22% more in a low income neighbourhood area compared with a higher-income area and is often of lower quality (15). Canadians, asked about particular problems related to food acquisition on the 1998-1999 NPHS, indicated that barriers included lack of money for transport, lack of transportation and that stores were too far away (14).

The second type of proximal risk factor, personal/household attributes, was first tested with the hypothesis that those respondents from food insecure households would rate their skill at food preparation for children lower compared to those from food secure households. After adjustment for household income, parents who rated their cooking skills as basic were significantly more likely to be in a food insecure household compared to those rating themselves as extremely skilled at food preparation. Food preparation skills and methods are typically learned within the family and transmitted through generations as other opportunities to gain these skills are limited, for Canadian children, to a home economics class (16).

Through qualitative research with low income women there are indications some welcome and benefit from opportunities to develop skills through community cooking programs while others have no perceived need for new skills (17). The food security status of the low income women in this study is not known. Opportunities for women to gain the skills they want in order to feel competent at preparing nutritious food for children may contribute to increased household food security.

The second risk factor related to personal/household attributes was tested with the hypothesis that a home kitchen with fewer than 3 cooking appliances was associated with greater risk of food insecurity. After controlling for income, households with 3-4 cooking appliances were 3.5 times more likely to be categorized as food insecure compared to those with 7 or more appliances. Having 2 or fewer appliances was not predictive of food insecurity as only 3 participants were included in this category and none perceived food security indicators as a concern, perhaps due to their skill and resourcefulness with food. In general, appliances are required for safe food storage, to allow bulk food purchasing, cooking from less expensive unprocessed ingredients, and for

time-efficient food preparation. The number of cooking appliances in a household is also an indication of quality of housing.

A risk factor related to the social environment at the individual level was tested with the hypothesis that limited social networks or isolation would be associated with greater risk of food insecurity. In this study, respondents who felt socially isolated were significantly more likely to report household food insecurity. It is not possible in this cross-sectional study to determine whether social isolation precedes food insecurity, in which case those with a more limited social network to call upon for supplemental money, housing or food in times of need are more likely to become food insecure. Alternatively, the isolated and excluded feelings are triggered by food insecurity and the associated inability to participate in the social aspects of life, which frequently revolve around food either in entertaining or in eating out (18).

Multivariate Analysis

To assess whether variables influenced household food security in a manner consistent with the theoretically derived hypotheses when grouped into categories related to the physical and social environments or personal/household attributes, four models were created. The socio-demographic variables were forced into all the models as they are not modifiable.

When only the socio-demographic variables were considered, language spoken at home, education and income remained predictive of food insecurity. In contrast to the univariate analysis, single parents were not more likely to be food insecure in the adjusted model. Younger parents were at increased risk for food insecurity except in the model with social environment variables added, however; the confidence intervals cross 1 in each case so the inference is not definitive. As in the univariate analysis, years of residence in Canada remained a poor predictor of food insecurity.

After adding the variables related to the physical environment to the socio-demographic characteristics, perceived access to quality food remained predictive of food insecurity. Both variables related to personal and household attributes were predictive of food insecurity. The variables related to social environment were both correlated to food insecurity.

Although a strong relationship exists between low income and food insecurity, in this study poverty was not a perfectly sensitive or specific predictor as not all low income households were food insecure and very few experienced hunger while some households above an income-based poverty line experienced food insecurity. The results of this study indicate that factors in the social environment (in addition to income), the physical environment, as well as personal and household attributes mediate the experience of household food insecurity. In other words, if a causal relationship exists, low household income is a component cause but not a sufficient cause for food insecurity. The results suggest a complex causal web for food insecurity. Ecological models define health as a product of the interdependence between the individual and subsystems of the ecosystem, which include the individual, family, community, culture, physical and social environments (15, 19). Because the issue of food touches all these domains, the framework would be useful in guiding further research and planning intervention.

3.3.6 Assessment of the Outcome Measurement Survey Tool

While the purpose of this study was not to validate the Core Food Security Module, some discussion of the outcome measurement tool is useful as it determines the degree of confidence that can be placed on inferences made about participants based on their scores on the scale (20). This section discusses content and criterion validity of the tool and these factors in relation to the outcomes.

3.4.6.1 Content validity

Content validity relates the comprehensiveness of the measurement tool and whether it includes items which represent the all important aspects of the phenomenon of household food insecurity. The sub-domains covered by the CFSM include the psychological impact on the responsible adult: anxiety over insufficient food (1 question), qualitative changes in food consumed (3 questions), and quantitative changes in food intake by adults (7 questions) and by children (8 questions). These questions cover only some of the dimensions indicated in original qualitative research which indicated food insecurity consists of depletion of household food supplies, eating unsuitable food, worrying about the food supply, and acquiring food in socially unacceptable ways (21).

Results of this study confirm food security as a phenomenon with sequential effects. The

psychological impact subdomain was the most prevalent aspect of food insecurity as 74.6% of respondents in food insecure households indicated anxiety over running out of food before they got money to buy more. Next, changes in qualitative aspects of food were indicated by two thirds of food insecure respondents: food did not last, they relied on a few kinds of low cost food for children and felt unable to afford to eat balanced meals.

These content subdomains would not be reflected in prevalence rates with the current recommendation of a minimum of 3 affirmative answers required to qualify as food insecure on the CFSM. A recent validation study found CFSM respondents with only one affirmative response indicating worry about food supplies, exhibited other behaviours consistent with food insecurity such as decreased vegetable intake and greater reliance on low cost foods or free supplementary foods (22). In this study, 8.1% of respondents would be misclassified as food secure under the current recommendations.

Under representation of the severity of food insecurity may occur across the scale, because the scale score is based on the total number of affirmative responses, not the pattern of responses to individual questions. For example, households can be classified as food insecure with risk of adult hunger, when, in fact, child hunger was reported in response to a specific question. This occurred in at least 8.5 % of cases.

A missing subdomain in the CFSM, which was important in the qualitative work done to develop the tool are the social aspects of food such as the use of free food assistance, ability to join others for food away from home in restaurants or to have others over for meals. In the current study, use of free supplementary food programs was predictive of food insecurity but there was only a 15% difference in the proportions of participants using these programs. This cross sectional study is not able to detect if the supplementary food programs protected some families from food insecurity.

In this study, households that spoke either Cantonese or Mandarin at home were half as likely to be food insecure as those speaking English at home. The CFSM has been tested in Hawaii where at least 50% of the population is of Asian or Pacific Islander descent and items had a goodness-of-fit similar to that for the American population (5). Review of the CFSM items for both literal

meaning and cultural significance of the items would be useful to help clarify the reason why, given no difference in prevalence of low income, the rates of food insecurity differ by language group.

The CFSM items have not been validated in the general Canadian population, who may, as a group, have different meanings for terms such as “balanced meals” or “not eating enough” compared to Americans. Clarification of terminology is needed as, among a small sample of Hawaiians asked for their interpretations of what a “balanced meal” meant, a number of interpretations emerged ranging from meals with 4, 3 or 2 food groups while 30% gave answers that indicated a limited understanding of the term as intended (5). New immigrants or those whose expectations of meals have changed because of food insecurity may have different connotations of the term. Future work in Canada using the CFSM should include an analysis of item response pattern to assess food insecurity as a managed process in this country.

3.4.6.2 *Criterion validity*

Criterion validity refers to the correlation of a scale with another measure of the subject under study, ideally, a gold standard. There is no clear gold standard for the measurement of food insecurity and the selection, scoring, and categorization of survey items are all arbitrary. Indications of criterion validity come from comparison of the CFSM to other measures of food security. The questions in the following measurement tools were used as the basis for the CFSM and the content overlaps considerably: the Face Valid Food Security Measure, Radimer/Cornell Measure and Community Child Hunger Identification Project (6). Work conducted in Hawaii found the CFSM classified 6.7% fewer subjects as food insecure compared to the 3 other measures which agreed with each other (6). At the higher end of the scale, the CFSM classified half as many in the most severe classification compared to other measures. However, on other measures the classification of food insecurity begins with an affirmative response to one question. Comparing the classification of participants to a criterion measure of food insecurity derived from assessments of household income, food stores, food sources, expenditures and intake, and use of charitable food sources; these 3 other instruments previously used were found to correctly classify 63-71% of the truly food secure and 84-89% of the truly food insecure households (23). In the CFSM, the cut off of 3 affirmative answers probably decreases the sensitivity (correct identification of those actually food insecure) but increases specificity. Food insecurity, in its

current conceptualization, would be underreported. This study did not follow the recommended classification at the lower end of the scale and classified those responding yes to one question as food insecure, resulting in a sensitivity and specificity closer to those of previously developed measurement tools. However, misclassification of households with higher levels of food insecurity likely occurred.

3.3.7 Other Limitations

The conclusions drawn from this study must be considered in light of potential bias. These systematic deviations include information and selection bias as well as confounding. Other limitations of the study are also discussed.

3.3.7.1 Selection bias

A number of parents registered for the study, did not show up for their appointment and were lost to inclusion in the study. We did not follow up with this group and there may have been differences between participants and non-participants with respect to either dependent or independent variables, leading to either an underestimate or overestimate of association. Secondly, the members of this convenience sample were recruited in 4 specific inner city communities and may have differed systematically from the population in those communities and in Vancouver; therefore, study results are not representative of the population. Thirdly, there was a bias toward the English, Mandarin and Cantonese speaking communities. Those not speaking one of these languages were not enrolled into the study. Since there may be high-risk groups in the non-English/Chinese speaking population, low participation of these groups would lead to an underestimate of the association.

3.3.7.2 Information bias

The stigma associated with food insecurity may lead to underreporting of the severity of experience by some respondents. This is a particular concern with respect to questions about hunger and food deprivation among children. Secondly, despite careful selection and training, the 3 interviewers may have interacted differently with participants, leading to systematically different levels of rapport and disclosure by participants.

3.3.7.3 Confounding

In the data analysis, there was limited ability to adjust for the 7 socio-demographic and 7

covariates due to the small numbers of subjects in this study. Associations among the socio-demographic variables reduced the stability of some coefficients and increased the standard error in multivariate models, resulting in large confidence intervals. As a result, models were adjusted for only household income, as it is known from the literature to be the primary determinant of food insecurity. Otherwise, in table 3.8 all socio-demographic variables were used in order to assess the effects of all variables on the others.

3.3.7.4 Other Limitations

Limited numbers of dependent variables were assessed in this study and others may be more predictive. The social ecological model may be useful in deriving additional variables. The ability to detect a deviation from the null hypothesis may be limited for some variables or combinations of variables due to the small numbers of participants in each response category for dependent variables.

Finally, the cross-sectional nature of this study makes it impossible to draw causal inferences. While it is logical to think the risk factors related to the physical or social environments or to personal attributes precede food insecurity, the reverse may be true.

3.4 Summary

This study assessed the prevalence and variation in severity of food insecurity within a Canadian sample thought to be at high risk. It used a methodology that directly measured a wide variation in household food insecurity, allowing detection of factors influencing food security in addition to household income and other well-documented socio-demographic characteristics. The research examined household food insecurity within a framework outlining potential predictor variables at the individual and household levels. Novel risk factors related to the physical and social environments as well as personal/household attributes were explored for their association with household food insecurity. Since food insecurity is a multidimensional construct and its conceptualization is evolving, the cross-sectional differences between subjects found in this study support and extend its dimensions.

Further research is indicated to explore the construct using the social ecological model as a guiding framework. The physical environment particularly merits further investigation to assess

the relationship between access to quality food and food insecurity. Mapping food insecurity by postal code in relationship to fast food outlets, convenience stores and grocery stores would provide further insight.

3.5 *Figures and Tables*

Table 3.1. Item Calibration Values: 1998 US National Benchmark Levels*

Questionnaire Item*: In the last 12 months have you...(item)... because you didn't have enough money for food	Item Calibration
2. Worried food would run out	1.4888
3. Bought food did not last	2.793
5. Relied on a few kinds of low cost food for children	3.268
4. Couldn't afford to eat balanced meals	3.669
6. Couldn't feed child/ren balanced meals	5.040
8. Adult cut size of or skipped meals	5.374
9. Respondent ate less than should	5.534
8a. Adult cut size of or skipped meals (3 or more months)	6.424
7. Felt the child/ren were not eating enough	6.661
10. Respondent hungry but did not eat	7.545
11. Respondent lost weight	8.613
13. Cut the size of children's meals	8.791
12 Adult did not eat for a whole day	9.122
15. Children hungry but couldn't afford more food	9.240
12a. Adult did not eat for a whole day (3 or more months)	9.934
14. Child/ren skipped meal	9.935
14a. Child/ren skipped meals (3 or more months)	10.627
16. Child/ren did not eat for a whole day	11.944

(Source: US Census Bureau data from the Food Security supplement to the August 1998 Current Population Survey in: (2)

*Items are ordered in the table by severity as indicated by the item calibration. The question numbers are the order of administration of the questions.

Table 3.2. Socio-demographic characteristics of a sample of households in East Vancouver, 2004 (n = 142).

	Total	
	Number	Percentage
Responding parent aged 25 or less	16	11.3
Single parent family	35	24.6
Language spoken at home		
English	59	41.5
Cantonese/Mandarin	62	43.7
Other* (11 languages)	21	14.8
Income category		
<50%LICO	52	36.9
50-100% LICO	43	30.4
100-150% LICO	21	14.9
>150% LICO	25	17.7
missing	1	
Education level		
Less than high school	27	13.4
High school graduate	32	22.7
Some college or university	28	19.9
College or university graduate	54	38.3
missing	1	
Years in Canada		
All of life	47	33.3
5 or more years	62	44.0
1 to 5 years	27	19.1
Less than 1 year	5	3.5
missing	1	
Uses supplementary food programs	50	35.2

*Other included 11 languages: Arabic, Vietnamese, Japanese, Spanish, French, Hungarian, Korean, Polish, Burmese, Philipino, and Bengali.

Table 3.3. Total number of affirmative answers, categories of food insecurity, and Core Food Security Module scale values for the sample.

Category¹	Total Affirmative Responses	Scale Value²	Number in Sample	% of Sample
Presumed food secure	0	0.0	71	50
Food insecure with anxiety about food supply	1	1.0	15	10.6
	2	1.8	8	5.6
Food Insecure with few or no hunger indications	3	2.4	11	7.7
	4	3.0	6	4.2
	5	3.4	5	3.5
	6	3.9	5	3.5
	7	4.3	3	2.1
Food Insecure with indicators of adult hunger	8	4.7	3	2.1
	9	5.1	4	2.8
	10	5.5	3	2.1
	11	5.9	4	2.8
	12	6.3	3	2.1
Food Insecure with indicators of child hunger and more severe adult hunger	13	6.6	1	0.7
	14	7.0	0	0
	15	7.4	0	0
	16	8.0	0	0
	17	8.7	0	0
	18	9.3	0	0

¹Categorization of food insecurity

²Scale value (from 0-10) is calculated based on the number of affirmative responses out of 18 questions.

Table 3.4. Households categorized by official Core Food Security Module categories and categories based on all risk factors.

Official CFSM Category ¹	% of sample in CFSM	Study Categories ²	% of Sample
Food Secure	66.2	Food Secure	50
		Food insecure with anxiety about food supply	16.2
Food Insecure Without Hunger	21	Food Insecure with few or no hunger indications	21
Food Insecure With Hunger, Moderate	11.9	Food Insecure with indicators of adult hunger	11.9
Food Insecure With Hunger, Severe	0.7	Food Insecure with indicators of child hunger and more severe adult hunger	0.7

¹Categorical measure of household food security status

according to the Guide to Measuring Household Food Insecurity (2000).

²Categories of food security used in this study.

Table 3.5. Number of affirmative responses to each questionnaire item by food insecure households (n=71).

Questionnaire Item: In the last 12 months have you...(item)... because you didn't have enough money for food	Affirmative Responses (n)	% of Food Insecure
2. Worried food would run out	53	74.6
3. Bought food did not last	44	61.9
5. Relied on a few kinds of low cost food for children	47	66.2
4. Couldn't afford to eat balanced meals	47	66.2
6. Couldn't feed child/ren balanced meals	34	47.9
8. Adult cut size of or skipped meals	18	25.4
9. Respondent ate less than should	20	28.2
8a. Adult cut size of or skipped meals (3 or more months)	13	18.3
7. Felt the child/ren were not eating enough	24	33.8
10. Respondent hungry but did not eat	14	19.7
11. Respondent lost weight	13	18.3
13. Cut the size of children's meals	1	1.4
12 Adult did not eat for a whole day	1	1.4
15. Children hungry but couldn't afford more food	6	8.5
12a. Adult did not eat for a whole day (3 or more months)	3	4.2
14. Child/ren skipped meal	2	2.8
14a. Child/ren skipped meals (3 or more months)	6	8.5
16. Child/ren did not eat for a whole day	1	1.4

Table 3.6. Odds ratios for food insecurity for various socio-demographic characteristics.

Characteristic	Food Secure score=0		Food Insecure score ≥1		Unadjusted OR for Reporting Food Insecurity	95% CI
	Number	Percent	Number	Percent		
Parent respondent age						
Over age 25	67	94.4	59	83.1	1.00	
Under age 25	4	5.6	12	16.9	3.41	1.04 , 11.1
Not a single parent	62	87.3	45	63.4	1.00	
Single Parent	9	12.7	26	36.6	3.98	1.7 , 9.3
Language spoken at home						
English	31	43.7	28	39.4	1.00	
Cantonese/Mandarin	36	50.7	26	36.6	0.54	0.3 , 1.1
Other ¹	4	5.6	17	23.9	5.27	1.8 , 15.2
Income category						
>150% LICO ²	22	31.0	3	4.3	1.00	
100-150% LICO	17	23.9	4	5.7	1.72	0.3 , 8.5
50-100% LICO	21	29.6	22	31.4	7.67	2.1 , 28.7
<50%LICO	11	9.8	41	58.6	27.29	7.1 , 105.3
Education level						
College or university graduate	41	57.7	13	18.6	1.00	
Some college or university	9	12.7	19	27.1	6.66	2.4 , 18.3
High school graduate	13	18.3	19	27.1	4.61	1.8 , 11.8
Less than high school	8	11.3	19	27.1	7.49	2.7 , 21.1
Years in Canada						
All of life	25	35.2	22	31.4	1.00	
5 or more years	32	45.1	30	42.9	1.07	0.5 , 2.3
1 to 5 years	12	16.9	15	21.4	1.42	0.5 , 3.7
Less than 1 year	2	2.8	3	4.3	1.70	0.3 , 11.1
Uses supplementary food programs	19	26.8	31	43.7	2.12	1.05 , 4.3

1. Other languages include Arabic, Vietnamese, Japanese, Spanish, French, Hungarian, Korean, Polish, Burmese, Philipino, and Banagali
2.Low Income Cut Off

Table 3.7. Odds ratios for food insecurity for variables associated with physical and social environments as well as personal/household attributes.

Environments as well as personal/household attributes.						
	Food Secure		Food Insecure			
Variable	Households (n)	%	Households (n)	%	OR* (95% CI)	OR** (95% CI)
Where you shop						
is the food...						
...Reasonably priced?						
Strongly agree	14.0	20.0	7.0	10.0	1.0	1.0
Agree	44.0	62.9	39.0	55.7	1.8 (0.7, 4.8)	1.2 (0.4, 4.0)
Neutral	6.0	8.6	10.0	14.3	3.3 (0.9, 12.9)	1.7 (0.3, 8.6)
Disagree/Strongly Disagree	6.0	8.6	14.0	20.0	4.7 (1.3, 17.3)	3.9 (0.8, 19.2)
...Of reasonable quality?						
Strongly agree	17.0	24.6	5.0	7.4	1.0	1.0
Agree	45.0	65.2	48.0	70.6	3.6 (1.2, 10.6)	2.9 (0.8, 10.3)
Neutral	2.0	2.9	11.0	16.2	6.2 (1.5, 25.5)	1.8 (0.4, 9.3)
Disagree/Strongly Disagree	5.0	7.2	4.0	5.9	6.8 (1.0, 48.7)	9.9 (1.1, 90.0)
Is there a reasonable variety?						
Strongly agree	21.0	30.4	12.0	16.9	1.0	1.0
Agree	41.0	59.4	49.0	69.0	2.1 (0.9, 4.8)	1.5 (0.6, 4.1)
Neutral	2.0	2.9	4.0	5.6	3.5 (0.6, 21.9)	4.9 (0.5, 52.0)
Disagree/Strongly Disagree	5.0	7.2	6.0	8.5	2.1 (0.5, 8.4)	1.5 (0.3, 8.1)
Number of cooking appliances						
7 or more appliances	27.0	38.0	14.0	19.7	1.0	1.0
5-6 appliances	32.0	45.1	29.0	40.8	1.7 (0.8, 4.0)	1.4 (0.6, 3.6)
3-4 appliances	9.0	12.7	28.0	39.4	6.0 (2.2, 16.2)	3.5 (1.1, 11.1)
2 or fewer appliances	3.0	4.2	0.0	0.0	na	
Self-rated food preparation skill						
Extremely skilled	8.0	11.3	6.0	8.5	1.0	1.0
Quite skilled	27.0	38.0	18.0	25.4	0.9 (0.3, 3.0)	1.8 (0.4, 8.0)
Average skills	30.0	42.3	26.0	36.6	1.2 (0.4, 3.8)	1.9 (0.5, 7.8)
Basic skills/don't cook	6.0	8.5	21.0	29.6	4.7 (1.2, 18.8)	7.6 (1.4, 41.8)
Frequency of meeting with others						
More than once per week	34.0	47.9	23.0	32.4	1.0	1.0
Once per week	20.0	28.2	16.0	22.5	1.2 (0.5, 2.8)	1.3 (0.5, 3.7)
At least once per month	14.0	19.7	20.0	28.2	2.1 (0.9, 5.0)	1.5 (0.5, 4.0)
About once per year/never	3.0	4.2	12.0	16.9	5.9 (1.5, 23.2)	7.0 (1.3, 36.8)
Rating of social life						
Very satisfying	20.0	28.6	10.0	14.1	1.0	1.0
Mostly satisfying	42.0	60.0	31.0	43.7	1.5 (0.6, 3.6)	0.8 (0.2, 2.3)
Somewhat dissatisfying	7.0	10.0	22.0	31.0	6.3 (2.0, 19.6)	4.0 (1.0, 15.6)
Very dissatisfying	1.0	1.4	8.0	11.3	16.0 (1.9, 137.1)	19.5 (1.3, 282.2)

*Unadjusted odds ratio

** Odds ratio adjusted for income

Table 3.8. Multivariate analysis of risk factors for food insecurity.

Variable	Model 1		Model 2		Model 3		Model 4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Parent respondent age								
Over age 25	1.0		1.0		1.0		1.0	
Under age 25	2.1	0.4 , 10.3	4.2	0.7 , 25.4	3.1	0.4 , 23.7	0.8	0.1 , 5.8
Not a single parent	1.0		1.0		1.0		1.0	
Single Parent	0.6	0.2 , 2.6	0.6	0.1 , 3.0	0.5	0.1 , 2.5	0.5	0.1 , 2.8
Language spoken at home								
English	1.0		1.0		1.0		1.0	
Cantonese/Mandarin	0.1	0.02 , 0.9	0.1	0.01 , 0.9	0.03	0.00 , 0.3	0.1	0.01 , 0.6
Other ¹	3.5	0.5 , 25.4	4.5	0.4 , 49.5	9.3	0.6 , 136.1	4.7	0.3 , 65.5
Income category								
>150% LICO ²	1.0		1.0		1.0		1.0	
100-150% LICO	2.5	0.3 , 18.2	1.7	0.2 , 17.5	1.2	0.1 , 11.6	3.2	0.2 , 61.0
50-100% LICO	11.3	1.8 , 69.8	9.0	1.3 , 65.2	13.1	1.6 , 106.2	32.1	2.1 , 495.4
<50%LICO	62.4	8.2 , 474.3	51.2	5.1 , 514.8	76.3	7.3 , 800.7	228.2	10.5 , 4943.4
Education level								
College or university graduate	1.0		1.0		1.0		1.0	
Some college or university	4.9	1.3 , 18.8	11.5	1.8 , 73.7	8.8	1.8 , 44.2	14.9	2.5 , 88.5
High school graduate	2.4	0.7 , 8.8	1.9	0.5 , 8.1	2.2	0.4 , 11.0	6.3	1.1 , 37.4
Less than high school	10.4	2.3 , 47.8	13.0	2.2 , 75.8	11.2	1.8 , 68.0	49.5	6.9 , 354.4
Years in Canada								
All of life	1.0		1.0		1.0		1.0	
5 or more years	1.5	0.3 , 8.6	1.2	0.1 , 9.8	2.7	0.4 , 18.7	1.5	0.2 , 13.2
1 to 5 years	1.2	0.1 , 9.7	1.0	0.1 , 13.8	1.5	0.1 , 17.1	0.4	0.03 , 6.3
Less than 1 year	0.4	0.02 , 6.0	0.7	0.03 , 18.3	0.4	0.01 , 18.2	0.2	0.00 , 8.7

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Chapter 4 Preschool Children's Nutritional Status and Household Food Security: a Cross-Sectional Study

4.1 Methods

4.1.1 Study design

We conducted a cross-sectional study in March, 2004 on a convenience sample of children aged 2-5 years in which their nutritional status, primarily indicators of iron and zinc nutrition, as well as body mass index, were compared among categories of household food security.

4.1.2 Sampling, recruitment and consent

Eligible children were 2-5 years of age, lived in the City of Vancouver, and the primary caregiver was fluent in English, Cantonese or Mandarin. Children with chronic medical problems or fever within the previous 3 days were excluded. The initial intention to exclude children taking vitamin-mineral supplements or not consuming meat, fish or poultry would have reduced recruitment to an unfeasible level and was not implemented. Instead, the presence of these potential confounders was documented. Only one child per family was eligible for inclusion in the study. If a parent requested that more than one child have a blood sample analyzed, the included subject alternated between the older and younger child.

Informed written consent was obtained for all participants. The consent form was verbally reviewed with participants in English, Cantonese or Mandarin but the form was written only in English. Registration forms were translated into Chinese script and checked by 2 other study staff for accuracy. Interviews were conducted in English, Cantonese and Mandarin. The investigator gave Chinese speaking interviewers survey in advance and discussed the content and intent them. They also observed a number of English interviews before conducting interviews in other languages. Ethics approval for the study protocol was obtained from the University of British Columbia Clinical Research Ethics Review Board, Children's & Women's Health Centre of British Columbia Research Review Committee and the Vancouver School Board. For children identified with possible iron deficiency anemia or other pathology, parents and family physicians (if the parent authorized) were contacted and arrangements made for retesting and treatment with iron supplements and multivitamin supplements, if appropriate. Parents indicating food insecurity

were informed of food programs such as food banks, good food box programs, and community kitchens.

Data collection clinics occurred in East Vancouver, a multi-cultural area where at least 30% of family incomes fell below the Statistics Canada low income cut off in 2001 (1). The neighbourhoods were chosen to increase the probability of recruiting enough children from food insecure households to allow statistical comparison. Parents were invited to attend 1 of 6 nutrition research clinic days held by the Nutrition Research Program of the BC Research Institute for Children's and Women's Health at 1 of 4 community facilities. Within each of the 4 areas, parents were recruited from community centres, neighbourhood houses, libraries, daycares, and preschools. Advertisements were posted in English and Chinese on community bulletin boards. Appointments were made with parents recruited in advance but drop-ins were accepted. Parents with appointments were telephoned to confirm or change their appointments if necessary.

The desired sample size of 49 children in each of the food secure and food insecure comparison groups was based on the assumption of a 20% difference (10% vs. 30%) in the proportions of children with a mean serum nutrient level below a cut off of 12 µg/L serum ferritin, providing an 80% chance of detecting a significant difference at the 0.05 significance level (2 tailed).

4.1.3 Protocol

4.1.3.1 Determination of blood iron and zinc indicators

From each subject, 3.2 mL of blood were drawn into a polypropylene syringe (Sarstedt S-Monovette Neutral, 4.5 mL: Newton, NC) using a butterfly needle (Sarstedt Multifly, 23G) by a pediatric phlebotomist from B.C. Children's Hospital. One mL whole blood was aliquoted to an EDTA VacutainerTM (Becton Dickinson: Franklin Lakes, NJ) for complete blood count hematology and zinc erythrocyte protoporphyrin analysis.

One mL blood was transferred to a serum trace metal VacutainerTM, where it was left at room temperature for 30 minutes to clot. An aliquot (200 µL) was transferred from the heparin VacutainerTM to an acid-washed plastic tube and stored at 4°C until analysis for whole blood metals. The clotted blood was stored on ice for several hours followed by isolation of serum, which was frozen until analysis for ferritin level. The remaining 1.2 mL blood was transferred to

a heparin VacutainerTM for other analyses.

Processing was completed with the use of powder-free gloves, deionized water-rinsed plastic pippets, and acid rinsed tubes to minimize contamination of samples. The laboratory at BC Children's Hospital investigated the potential for contamination from the collection apparatus by passing 2 mL of 0.1% nitric acid through collection tubes, regular double-tip needles and butterfly needles and analyzing the washings.

Commercial assay systems were used to measure ferritin (Dade Behring BN II: Deerfield, IL), transferrin saturation (Ortho-Clinical Diagnostics Vitros 950: Rochester, NY), hematology indices, including hemoglobin (Sysmex SE-9000: Mundelein, IL) and zinc protoporphyrin (Helena Laboratories: Beaumont, TX). Serum zinc was analyzed by an inductively coupled plasma mass spectrometer (Perkin Elmer ELAN 6100DRC: Boston, MA). Samples (90 µL) were diluted with an alkaline detergent solution (4.5 mL; 10 mmol/L ammonium hydroxide, 1000 µg/L gold, 0.2 mmol/L EDTA, 0.02% Triton X-100) and analyzed by standard addition of serum using gallium, rhodium and iridium as internal standards. Quality control samples (SERO AS: Billingstad, Norway; Centre de Toxicologie: Quebec, Canada) were analyzed with every run.

4.1.4 Covariates

4.1.4.1 Measurement of Socio-demographic Characteristics

Socio-demographic characteristics collected included years of family residence in Canada, language spoken at home, participation in a program providing supplementary food (such as a food bank) in the past year, age of respondent (25 years and under or over 25), single parent status, household income category as a percentage of the Statistics Canada low income cut off (LICO) and respondent education level. Number of years of family residence in Canada was categorized as all the respondent's life, more than 5 years, 1-5 years, and less than one year. Before tax household income was categorized as <50%, 50-100%, 100-150% or >150% of the LICO. The LICOs are gross income levels below which households spend 54.7% or more on the necessities of food, shelter, and clothing. The LICOs are set for seven categories of household size and five community sizes (based on the population) (2). Education levels were categorized as less than high school completion, high school graduate, some college or university (including trade school) and college or university graduate.

4.1.4.2 Measurement of Covariate of Interest: Food Security

Food insecurity was measured using the 18-item US Department of Agriculture's Food Security Core-Module Questionnaire and scored according to the *Guide to Measuring Household Food Security* (3). The recommended wording of the questions, response categories and skip patterns were used.

The household food insecurity construct measured focuses on inadequate food related to household financial limitations. The module asks about household conditions and behaviours in relation to access to food including:

- Anxiety over the possibility of insufficient food
- Experiencing running out of food, without money to obtain more
- Perception of household members consuming an inadequate quality or quantity of food
- Strategies of coping with food shortage, such as buying less varied and cheaper foods than usual
- Reduced food intake, hunger or weight loss by adults in the household and
- Reduced food intake or hunger among children in the household.

For this study, a household was categorized as food insecure if at least 1 question on the survey was answered affirmatively as the study objective is to examine the effects of concern about household food shortage or hunger on the nutritional status of children. Where the food security score is used, it is the scale score from 0 to 10 based on the number of "yes" responses to the 18-item survey.

4.1.4.3 Measurement of Outcome: Blood Iron and Zinc Indicators

For this study, children were considered to have depleted iron (low iron stores) if serum ferritin levels were $<12 \mu\text{g/L}$ (4). Mild iron depletion was defined as serum ferritin levels of $12\text{--}24 \mu\text{g/L}$ (4). These two categories were grouped as at least mild iron depletion for serum ferritin levels $\leq 24 \mu\text{g/L}$. Iron deficiency anemia was defined as hemoglobin of $\leq 110 \text{ g/L}$ and two of three indicators of low iron status: zinc erythrocyte protoporphyrin (ZPP) $>70 \mu\text{mol/mol heme}$, serum transferrin saturation $<7\%$, or serum ferritin $<12 \mu\text{g/L}$ (5, 6). Iron deficiency was defined as serum ferritin $<12 \mu\text{g/L}$ and either zinc erythrocyte protoporphyrin (ZPP) $>70 \mu\text{mol/mol heme}$ or serum

transferrin saturation <7%.

Serum zinc levels were compared to recent guidelines specific to children with a cut off for deficiency set at the 2.5th percentile using data derived from the second National Health and Nutrition Examination Survey (7), adjusted for time of day of blood collection and fasting status (8). For children under 10 years of age, the morning non-fasting cut off was 9.94 µmol/L and the afternoon cut off was 8.72 µmol/L.

4.1.4.4 Measurement of Outcome: Anthropometric Indicators

Taken according to US Centre for Disease Control guidelines, standing height was measured to the nearest eight of an inch with a portable direct reading stadiometer while the subjects were shoeless. Heights were converted to metric units. Body weight was measured to the nearest 0.1 kg with a digital scale while the subjects were wearing light indoor clothing and no shoes. Body mass index (BMI) was calculated as weight (kg)/height² (m). Nutstat, the anthropometry component of Epi Info, (9) was used to calculate percentiles and z-scores for BMI, height and weight-for-age. The gender specific US Centre for Disease Control BMI-for-Age growth charts were used as the comparison population (10). The reference population used to construct the CDC Growth Charts was a representative sample of American children. The composition of this reference sample differs from the sample group as the sample group contained a high proportion of children of Asian ethnicity and no black children. The reference data were obtained from national health examinations and surveys conducted from 1963–1994.

For body mass index, the cutoffs for children aged 2 years and over are <5th percentile (z-score ≤ -1.65) for underweight, 5-85th percentile for healthy weight (z-score -1.64-1.03), 85th –95th percentile for at-risk of overweight (z-score 1.04-1.64), and over the 95th percentile (z-score ≥ 1.65) for overweight. Height-for-age and weight-for-age were categorized similarly.

4.1.4.5 Statistics

The primary analyses in this research examined the associations between body mass index and household food security status and between indicators of iron and zinc nutrition and household food security status. Statistical analyses were performed using SPLUS Version 6.1 (11).

Household food security score was calculated according to the *Guide to Measuring Household Food Security* (3). Descriptive statistics for socio-demographic variables and potential confounders were calculated including: children's age category, sex, vitamin supplement use, consumption of meat, fish and poultry, household income group, number of children in the household and language spoken at home.

4.1.4.5a Hemotological and Serum Nutrient Analysis

Summary statistics were calculated for continuous variables hemoglobin, ZPP, ferritin, transferrin saturation, and zinc. Scatter plots were used to identify outliers. Histograms were plotted for each variable to assess for a normal distribution. The serum zinc data was normally distributed while the serum ferritin data was right skewed.

Bivariate analyses were performed for all variables. For 2 categorical variables, chi-square statistics were calculated to assess the association between determinant and explanatory variables and assess for collinearity between explanatory variables. The p values associated with these statistics are presented in Appendix C. Box plots were used to assess the relationship between each categorical and continuous variable, particularly between the categorized food security variable and continuous serum nutrient levels.

To better understand the sample data, median levels of sample blood variables were compared to NHANES II age-specific median levels, except for serum ferritin, which was compared to NHANES III data.

Median values for hemoglobin, ZPP, serum ferritin, transferrin saturation and serum zinc were compared between food security groups using a Wilcoxon signed-rank test. Spearman rank correlation was used to assess the strength of association between the continuous non-normally distributed household food security score and continuous blood variables.

A dichotomous indicator variable was created for each of hemoglobin, ZPP, serum ferritin, transferrin saturation, and serum zinc according to the established cutoff values to differentiate between those above the cut off (coded as 0) and below the cut off (coded as 1). The prevalence of depletion or deficiency conditions was compared between food security categories using

Fisher's exact test because the expected cell values were less than 5.

4.1.4.5b Secondary Hematological Analyses

Secondary analyses were conducted to analyze the distribution of children with depleted iron stores by income category, language spoken at home, sex and age.

An indicator variable was created to represent at least mild iron depletion (serum ferritin ≤ 24 $\mu\text{g/L}$) (coded as 1) or iron replete (serum ferritin >24 $\mu\text{g/L}$) (coded as 0). Logistic regression (12) modeled the association between income category and the likelihood of at least mild iron depletion with the odds ratio as the measure of this association. These associations were also adjusted for food security status in multivariate models.

4.1.4.6 Anthropometric Analysis

Children's height, weight and body mass index values were transformed into z-scores in order to standardize these values for different ages and sexes. The reference data in the 2000 CDC growth charts was used as the basis for standardization. Histograms were created to assess the distribution of each continuous variable. Boxplots were used to assess the relationship between the continuous food security scale score and BMI categories.

Categories were created for body mass index according to the recommendations of the U.S. Centers for Disease Control (13). The cutoffs for children aged 2 years and over were $<5^{\text{th}}$ percentile (z-score ≤ -1.65) for underweight, 5-85th percentile for healthy weight (z-score -1.64-1.03), 85th -95th percentile for at-risk of overweight (z-score 1.04-1.64), and over the 95th percentile (z-score ≥ 1.65) for overweight. Height-for-age and weight-for-age z-scores were categorized similarly by z-score.

Bivariate analyses were performed for all variables. For 2 categorical variables, chi-square statistics or Fisher's exact tests were calculated to assess the association between determinant and explanatory variables and assess for collinearity between explanatory variables. The p values associated with these statistics are presented in Appendix D.

To compare mean height, weight and body mass index z-scores between children in food secure

and food insecure households, two-sample t-tests were used. Two-sample Wilcoxon signed-rank test compared median body mass index z-scores in each category (underweight, healthy weight, at-risk of overweight and overweight). Spearman rank correlation was used to assess the strength of association between the non-normally distributed continuous household food security score and continuous body mass index z-scores.

Univariate logistic regression modeled the association between household food insecurity and the likelihood of each of underweight, healthy weight, at-risk of overweight/overweight (combined) and overweight category with the odds ratio as the measure of this association.

Multivariate logistic regression modeled the association between household food insecurity and the likelihood of children categorized as underweight, healthy weight, at-risk of overweight/overweight (combined) and overweight with the odds ratio as the measure of this association. For the multivariate analysis, potential confounders were chosen based on the significance of chi-square tests between each variable and the dichotomous body mass index variable, significance of univariate regression coefficients and information from the literature.

4.1.4.7a Secondary analyses

Secondary analyses were conducted to assess the relationship between body mass index and serum ferritin levels using Spearman rank correlation as increasing BMI has been associated with elevated serum ferritin values. The relationship between height and serum zinc was assessed using Spearman rank correlation.

The relationship between serum nutrients and household food security as well as body mass index and food security were modeled with logistic regression using food insecurity as the outcome variable. This allowed an assessment of the association between continuous serum ferritin and body mass index z-score variables versus risk of food insecurity.

4.2 Results

4.2.1 General

A total of 154 children enrolled in the study. Of these children, their parents withdrew 9 and 3 siblings were eliminated from the analysis; therefore, the sample used in this research consisted of 142 parent-child dyads. Parents or primary caregivers completed the food security questionnaires. Blood was drawn from 126 subjects. After completing the survey, 5 children or parents refused the blood sample and the phlebotomist's venipuncture was unsuccessful in drawing blood in 11 cases. In 36 cases, insufficient blood was drawn or aliquoted to provide data on all variables. Anthropometric measures were taken on 138 children (4 children refused). Two children within 2 weeks of their 2nd birthdays were rounded to 2 years of age. One child of 21.7 months was omitted from the analysis of body mass index. One third of the interviews were conducted in Cantonese or Mandarin and the remainder in English. One subject with a ferritin value of 177 µg/L was removed from the analysis of serum ferritin. The subject had a normal hemoglobin value of 122 g/L and a normal zinc protoporphyrin value of 46 µmol/mol, therefore; the elevated serum ferritin value may indicate the child had an infection or other condition affecting serum ferritin.

4.2.2 Level of Food Insecurity

Scoring the Food Security Core Module (3) indicated 71 (50%) of households were food secure; 53 (37%) were concerned about food supply or food insecure without hunger; 17 (12%) were food insecure with moderate hunger, more likely among adults in the household and 1 (0.7%) was food insecure with severe hunger, with higher potential for child hunger. Further data on the food security status of the sample is reported elsewhere. For the chi-square and logistic regression analysis food security status was categorized as food secure (71 households, 50%) and food insecure (71 households, 50%).

4.2.3 Description of the children

Baseline characteristics of the sample and covariates used in analyses are shown in table 4.1. The average age of the children sampled was 46.6 months (SD=12.5) with a range of 21.6 – 74.5 months. Two-thirds of the families were living at or below the Statistics Canada low income cutoff (14). Two-thirds spoke languages other than English at home, primarily Chinese languages

(43.7%) but also Arabic, Vietnamese, Japanese, Spanish, French, Hungarian, Korean, Polish, Burmese, Philippine, and Bengali (14.8%). There were 4 children in the sample who did not consume meat, fish or poultry and 43 (30.3%) who used vitamin-mineral supplements.

Study groups were similar in the proportions of each sex, age group, number of children per household, and number who did not consume meat, fish or poultry (table 4.2). Vitamin-mineral supplement use was slightly more common among children living in food secure homes (36.6% vs. 23.9%, $p = 0.1$). The prevalence of food insecurity varied by language spoken at home with those not speaking either English or Chinese more likely to be food insecure. Half of English-speaking households and about one third of Chinese-speaking households scored as food insecure. Across decreasing income categories the proportion of households scored as food insecure rose: about 1/10 among those with incomes above 150% of the low income cutoff, 1/5 of households with incomes 100-150% of the LICO, 1/2 of those with incomes 50-100% of the LICO and 4/5 of households with incomes less than 50% of the LICO.

4.2.4 Hematological and Serum Nutrient Indicators

4.2.4.1 Overall Results: Iron

None of the 93 children for whom all 4 iron indicators were available had iron deficiency anemia. Six children (5.0%) with low hemoglobin levels had complete data available but did not meet the criteria of having at least 2 other abnormal indicators of iron status. The use of multiple measures to classify iron status limits the potential for false positive results. The sample mean hemoglobin level was 124.8 g/L (SD 9.3 g/L) and median 126.0 g/L.

Among the 110 children for whom serum ferritin values were available, 5 (4.5%) had low iron stores and 46 (41.8%) had at least mild iron depletion (serum ferritin ≤ 24 $\mu\text{g/L}$). Mean ferritin level for all subjects was 33.46 $\mu\text{g/L}$ (SD 22.5 $\mu\text{g/L}$). The distribution was right skewed with a median level of 27.5 $\mu\text{g/L}$.

4.2.4.2 Zinc

Of the 122 children for whom serum zinc levels were available, 6 (5%) were deficient. The mean serum zinc level was 11.97 mmol/L (SD 2.17 mmol/L) and the median was 11.64 mmol/L. The

values were normally distributed.

4.2.5 Comparison to population data

Comparing levels of nutritional indicators found in this convenience sample to National Health and Nutrition Examination Survey (NHANES) data, the only North American population based data available for preschoolers, indicated comparable distributions for hemoglobin, serum transferrin saturation, zinc protoporphyrin and serum zinc (table 4.3). Ferritin values appear to be skewed higher in the study group.

4.2.6 Relationship Between Food Security and Nutritional Status

4.2.6.1 Comparison of continuous values for nutritional indicators

Median levels of hemoglobin, ferritin and serum transferrin did not differ between children in households categorized as food secure vs. food insecure (table 4.4). Zinc protoporphyrin levels were slightly higher in the food insecure group ($p = 0.07$). The measure indicates that the erythrocytes developed at a time when iron supply was suboptimal (15). In iron deficiency, zinc can be incorporated into protoporphyrin, resulting in the formation of zinc protoporphyrin. Median serum zinc levels were lower among children from food insecure households ($p = 0.01$).

Spearman's correlation coefficient indicates the level of agreement between food security scores on a scale from 0 to 10 and continuous nutritional indicator values. This provides a measure of association without loss of information that occurs with categorization of variables. Spearman's correlation showed no significant associations between household food security level and children's nutritional status, although the association between serum zinc and food security level showed a trend toward increasing food insecurity with decreasing serum zinc values ($\rho = -0.13$, $p = 0.15$). Zinc protoporphyrin levels generally increased with increasing food insecurity ($\rho = 0.15$, $p = 0.11$) (table 4.5).

4.2.6.2 Comparison by categorical measures for nutritional indicators

Neither group contained children with iron deficiency anemia (table 4.6). Depleted iron stores were equally likely in children in food secure as food insecure groups (6.9%, and 1.9%, $p = 0.37$). Similarly, proportions of those with mildly depleted iron stores were in equal between food secure and food insecure groups (44.6% and 40.3%, $p = 0.85$). Proportions of zinc deficient children were not significantly different: 6.5% of the food secure group and 3.3% of the food

insecure group ($p = 0.68$). There were no differences in the occurrence of only one indicator of early iron deficiency, elevated zinc protoporphyrin or reduced serum transferrin saturation.

4.2.6.3 Secondary Analyses

4.2.6.3a Other predictors of iron status.

In a secondary analysis, notable differences were found in the distributions of children with at least mildly depleted iron stores across income categories ($p = 0.006$) (table 4.7).

Overall, the proportion of children with at least mild iron depletion was highest among children living in households in the highest income category with 74% of children affected. In the lowest income group, 46% of children were affected.

Analyzing the food security categories separately indicates, within the food secure group, 13 of 17 (76%) children in the highest income group were mildly iron depleted along with 3-5 (about 30%) of children in each of the other 3 income categories ($p = 0.01$) (Table 4.8). Among the food insecure group, the proportions of subjects with low iron stores did not differ significantly across groups ($p = 0.45$). One out of 2 subjects in the each of the two highest and 15/31 in the lowest income category had low iron stores, as did one quarter of the second lowest group.

Differences in proportions of children with at least mild iron depletion were apparent by language category. Iron depletion occurred in 60% of children in English speaking households, 20% of those in Chinese speaking households and 50% of children in households speaking other languages ($p = 0.002$). Among food secure households, 19 of 25 (76%) of children in English speaking homes, 4 (14%) from Chinese speaking homes, and 2 (50%) from homes speaking other languages ($p < 0.0001$) were iron depleted. Among food insecure households, 9 of 22 (41%) children in English speaking homes, 5 (29%) from Chinese speaking homes, and 7 (50%) with other home languages ($p = 0.49$) were iron depleted.

The proportions of children with low iron stores did not vary by sex ($p = 0.51$) but two thirds of children aged 2 years were iron depleted compared to 38%, 25%, and 50% of children aged 3, 4 and 5 years ($p=0.01$).

4.2.6.3b Functional outcome of zinc deficiency.

Stunting, defined as a height-for-age z-score less than the 5th percentile, is a known outcome of zinc deficiency (15). In this sample, among the 117 children for whom both zinc and height-for-age was available, 9 were stunted and 6 zinc deficient. However, none of the stunted children was also zinc deficient ($p=1$). Spearman's rank correlation did not reveal any correspondence between the continuous food security scale score and height-for-age z-score ($\rho=0.02$, $p=0.82$).

4.2.7 Children's Anthropometric Indicators

4.2.7.1 Overall results

4.2.7.1a Body mass index

One third of the children sampled had body mass index values at or above the 85th percentile and were classified as at-risk of overweight or overweight (table 4.9). Overweight children, BMI >95th percentile, composed 21.7% of the sample. The median BMI z-score for boys was 0.47 and for girls 0.30. There was no excess of underweight children, 5.8% had BMI values less than the 5th percentile.

4.2.7.2 Height-for-age

One tenth of the children were stunted while approximately and one tenth had heights above the 95th percentile of the reference population. Low height-for-age (stunting) may indicate past under nutrition or chronic malnutrition. It is associated with a number of long-term factors including chronic insufficient protein and energy intake, frequent infection, sustained inappropriate feeding practices and poverty (15).

4.2.7.3 Weight-for-age

Weight-for-age index identifies children who are under or overweight for their age. Weights were skewed to the upper percentiles in the sample and only 2 (1.4%) were underweight while 23 (16.7%) of weights fell between the 85th and 95th percentiles and 16 (11.6%) fell above the 95th percentile. Underweight reflects both past (chronic) and/or current undernutrition. However, it does not distinguish tall, thin children from short, well-proportioned children (13).

4.2.8 Anthropometric Measures of Children Compared to Reference Population.

Tables 4.9, 4.10, and 4.11 compare the CDC 2000 reference data with z-scores at selected

percentiles for the all sample children and for children in households scored as food secure and food insecure. Body mass index values are skewed upward overall but particularly among children in the food insecure category. The distribution of height-for-age scores is wider for the sample group compared to the reference population. The food insecure group contains both the shortest and tallest children in the sample. The weight-for-age distribution again reinforces the upward shift in weights, particularly among the children in the food insecure category.

4.2.9 Relationship Between Food Security and Anthropometric Status

4.2.9.1 Comparison of continuous values for body mass index and level of household food security

Children in the food insecure category had a significantly higher mean body mass index z-score and weight-for-age z-score compared to the food secure group (table 4.13).

Within the body mass index categories, the median z-scores were significantly different between food secure and food insecure categories for children at healthy weights and at-risk for overweight (table 4.14). The Wilcoxon signed-rank test focuses on the differences in ranks between comparison groups and is the appropriate test within each BMI classification, as the data is not normally distributed.

Spearman's coefficient indicates the correlation between household food security score on a scale of 0 – 10 and anthropometric z-score for each child (table 4.15). This provides a measure of association without the loss of information that occurs with categorization of variables. The test shows a significant association between increasing body mass index z-score and increasing household food insecurity ($\rho = 0.18$, $p = 0.04$). Weight-for-age correlates similarly with food security score at the 0.10 level of significance. No relationship was found between height-for-age and household food security score ($\rho = 0.02$, $p = 0.83$).

4.2.9.2 Multiple Logistic Regression Analysis: Comparison of categories of body mass index and household food security

Logistic regression measured the effect of household food insecurity on the likelihood of

children's BMI indicating underweight, healthy weight, at-risk of overweight/overweight (combined) or overweight (table 4.16). For each BMI category, the association with household food insecurity is also adjusted for household income, language spoken at home, children's sex and age. Children in food insecure households were less likely to be underweight than those in food secure homes, adjusted OR 0.02 (95% CI: 0.0, 1.1). Children living in food insecure households were less likely to be at healthy weights, although the association was not statistically significant OR 0.62 (95%CI: 0.3, 1.5). Children in food insecure households were over twice as likely to have BMI values over the 85th percentile compared to those in food secure households OR 2.6 (95%CI: 1.02, 6.5). Similarly, children in food insecure households had twice the odds of being overweight compared to food secure children, although the association was not definitive as the confidence interval crosses one OR 2.3 (95% CI: 0.8, 6.4).

4.3 Discussion

This is the first study in Canada to examine the relationship between household food security and measures of children's biochemical and anthropometric nutritional status. The results of this study support existing literature on the prevalence of overweight among children and provide data on the association between household food insecurity and nutritional status of children.

4.3.1 Discussion of Overall Results

4.3.1.1 Body Mass Index

This research provided a current sample of measured weights and heights among preschoolers. Overall, the results are consistent with existing evidence of a secular trend toward a higher prevalence of overweight among Canadian children aged 7 – 13 years of age between 1981 and 1996 (19). Of the preschool children sampled, 33.3% had body mass index values at or above the 85th percentile. Overweight children, with a BMI >95th percentile, composed 21.7% of the sample. In comparison to a sample of Canadian preschoolers from low income families in 1996 in which 18% of children had BMI values over the 85th percentile (16), our sample included almost twice the proportion of children at-risk for overweight or overweight. The proportion of overweight in this sample of children from an inner city area is equal to that found in 2003 in a large sample of Latino preschoolers from low-income areas of California (17). The prevalence of overweight is double the 10.4% found among American preschoolers in the 1999-2000 NHANES

population-based study of children aged 2-5 (18).

The prevalence of overweight found in this study is within expectations based on published data, as rates of overweight have increased more dramatically among younger children in recent years. While no data is available for Canadian children younger than 7 years, statistics from the 1996 cross-sectional NLSCY indicate that among boys, the prevalence of overweight was highest among younger children with 21% of 7 year olds compared to 6% of 13 year olds with BMI scores over the 95th percentile (19). Similar data for girls found 16% of 7 year olds and 4% of 13 year olds with BMI values over the 95th percentile. The rates of overweight found in this study indicate a public health issue as one longitudinal study found that half of children with a BMI greater than the 95th percentile at 3-6 years of age were obese at age 25 (20). Overweight children are more likely to have hyperlipidemia, hypertension and abnormal glucose tolerance, risk factors for chronic disease usually found only in older adults (21).

4.3.1.2 Iron Nutrition

The overall results for the sample confirm low rates of iron deficiency found in recent population-based studies of American preschoolers. In the United States, better iron nutrition related to increased use of iron-fortified formula and foods as well as improved iron bioavailability is credited with a 48-75% reduction in the rate of iron deficiency anemia among children 6-60 months of age from the early 1980's to mid-1990's (22) to a current national prevalence of less than 1% (6, 23). Rates may have fallen among preschoolers in this country as Canadian study samples from 1987 and 1989 indicated rates of iron deficiency anemia of 10.5-16.5% (24, 25). According to the criteria used in this study, none of the children for whom all iron indicators were available had iron deficiency anemia, 0.9% were iron deficient, 4.5% had low iron stores (serum ferritin <12 µg/L) and 41.8% were at least mildly iron depleted (serum ferritin ≤ 24 µg/L).

The prevalence of low serum ferritin values, reflecting storage iron depletion, has fallen since the Nutrition Canada survey of the early 1970s in which iron depletion affected 40% of children 1-4 yrs of age (26). While few children entirely lacked iron stores, the prevalence of mild iron depletion is of potential concern. Most literature indicates storage iron depletion, defined as a serum ferritin concentration less than 12 µg/L, has no immediate health impact but jeopardizes the supply of iron to the functional compartment, particularly heme content in erythrocytes (15).

However, one recent randomized, placebo controlled study found oral iron therapy improved perceived level of fatigue more than placebo in adult women with serum ferritin concentrations less than 50µg/L (27). If mild iron depletion deprives some tissues of iron, particularly the brain, there is a potentially important health impact of the deprivation, unrelated to heme iron.

4.3.1.3 Zinc Nutrition

This study provided a data on zinc status in a sample of preschool children, a nutrient for which no recent serum data exists for Canadian children. The median serum concentration was 11.64 mmol/L. Applying a conservative cut off for deficiency, 5% of children were deficient. This proportion is double that found in the reference population based on an arbitrary cut off of the 2.5th percentile for children's serum zinc data from NHANES II (1976 – 1980) (8). The rate of deficiency found in this sample is low compared to that found among Mexican preschool children, approximately 30% of whom had low serum zinc levels (28).

4.3.2 Food insecurity and Biochemical Markers of Nutritional Status

4.3.2.1 Food Security and Iron Nutrition

Median levels of serum ferritin and other indicators of iron nutrition did not differ between children in food secure and food insecure households. Median serum ferritin levels in both groups were slightly above the cut off for mild iron depletion with 43.1% and 40.4% of children in food secure and food insecure households at least mildly iron depleted. Spearman's correlation showed no significant associations between household food security level and children's serum ferritin level. The only comparison data available contrasted serum ferritin concentrations between adults from food-sufficient households and food-insufficient households in the NHANES III study (1988 – 1994) and found no significant difference. In that study, significant differences were found in serum levels of cholesterol, carotenoids, carotene, and vitamin A.

Low household income did not increase children's risk of iron depletion in this study, contrary to past literature. In the United States, the Special Supplemental Nutrition Program for Women, Infants and Children, which provides iron-fortified formula and food free-of-charge to low income families is credited with reducing the prevalence of iron deficiency anemia since its launch in 1972 (22). Canada does not have a comparable level of food supplementation available in publicly funded programs for low income pregnant women and young children. However, Health Canada allows the fortification of inexpensive grain products, such as breakfast cereals, with iron. In 1996, a sample of Canadian preschoolers received 25% of their mean iron intake from ready-to-eat or cooked cereals and 18% from buns, crackers, muffins and other bread products (29). A serving of children's cereal may provide 30-100% of the recommended dietary allowance for iron. As a result, the utility of iron intake as a marker of overall nutritional quality of the diet and corresponding serum levels in children is diminished today due to the fortification of less nutritious foods with a single nutrient.

In the relationship between food security and ferritin status, income was a moderating factor. Within the food secure group, a significantly greater proportion of children in the highest income group had at least mild iron depletion compared to each of the other income categories. Among the food insecure group, the proportions of subjects with at least mild iron depletion did not differ significantly across groups with about half of children in 3 of 4 income categories affected. These differences indicate food insecurity may be a useful predictor of iron depletion. These findings suggest that the higher income food secure children may have consumed more whole grains and fewer fortified foods. Lower income food secure children may have consumed more fortified products or meat and meat alternates. The data suggests food insecure children were eating fewer fortified foods and less meat. The relationship of food security to dietary intake and the utility of food security level in predicting iron depletion should be further studied.

4.3.2.2 *Food Security and Zinc Nutrition*

Median serum zinc levels were significantly lower among children from food insecure households. However, the median zinc levels in both groups were between the 25th and 50th percentile values in the NHANES II population of preschoolers, suggesting the difference is not meaningful from a public health viewpoint. However, qualitative differences in the food consumed between groups of children may exist. No other data exists comparing serum zinc

concentrations between individuals with different household food security levels. Support for a difference in serum levels between food security categories is provided by evidence from the 1989-1991 Continuing Survey of Food Intakes by Individuals, which found zinc intakes of children 1-5 years of age from food sufficient households averaged 71.4% of the RDA while those from food insufficient households averaged 63.0% of the RDA (30). While the difference was not statistically significant, it may reflect important qualitative differences in food intake.

Since the primary food sources of zinc for preschoolers are meat and fluid milk (29), the serum zinc nutrient results support the possibility of a lower meat intake among food insecure children as found among food insecure Mexican-American children (31) or lower meat and milk intakes as found in a second study of Mexican-American preschool children (32).

Spearman's correlation showed no significant association between household food security level and children's serum zinc status, although the association between serum zinc and food security level showed a trend toward increasing food insecurity with decreasing serum zinc values. A correlation between food security status and serum zinc is worthy of further investigation considering serum zinc responds primarily to severe depletion but not mild to moderate depletion. Among individuals, two studies involving adult men found biochemical measures of zinc including plasma zinc concentration and urinary zinc excretion fell significantly during severe depletion, but did not change in response to marginal zinc intake (33, 34). However, measurable differences in serum zinc levels have been observed in groups, which correlated to total dietary intake (8). The small sample size in this study may have limited the statistical power to detect a significant correlation between variables.

A limitation of the food security measurement tool may also have affected the correlation between food security scale score and serum zinc level. Under representation of the variation of food insecurity at more severe levels may have occurred because the scale score is based on the total number of affirmative responses, not the pattern of responses to individual questions. For example, none of the households in the sample scored above 6.6 out of 10 on the scale, when, in fact, child hunger was reported in response to specific questions. This lack of variation occurred in at least 8.5% of cases and may represent a misclassification of households with higher levels of food insecurity. As shown in table 3.5, 8.5% of food insecure respondents indicated their children

were hungry but they could not afford more food and 8.5% indicated children skipped meals.

4.3.2.3 Food Security and Body Mass Index

Children in the food insecure category had a mean body mass index and a mean weight-for age z-score significantly higher than those in the food secure group. Children in food insecure households had odds of 2.6 for a BMI over the 85th percentile compared to those in food secure households. A significant correlation between increasing body mass index z-score and increasing household food insecurity scale score ($\rho = 0.18$, $p = 0.04$) was found.

In contrast to the results of this study, 2 studies of Hispanic preschool children in California found the numbers of children at-risk for overweight did not vary significantly across 4 levels of food insecurity. In the first study, 211 households were classified according to the Core Food Security Module (3) and the proportions of preschoolers with BMI >85th percentile were: 41% of the food secure category, 48% of children in the food insecure without hunger group, 36% of those in food insecure with higher risk of adult hunger group, and 29% of those in food insecure with higher risk of child hunger category(32). In the second study, involving 100 children, the percentages of preschoolers with BMI >85th percentile were: 36.6% (food secure), 39.2% (food insecure without hunger), 34.3% (food insecure with higher risk of adult hunger) and 47.8% (food insecure with higher risk of child hunger) (17). Differences between the 2 countries, such as norms of food preferences or food availability may be responsible for higher weights among all American preschoolers.

Alternatively, in this study a greater proportion of food insecure households were classified as food insecure without hunger, the less severe category that is characterized by anxiety over food supply. This group may have greater ability to make adaptations in food purchasing habits or patterns of child feeding in response to concern over food supply, which lead to greater rates of overweight. When children are actually consuming inadequate food or energy at least some of the time, unless compensating at other times, a smaller proportion would be expected to be overweight.

Recent national studies that examined the relationship between household food insufficiency and risk of overweight have not provided consistent results either. In one population based study

children in low income food insufficient households were more likely to be overweight (35) while a second found children in food secure households were at greater risk of overweight (36). In future, use of the Core Food Security Module in population studies will more finely characterize household food insecurity and may clarify any relationship between the severity of household food insecurity and risk of overweight in children.

4.3.3 Family Adaptations to Household Food Insecurity

This section discusses the combined results indicating no distinct differences in biochemical nutritional status between children in categories of food security along with higher rates of overweight in food insecure children in light of the findings of related research.

In the literature, mother's dietary intakes show strong systematic variation according to the severity of household food insecurity but their children are protected until household food shortages become acute (37). It is likely that the parents in this study protected their children from the effects of food insecurity and only in times of acute shortage were children's intakes affected. The result was sufficient food intake to meet biochemical indicators of nutritional adequacy, which represent average intake. A mother's concern about the adequacy of a child's diet may cause her to become more controlling over the child's food intake, encourage the child to eat more or offer larger portions of food. These behaviours are positively related to weight gain in young children (38). The high prevalence of mild iron depletion, a nutrient that is widespread in the food supply, combined with the high rates of overweight, may indicate that children's excess calories were not provided by nutrient dense foods.

Activity levels have an important impact on weight and confound the relationship between diet and weight. There is evidence in the general population that, while the prevalence of obesity has been increasing, there has been a reduction in overall energy intakes (16). However, data from the 1994-1995 NLSCY indicated that equal proportions, only 38%, of both overweight and healthy weight preschoolers met the criteria to be considered physically active (39). Lack of physical activity may partially explain high BMI values among the preschoolers in this study but not the excess of overweight among children in the food insecure group.

4.3.4 Limitations

The conclusions drawn from this study must be considered in light of potential bias. These systematic deviations include information and selection bias as well as confounding.

4.3.4.1 *Information bias*

Cutoffs for biochemical indicators of iron and zinc nutrition were set at levels recommended in the literature. For serum zinc, the reference cut off used was based on an arbitrary level, rather than one based on biological evidence of deficiency. However, since no single measure of zinc is a sensitive and specific measure of nutritional status, a conservative cut off for the best available measure was used. The direction of bias, if any, would be toward an underestimate of the association.

BMI is a highly sensitive and specific for predicting body fatness in the population. However, measuring skinfold thickness would have provided confirmation that children who were overweight were also over fat. Given the low levels of physical activity among preschoolers, it is unlikely many children had BMI values over the 85th percentile due to increased muscle mass or bone mass.

4.3.4.2 *Selection bias*

The participants in this convenience sample were recruited in 4 specific inner city communities and may have differed systematically from the population in those communities and from preschoolers in Vancouver; therefore, study results are not representative of the population. Study participants were volunteers and may have been systematically different from those who do not volunteer. If parents of healthier children tended to participate, the bias is toward an underestimate of the association.

4.3.4.3 *Confounding*

Biochemical nutrient data must be interpreted with caution because concentrations are affected by factors other than diet or size of stores. Concentrations are increased in the presence of infection, depend on time of day of sample collection, fasting status and other factors. Thus, levels may fall within the normal range in individuals who are poorly nourished. It is less likely to have false

positive readings (low serum concentrations) for ferritin and zinc. Therefore, any error would result in an underestimate of the association. To avoid this source of confounding, we rescheduled appointments with children with a fever in the past 3 days. As well, cutoffs for serum zinc were adjusted for time of day and fasting status. Despite the influence of various unrelated factors on serum ferritin and serum zinc concentrations, these indicators are the most sensitive indicators of stores of these nutrients available.

Elevated serum ferritin concentrations are associated with increasing body mass index and elevated plasma glucose concentrations in adults (15). Secondary analyses relating body mass index to serum ferritin showed no association in this sample.

Multiple associations among socio-demographic variables was an issue in this study. Food security, household income and language spoken at home were correlated among children with body mass index values above and below the 85th percentile. Associations were adjusted for these variables as each additional variable changed the food security coefficient by at least 10% in one of the BMI categories, in general, without increasing the standard error of the regression. Our knowledge of potential confounders is incomplete and it is possible other more important confounders exist.

4.4 Figures and Tables

Table 4.1. Socio-demographic characteristics of a sample of preschoolers and their families in East Vancouver, 2004 (n = 142).

Characteristic	Number	Percentage
Sex		
male	71	51.0
female	69	49.0
missing	2	
Age (months)		
22 - 36	34	24.3
36-48	38	27.1
48-60	48	34.3
60-75	19	14.3
missing	3	
Vitamin supplement use		
Any	43	30.3
None	99	69.7
Eats meat, poultry or fish		
Never	4	2.8
Ever	138	97.2
Number of children in household		
One	51	35.9
Two	61	43.0
Three to four	30	21.1
Language spoken at home		
English	59	41.5
Cantonese/Mandarin	62	43.7
Other (11 languages)	21	14.8
Family income category		
<50% LICO	52	36.9
50-100% LICO	43	30.4
100-150% LICO	21	14.9
>150% LICO	25	17.7
missing	1	

Table 4.2. Socio-demographic and individual characteristics of preschoolers from food secure and food insecure households (n=142).

	Food Secure		Food Insecure		p value*
	Number	Percentage	Number	Percentage	
Sex					
male	38	53.5	33	47.8	0.61
female	33	46.5	36	52.2	
missing			2		
Age (months)					
22 - 36	15	21.1	19	27.9	0.62
36-48	22	31.0	16	23.5	
48-60	26	36.6	22	32.4	
60-75	8	11.3	11	16.2	
missing			2		
Vitamin supplement use					
Any	26	36.6	17	23.9	0.10
None	45	63.4	54	76.1	
Eats meat, poultry or fish					
Never	2	2.8	2	2.8	1.00
Ever	69	97.2	69	97.2	
Number of children in household					
One	25	35.2	26	36.6	0.20
Two	35	49.3	26	36.6	
Three to four	11	15.5	19	26.8	
Language spoken at home					
English	31	43.7	28	39.4	0.007
Cantonese/Mandarin	36	50.7	26	36.6	
Other	4	5.6	17	23.9	
Income category					
>150% LICO	22	31.0	3	4.3	<.0001
100-150% LICO	17	23.9	4	5.7	
50-100% LICO	21	29.6	22	31.4	
<50%LICO	11	15.5	41	58.6	
missing			1		

*Chi-square or Fisher's exact

Table 4.3. Study sample nutritional indicators compared at selected percentiles to NHANES population data.

	Hemoglobin (g/L)		Ferritin (ug/L)		Serum Transferrin Saturation (%)		Zinc protoporphyrin (umol/mol heme)		Zinc (mmol/L)	
Percentile	Sample	NHANES II*	Sample	NHANES III**	Sample	NHANES II*	Sample	NHANES II*	Sample	NHANES II*
5th	111.0	110.0	14.5	10.5	6.0	10.1	36.0	36.0	9.2	9.3
25th	118.0	118.0	20.0	18.7	16.0	16.7	46.0	46.1	10.4	10.8
50th	126.0	123.0	28.0	26.7	21.5	21.2	55.0	55.0	11.6	12.0
75th	131.0	129.0	40.0	37.9	27.8	27.8	64.0	65.0	13.2	13.4
95th	138.0	137.0	77.0	66.1	37.0	39.2	79.0	93.1	16.0	15.9

*NHANES II (1976-1980) reference data for children ages 3-5 years.

**NHANES III (1988-1994) reference data for children ages 1-8 years.

Table 4.4. Comparison of median nutritional indicators by food security group.

Nutritional indicator	Median value	Median value	P value*
	Food Secure group	Food insecure group	
Hemoglobin (g/L)	127.0	125.0	.68
Serum ferritin (ug/L)	27.5	27.5	.41
Serum transferrin saturation (%)	22.0	21.0	.73
Zinc protoporphyrin (mmol/mol heme)	55.0	57.0	.07
Serum zinc (mmol/L)	11.79	11.17	.01

*Wilcoxon signed-rank test (two-tailed)

Table 4.5. Correlation between continuous values of nutritional indicators and food security score.

	Spearman's Correlation	
	Coefficient	p value
Zinc (mmol/L)	-0.13	0.15
Hemoglobin (g/L)	-0.08	0.36
Ferritin (ug/L)	0.04	0.97
Zinc protoporphyrin (mmol/mol heme)	0.15	0.11
Serum Transferrin Saturation (%)	0.001	0.99

Table 4.6. Prevalence of iron and zinc depletion or deficiency conditions by food security status.

Nutritional Indicator	Food Secure		Food Insecure		P value*
	Number	Percentage	Number	Percentage	
Iron deficiency anemia (n=121)	0	0	0	0	0.48
Iron deficient (serum ferritin <12µg/L and either ZPP >70 mmol/mol heme or Serum transferrin saturation <7%) (n=98)	1	1.8	0	0	1.0
ZPP >70 mmol/mol heme or Serum transferrin saturation <7% (Indicators of early iron deficiency) (n = 126)	10	15.3	12	19.7	0.56
Depleted iron stores (ferritin<12µg/L) (n = 110)	4	6.9	1	1.9	0.37
Mildly depleted iron stores (ferritin≤24µg/L) (n = 110)	25	43.1	21	40.4	0.85
Zinc deficient (n=122)	4	6.5	2	3.3	0.68

*Fisher's exact test

Table 4.7. Prevalence of at least mild iron depletion by income category.

Risk Factor	Iron Replete		Iron Depleted		Odds Ratio for Iron Depletion	95% Confidence Interval
	n	%	n	%		
>150% LICO*	5	26.3	14	73.4	1.00	
100-150% LICO	12	70.6	5	29.4	0.15	0.03 , 0.64
100-150% LICO (adjusted)**					0.15	0.03 , 0.64
50-100% LICO	24	72.7	9	27.3	0.15	0.04 , 0.52
50-100% LICO (adjusted)**					0.14	0.04 , 0.51
<50% LICO	22	55.0	18	46.0	0.29	0.09 , 0.97
<50% LICO (adjusted)**					0.25	0.06 , 0.98
Food Insecure**					1.27	0.48 , 3.31

*Low income cut off

**Variables are adjusted for the other

Table 4.8. Proportion of iron replete and iron depleted children by household food security status and household income group.

Food Secure Households		
	Iron Replete n (%)	Iron Depleted n (%)
> 150% LICO*	4 (24)	13 (76)
100-150% LICO	11 (73)	4 (27)
50-100% LICO	12 (71)	5 (29)
<50% LICO	6 (67)	3 (33)

Food Insecure Households		
	Iron Replete n (%)	Iron Depleted n (%)
> 150% LICO*	1 (50)	1 (50)
100-150% LICO	1 (50)	1 (50)
50-100% LICO	12 (71)	4 (24)
<50% LICO	16 (52)	15 (48)

*Low income cut off

Table 4.9. Distribution of anthropometric measures in the sample of preschoolers.

				<5th percentile 5-85th percentile 85-95th percentile >95th percentile							
				n	%	n	%	n	%	n	%
	mean	SD	median								
Body Mass Index Z-score	0.48	1.37	0.42	8	5.8	84	60.1	16	11.6	30	21.7
Height-for-age Z-score (HAZ)	-0.04	1.47	-0.18	14	10.2	89	65.0	20	14.6	14	10.2
Weight-for-age Z-score (WAZ)	0.27	1.19	0.35	2	1.4	97	70.3	23	16.7	16	11.6

SD (standard deviation)

Table 4.10. Study sample body mass index distribution compared at selected percentiles to the CDC population reference.

Reference Percentile	Reference z-score	Body Mass Index z-score		
		All children	Children in Food Secure Households	Children in Food Insecure Households
5th percentile	-1.65	-1.65	-1.66	-1.35
25th percentile	-0.68	-0.34	-0.73	-0.15
50th percentile	0	0.42	0.13	0.76
75th percentile	0.68	1.36	1.15	1.78
95 percentile	1.65	2.71	2.20	2.99

Table 4.11. Study sample height-for-age distribution compared at selected percentiles to the CDC population reference.

	Reference percentile z-score	Height-for-Age z-score		
		All children	Children in Food Secure Households	Children in Food Insecure Households
5th percentile	-1.65	-2.68	-2.55	-3.14
25th percentile	-0.68	-0.95	-1.03	-0.94
50th percentile	0	-0.18	-0.10	-0.18
75th percentile	0.68	1.00	1.12	0.93
95 percentile	1.65	2.19	1.83	2.71

Table 4.12. Study sample weight-for-age distribution compared at selected percentiles to the CDC population reference.

Reference Percentile	Reference z-score	Weight-for-Age z-score		
		All Children	Children in Food Secure Households	Children in Food Insecure Households
5th percentile	-1.65	-1.50	-1.55	-1.47
25th percentile	-0.68	-0.61	-0.82	-0.40
50th percentile	0	0.35	0.19	0.42
75th percentile	0.68	1.11	0.84	1.26
95 percentile	1.65	1.91	1.74	2.42

Table 4.13. Comparison of preschoolers mean BMI, weight-for-age and height-for-age z-scores.

	Food Secure category mean z-score	Food Insecure category mean z-score	p value*
Overall mean body mass index (BMI)	0.22	0.73	0.03
Overall mean weight-for-age	0.07	0.47	0.05
Overall mean height-for-age	-0.07	0.00	0.78

*t-test

Table 4.14. Comparison of median of z-score values within food security categories.

	Food Secure category median	Food Insecure category median	p value**
	z-score	z-score	
Underweight (BMI < 5th percentile)	-2.00	-2.61	0.25
Healthy weight (BMI 5th-85th percentile)	-0.04	0.08	0.00
At-risk of overweight/overweight (BMI 85-100th percentile)	1.72	1.93	0.003
Overweight (BMI >95 percentile)	2.05	2.61	0.26

**Wilcoxon signed-rank test

Table 4.15. Correlation between anthropometric z-score values and household food security scale score.

Anthropometric variable	Spearman's Correlation Coefficient	p value
Body mass index z-score	0.18	0.04
Height-for-age z-score	0.02	0.83
Weight-for-age z-score	0.14	0.10

Table 4.16. Odds of children in food insecure homes having a body mass index indicating underweight, healthy weight, at-risk of overweight, or overweight.

	Value	SE	OR	95%CI
Underweight (BMI<5th percentile)				
Food Secure			1.0	
Food Insecure	-0.46	0.75	1.6	0.4 , 6.9
Food Insecure (adjusted) ¹	-3.89	2.04	0.0	0.0 , 1.1
Healthy weight (BMI 5-85th percentile)				
Food Secure			1.0	
Food Insecure	-0.43	0.35	0.7	0.3 , 1.3
Food Insecure (adjusted) ¹	-0.47	0.45	0.6	0.3 , 1.5
At-risk of overweight/overweight (>85th percentile)				
Food Secure			1.0	
Food Insecure	0.57	0.37	1.8	0.9 , 3.7
Food Insecure (adjusted) ¹	0.94	0.47	2.6	1.02 , 6.5
Overweight (>95th percentile)				
Food Secure			1.0	
Food Insecure	0.53	0.42	1.7	0.7 , 3.9
Food Insecure (adjusted) ¹	0.81	0.53	2.3	0.8 , 6.4

¹Adjusted for income, language spoken at home, sex and age

4.4 References

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Chapter 5 Summary of Results and Implications for Measurement, Policy and Practice

5.1 Prevalence and severity of food insecurity

Among this sample, 50% of households were categorized as food secure, 16.2% as food insecure with anxiety about their food supply, 21.0% as food insecure with few or no hunger indications, 11.9% as moderately food insecure with indications of adult hunger and 0.7% as severely food insecure with higher risk of child hunger.

While the number of children classified as at high risk of hunger was low, the quality of food consumed may be reduced for children in food insecure households as half of parents indicated they relied on a few kinds of low cost food for children and one third of parents indicated they could not feed children balanced meals.

5.1.1 Implications

- The prevalence of household food insecurity in the present study indicates a need for monitoring of food insecurity among households with children in Canada. The measurement of household food insecurity in conjunction with other measures of nutritional vulnerability would facilitate the identification of children whose nutritional health is potentially compromised because of family financial resource constraints.
- Given the evidence available on the adverse impact of even less severe degrees of food insecurity on children's physical health, emotional and behavioural functioning as well as academic achievement, the findings of this study suggest the need for policy initiatives to address food insecurity and its effects on the quality and quantity of children's food intake.

5.2 Utility of the Core Food Security Module as a direct measure of household food insecurity in a Canadian sample.

The Core Food Security Module measured a wider variation in household food insecurity compared to measurement tools currently used in Canada. This direct assessment of food insecurity included content domains relevant to the Canadian population such as anxiety over insufficient food as well as measuring qualitative and quantitative changes in food consumed by both adults and children because of financial constraints.

In this study, the direct measure of food insecurity seemed a more sensitive and specific predictor of food insecurity compared to indirect indicators of food insecurity such as low household income and supplementary food program usage. Risk of food insecurity increased across decreasing income categories but not all low income households were food insecure. From highest to lowest income categories, prevalence of food insecurity increased in a gradient from 12% to 80% of households. In this sample, low income was not a sufficient cause for food insecurity.

This study supports recent questions about the appropriateness of the CFSM classifications (1). Under representation of the severity of food insecurity may occur across the scale when implemented according to the *Guide to Measuring Household Food Security*, because the scale score is based on the total number of affirmative responses, not the pattern of responses to individual questions (2). For example, households can be classified as food insecure with risk of adult hunger, when, in fact, child hunger was reported in response to a specific question. This occurred in at least 8.5% of cases in this study.

5.2.1 Implications

- A potential strategy, as implemented in this study, would be to change the recommended cut off from 3 affirmative answers to 1, increasing the sensitivity (correct identification of those actually food insecure) of the tool. Food insecurity would be reported more consistently with its current conceptualization which includes anxiety about food supply due to financial constraints and more consistently with other food security measurement instruments which are grounded in qualitative

research (3). Increasing the sensitivity of the CFSM to accurately classify severe levels of food insecurity requires further consideration.

- Public health based home care and family health programs offer an opportunity for direct monitoring food insecurity with the addition of the *Core Food Security Module* to assessment protocols. For most clients, the survey would involve asking 6 questions and require less than a minute. In the coming year, the Canadian Institute of Health Information will launch a national home care monitoring system, called the *Home Care Roadmap Indicators Data Standard* (3). It includes a nutritional assessment component, which could be expanded to include household food security. A similar protocol implemented in community health programs for children and families could generate data on food insecurity among young children, a population group not captured in the 3 questions asked in the Canadian Community Health Survey (4).
- Alternatively, the Core Food Security Module could be incorporated periodically into national surveys such as the Canadian Community Health Survey or the Statistics Canada Survey of Household Spending to provide a population-based assessment of food insecurity in Canada (1). Adding the CFSM to a longitudinal survey with repeated measures of household food security would provide insight into the impact on households of changes such as employment status or social policy. Monitoring would lay a foundation for the development of policies and programs to address the issue of household food insecurity.

5.3 Factors associated with food insecurity

5.3.1 Socio-demographic factors

In the multivariate analysis, after adjusting for all socio-demographic variables, household income, language spoken at home and parent's education remained predictive of food insecurity. The primary socio-demographic risk factor for household food insecurity, consistent with the hypothesis and the literature, was household income level. Compared to households with incomes greater than 150% of the low income cut off, households with an income or 50-100% were 7.7 times more likely to report food insecurity and households with an income less than 50% of the LICO were 27.3 times more likely to be food insecure. Food insecurity unexpectedly varied by language group as homes where Cantonese or Mandarin was spoken were half as likely to report food insecurity as homes where English was spoken.

5.3.2 Implications

- Given that 80.6% of Chinese-speaking participants had household incomes below the LICO and food insecurity is strongly associated with household income, further research for factors that mitigate food insecurity in this group in Vancouver is warranted.
- Future studies might conduct an analysis by postal code, mapping food insecurity in relation to potential risk factors.
- Qualitative research would be useful in exploring factors that prevent food insecurity in high-risk inner city communities.

5.3.3 Environmental correlates of food insecurity

Study results supported the hypotheses that factors related to the physical and social environments as well as personal/household attributes were associated with household food insecurity. After controlling for socio-demographic variables, parents with less access to food of reasonable quality, lower self-rated food preparation skills, fewer cooking appliances, and lower levels of social inclusion were more likely to experience household food insecurity.

5.3.4 Implications

- The relationships found suggests that social ecological principles were a useful guiding framework and further measurement of variables related to the physical and social environments as well as individual/household attributes would further develop the conceptual framework of food insecurity presented in this study and indicate areas of potential intervention (5).
- The results of the variables tested suggest implications for social planners who can influence the zoning of inner city areas to increase residents' access to quality food at reasonable prices.
- Community and social service agencies could assess the utility of providing small appliances and cooking lessons on the food security status of program participants. These agencies may consider including measurement of food insecurity in their program evaluations to assess whether

increasing social inclusion reduces the experience of deprivation that occurs in individuals and households experiencing food insecurity.

- The findings of this study suggest that mapping food security by postal code in relation to covariates related to the physical and social environments as well as household attributes would provide a better understanding of risk factors for food insecurity.

5.3 Household food insecurity in relationship to overweight in children

The results of this study support the hypothesized positive correlation between food insecurity and body mass index. Children in food insecure households were twice as likely to have a body mass index over the 85th percentile compared to those in the food secure group. As well, a significant correlation between increasing household food insecurity and increasing body mass index was found.

5.3.1 Implications

- These findings suggest a possible outcome of household food insecurity with health consequences for preschool children. This correlation provides evidence that food insecurity has adverse health consequences for young children and is a public health issue requiring both monitoring and intervention.
- Linking the predictors of food insecurity to the outcome variables in this study according to the conceptual framework of food insecurity used, suggests that environmental factors may influence the weight status of young children through their influence on food security, a link proposed in the literature related to older children (6).

5.4 Household food insecurity in relationship to preschooler's iron status

Study results did not support the hypothesized correlation between household food insecurity and serum ferritin depletion. However, a relationship between food security and serum ferritin status in which income was a moderating factor was apparent. Within the food secure group, 76% of children in the highest income group had at least mild iron depletion compared to about 30% in each of the other income categories. Among the food insecure group, the proportions of subjects

with at least mild iron depletion did not differ significantly across groups with about half of children in 3 of 4 income categories affected. These trends suggest differences in dietary patterns.

5.4.1 Implications

- Practitioners should continue to emphasize children's need for iron from a variety of nutritious foods as 42% of the children in the sample were at least mildly iron depleted.
- Population based research on children's nutritional status is needed to further assess nutritional status in children.
- Research on the sources of dietary iron in preschooler's diets in relationship to household food security status may explain the differing rates of iron depletion.
- Fortification of inexpensive grain products, including highly refined breakfast cereals, with high levels of iron has diminished the utility of serum ferritin as a marker of overall nutritional health in children. Future research should explore the dietary patterns associated with food insecurity and determine new biochemical markers of diet quality.

5.5 Household food insecurity in relationship to preschooler's zinc status

Median serum zinc levels were significantly lower among children from food insecure households, supporting the study hypothesis. Median levels in both food secure and food insecure groups were between the 25th and 50th percentile values found in the NHANES II comparison group, which suggests the difference may not be significant from a public health viewpoint. However, the difference points to qualitative differences in food consumed by food insecure children, potentially in meat and milk intake.

5.5.1 Implications

- Practitioners should emphasize children's need for zinc from a variety of nutritious foods. Grain products are fortified with lower levels of zinc compared to iron levels so naturally occurring sources of zinc are important.
- Public food programs need to ensure the provision of nutrient dense food to children to help mitigate possible chronic compromises in dietary quality related to household food insecurity that may have serious implications for health and well being over the long term.

This study explored household food security as both an outcome variable with correlates related to the physical and social environments and as a predictor with correlates related to preschool children's body mass index and serum iron/zinc nutrition by building on existing conceptual frameworks.

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6.0 Appendices

Appendix A. An Ecological Model of Food Security Promotion

	Individual/Household	Community/Organization	Policy	Leverage Point Aims
Personal Attributes	Hunger Health status Taste Enjoyment Physiology Metabolism Knowledge Skills Time			- Households - Women -Increasing skills and knowledge about food shopping, storage, preparation and gardening/production.
Social Environment	Values Friends and Family Socioeconomic status Use of income assistance programs Media Education Norms related to cooking/gardening	Institutional food provision by schools, daycares, worksites etc	-Adequacy of food provided by institutions -Nutrition policy -Minimum wage, welfare, alimony, disability pensions, unemployment insurance -Food as a human right	- Increase economic access to markets via increased income -Reduce requirement for income by provision of meals through public institutions -Increase community economy and individual employment incomes through increased local food production, distribution, processing, food service
Physical Environment	Proximity to grocery store/market Transportation	Grocery store product selection/prices	- Store pricing policies	
	Cooking facilities Food storage facilities	Location of grocery stores Public transportation Reliance on transported food	-Zoning bylaws -Transportation policy -Land use policy	- Adequate housing Community planning - Increase physical access to markets via transportation to store and location of quality stores
	Access to land/garden	Urban agriculture Property owners Public land for food production Sustainable agricultural practices	-Agricultural policy - Food import policy - Land use policy	-Increase personal food production via urban gardens -Increase local food production and sales -Increase long term viability of the food system

Appendix C. P values Associated with Correlations Between Categorical Variables.

Table 3.9. P values Associated with Correlations Between Categorical Variables: Primary Outcome Food Security Status. (Chi-square or Fisher's exact test)

	VS	MPF	clinic	Yr Can	Lang	SM	SP	Age	Inc	Educ	CF.Q1	CF.Q2	CF.Q3	CF.Q4	CF.Q5	CF.Q6	CF.Q7
FS Category	0.01	1	0.47	0.85	0.01	0.035	0.002	0.03	<0.001	<0.001	0.079	0.29	0.26	0.004	0.12	0.29	0.003

Abbreviations

Socio-demographic variables	Correlates of Interest
VS (Vitamin supplement use) MPF (Eats meat, poultry, fish) Clinic (Data collection clinic number) Yr Can (Years of life in Canada) Lang (Language spoken at home) SM (Supplementary meals eg. Food bank) Age (Respondent age category) Inc (Income category) Educ (Education category)	CF.Q1 (Access to food of reasonable price) CF.Q2 (Access to food of reasonable quality) CF.Q3 (Access to a reasonable variety of food) CF.Q4 (Number of cooking appliances) CF.Q5 (Self-rated food preparation skill) CF.Q6 (Frequency of meeting with friends) CF.Q7 (Satisfaction with social life)

Table 3.10. P values Associated with Correlations Between Categorical Variables: Food Secure Comparison Group

Food Secure

	YrCan*	Lang	SM	SP	Age	Inc	Educ	CFQ1	CFQ2	CFQ3	CFQ4	CFQ5	CFQ6	CFQ7
YrCan	X													
Lang	<0.001	X												
SM	0.43	0.21	X											
SP	0.86	0.59	0.25	X										
Age	0.93	0.58	0.02	0.44	X									
Inc	<0.001	<0.001	0.98	0.89	0.33	X								
Educ	0.05	0.001	0.88	0.7	0.20	0.016	X							
CFQ1	0.41	0.39	0.73	0.8	0.05	0.19	0.67	X						
CFQ2	0.08	0.04	0.09	0.67	0.43	0.01	0.45	0.01	X					
CFQ3	0.17	0.07	0.04	0.6	0.62	0.57	0.07	0.004	<0.001	X				
CFQ4	0.08	0.34	0.44	0.74	0.56	0.24	0.25	0.54	0.24	0.77	X			
CFQ5	0.35	0.001	0.78	0.12	0.03	0.06	0.93	0.47	0.14	0.15	0.3	X		
CFQ6	0.06	0.08	0.38	0.15	1.0	0.47	0.66	0.1	0.05	0.05	0.59	0.19	X	
CFQ7	0.56	0.3	0.75	0.07	0.23	0.16	0.79	0.58	0.61	0.65	0.93	0.61	0.14	X

Socio-demographic characteristics are highlighted in blue.

Table 3.11. P values Associated with Correlations Between Categorical Variables: Food Insecure Comparison Group
Food Insecure

	YrCan	Lang	SM	SP	Age	Inc	Educ	CFQ1	CFQ2	CFQ3	CFQ4	CFQ5	CFQ6	CFQ7
YrCan	X													
Lang	<0.001	X												
SM	0.19	0.36	X											
SP	0.02	0.003	0.18	X										
Age	0.01	0.09	0.02	0.09	X									
Inc	0.8	0.29	0.33	0.004	0.08	X								
Educ	0.05	0.009	0.75	0.68	0.96	0.42	X							
CFQ1	0.85	0.12	0.2	0.96	0.97	0.71	0.54	X						
CFQ2	0.47	0.78	0.6	0.44	0.45	0.22	0.11	0.02	X					
CFQ3	0.03	0.04	0.52	0.42	0.48	0.09	0.05	0.17	0.49	X				
CFQ4	0.87	0.24	0.17	0.98	0.19	0.01	0.03	0.32	0.45	0.05	X			
CFQ5	0.33	0.07	0.33	0.42	0.13	0.36	0.75	0.74	0.36	0.63	0.13	X		
CFQ6	0.36	0.04	0.73	0.98	0.04	0.29	0.16	0.49	0.53	0.07	0.11	0.06	X	
CFQ7	0.66	0.56	0.81	0.79	0.33	0.77	0.2	0.45	0.4	0.09	0.04	0.43	0.26	X

Appendix D. P values Associated with Correlations Between Categorical Variables.

Table 4.17. Entire Sample Group P values Associated with Correlations Between Categorical Variables. Primary Outcome: at Least Mildly Depleted Serum Ferritin (Chi-square or Fisher's exact test).

	Fsec	Sex	Age	VS	MPF	Lang	Inc
Serum Ferritin (≤ 24 ug/L)	0.46	0.37	0.02	<0.01	<0.01	0.002	0.06

Abbreviations

Fsec (Food Security)

Age (25 and under or over 25 years)

VS (Vitamin supplement use: any/none)

MPF (Eats meat, poultry, fish: any/none)

Lang (Language spoken at home: English/Chinese languages/other)

Inc (Income category: >150%/100-150%/50-100%/<50% Statistics Canada low income cutoff)

Table 4.18. Normal Serum Ferritin Value Group (serum ferritin >24 ug/L) P values Associated with Correlations Between Categorical Variables.

	Fsec Cat	Sex	Age	VS	MPF	Lang	Inc
Fsec Cat	X						
Sex	1.0	X					
Age 22-36	0.27	0.41	X				
VS	1.0	0.57	0.63	X			
MPF	<0.01	1.0	0.55	<0.01	X		
Lang	0.01	0.54	0.30	0.85	0.14	X	
Inc	0.003	0.54	0.37	0.26	0.60	0.67	X

Table 4.19. At Least Mildly Depleted Serum Ferritin Group (serum ferritin ≤ 24 ug/L) P values Associated with Correlations Between Categorical Variables.

	Fsec Cat	Sex	Age	VS	MPF	Lang	Inc
Fsec Cat	X						
Sex	0.87	X					
Age	0.51	0.47	X				
VS	0.006	1.0	1.0	X			
MPF	1	0.16	0.34	1.0	X		
Lang	0.05	0.68	0.07	0.16	1.0	X	
Inc	<0.01	1.0	0.45	0.004	1.0	0.13	X

Appendix E. P values Associated with Correlations Between Categorical Variables.

Table 4.20. P values Associated with Correlations Between Categorical Variables. Entire Sample Group. Primary Outcome BMI >85th percentile. (Chi-square or Fisher's exact test)

	Fsec	Sex	Age	VS	MPF	Lang	Inc
Body Mass Index (<85 th vs. ≥85 th percentiles)	0.10	0.27	0.51	0.84	0.60	0.77	0.97

Table 4.21. P values Associated with Correlations Between Categorical Variables. Body Mass Index >85th Percentile Group.

	Fsec Cat	Sex	Age	VS	MPF	Lang	Inc
Fsec Cat	X						
Sex	0.77	X					
Age	0.55	0.72	X				
VS	0.11	1.0	1.0	X			
MPF	1	0.49	1.0	0.1	X		
Lang	0.07	0.35	0.49	0.66	0.21	X	
Inc	<0.007	0.66	0.84	0.78	0.77	0.01	X

Table 4.22. P values Associated with Correlations Between Categorical Variables. Body Mass Index < 85th Percentile Group.

	Fsec Cat	Sex	Age	VS	MPF	Lang	Inc
Fsec Cat	X						
Sex	0.14	X					
Age	0.48	0.54	X				
VS	0.49	0.35	0.83	X			
MPF	1	0.50	1.0	1.0	X		
Lang	0.07	0.31	0.07	0.26	0.46	X	
Inc	<0.01	0.94	0.27	0.16	0.78	0.002	X

Appendix F. Table of Adjusted Odds Ratios for Food Insecurity

Table 4.23. Odds of children in food insecure homes having a body mass index indicating underweight, healthy weight, at-risk of overweight, or overweight (showing all adjustments).

	Value	SE	OR	95%CI
Underweight (BMI<5th percentile)				
Food Secure			1.00	
Food Insecure	-0.46	0.75	1.59	0.37 , 6.92
Food Insecure (adjusted) ¹	-0.58	0.82	0.56	0.11 , 2.77
Food Insecure (adjusted) ²	-2.66	1.27	0.07	0.01 , 0.85
Food Insecure (adjusted) ³	-3.50	1.55	0.03	0.00 , 0.63
Food Insecure (adjusted) ⁴	-3.89	2.04	0.02	0.00 , 1.11
Healthy weight (BMI 5-85th percentile)				
Food Secure			1.00	
Food Insecure	-0.43	0.35	0.65	0.33 , 1.30
Food Insecure (adjusted) ¹	-0.55	0.41	0.58	0.26 , 1.30
Food Insecure (adjusted) ²	-0.44	0.44	0.65	0.27 , 1.54
Food Insecure (adjusted) ³	-0.47	0.44	0.63	0.26 , 1.49
Food Insecure (adjusted) ⁴	-0.47	0.45	0.62	0.26 , 1.50
At-risk of overweight/overweight (>85th percentile)				
Food Secure			1.00	
Food Insecure	0.57	0.37	1.78	0.87 , 3.66
Food Insecure (adjusted) ¹	0.76	0.44	2.15	0.91 , 5.09
Food Insecure (adjusted) ²	0.84	0.46	2.31	0.94 , 5.68
Food Insecure (adjusted) ³	0.89	0.46	2.45	0.99 , 6.03
Food Insecure (adjusted) ⁴	0.94	0.47	2.57	1.02 , 6.47
Overweight (>95th percentile)				
Food Secure			1.00	
Food Insecure	0.53	0.42	1.71	0.75 , 3.90
Food Insecure (adjusted) ¹	0.73	0.52	2.08	0.75 , 5.77
Food Insecure (adjusted) ²	0.78	0.53	2.19	0.76 , 6.21
Food Insecure (adjusted) ³	0.81	0.53	2.25	0.79 , 6.39
Food Insecure (adjusted) ⁴	0.81	0.53	2.25	0.78 , 6.44

¹Adjusted for income

²Adjusted for income and language spoken at home

³Adjusted for income, language spoken at home, sex

⁴Adjusted for income, language spoken at home, sex and age

Appendix G. Effect of logistic regression modeling between nutritional indicators and food insecurity with food insecurity as the outcome.

Logistic regression measures the association between each of serum ferritin as a continuous variable, low iron stores (dichotomous variable), serum zinc as a continuous variable, and zinc deficiency (dichotomous variable) and likelihood of food insecurity (table 4.24). No association was found between either serum ferritin or mild iron depletion and food security level even after adjustment for language and supplement use. The odds of food insecurity were 19% lower with each 1 unit increase in serum zinc, OR 0.81 (95% CI: 0.68, 0.99). There was no association between zinc deficiency and food security status, adjusted OR 0.55 (95% CI: 0.09, 3.49).

Because the distribution of serum ferritin was skewed, it was transformed (natural logarithm). Unadjusted, the odds of food insecurity were 15% higher for each one unit increase in serum ferritin but the confidence interval is wide and includes 1, OR 1.15 (95% CI: 0.28, 4.7). After adjustment for vitamin supplement use and language, the odds ratio is not significant but indicates that the odds of food insecurity increased with increasing serum ferritin levels OR 2.64 (95% CI: 0.51, 13.6).

Table 4.24. Crude and adjusted odds ratios of food insecurity for indicators of nutritional status.

Nutritional Indicator	Value	Std. Error	OR	95%CI	
Mild iron depletion (ferritin $\leq$ 24 ug/l)	-0.17	0.39	0.84	0.39 , 1.81	
Mild iron depletion (ferritin $\leq$ 24 ug/l) (adjusted*)	-0.58	0.46	0.56	0.23 , 1.38	
Serum ferritin (continuous values)	-0.01	0.01	0.99	0.97 1.01	
Serum ferritin (continuous values) (adjusted*)	-0.003	0.01	1.00	0.98 1.01	
Zinc deficiency	-0.73	0.88	0.48	0.09 2.70	
Zinc deficiency (adjusted*)	-0.59	0.94	0.55	0.09 3.49	
Zinc (continuous values)	-0.16	0.08	0.85	0.73 , 1.00	
Zinc (continuous values) (adjusted*)	-0.20	0.10	0.82	0.68 , 0.99	

*Adjusted for language and supplement use

Appendix H. Effect of logistic regression modelling between BMI and food insecurity with food insecurity as the outcome.

Logistic regression measures the association between children's BMI indicating underweight, healthy weight, at-risk overweight/overweight (combined) and overweight and the likelihood of food insecurity (table 4.25). The odds of food insecurity were 41% higher with each 1-unit increase in BMI z-score, OR 1.41 (95% CI: 1.07, 1.84). There was no association between underweight and food security status, adjusted OR 0.57 (95% CI: 0.09, 3.51). Odds of living in a food insecure household were lower for children at healthy weights, although the association was not significant (OR 0.67 (95%CI: 0.33, 1.35). Children with BMI values over the 85th percentile were almost twice as likely to live in a food insecure household (OR 1.95 (95%CI: 0.92, 4.10). The odds of overweight children living in food insecure households was 1.75 (95% CI: 0.75, 4.07) but not significant.

Table 4.25. Odds ratios and 95 percent confidence intervals for food insecurity for body mass index classifications.

Covariate	Value	Std. Error	OR	95%CI
Body mass index z-score	0.28	0.13	1.32	1.02 , 1.71
Body mass index z-score ¹	0.34	0.14	1.41	1.07 , 1.84
Underweight (BMI less than 5th percentile)	0.11	0.84	1.12	0.22 , 5.74
Underweight (BMI less than 5th percentile) ¹	-0.57	0.93	0.57	0.09 , 3.51
Healthy weight (BMI 5th-85th percentile)	-0.43	0.35	0.65	0.33 , 1.30
Healthy weight (BMI 5th-85th percentile) ¹	-0.41	0.36	0.67	0.33 , 1.35
At-risk of overweight or overweight (BMI over 85th percentile)	0.58	0.37	1.78	0.87 , 3.66
At-risk of overweight or overweight (BMI over 85th percentile) ¹	0.67	0.38	1.95	0.92 , 4.10
Overweight (BMI over 95th percentile)	0.53	0.42	1.71	0.74 , 3.91
Overweight (BMI over 95th percentile) ¹	0.56	0.43	1.75	0.75 , 4.07

¹ Adjusted for language spoken at home.