University of Alberta

Assessing Energy Adequacy, Healthy Food Diversity, and Self-Reported Food Security in the United States, Canada, and India

by

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Abstract

In order to assess the effectiveness of public policy interventions (or lack of) aimed at food insecure households, an individual's socio-economic and demographic status, energy adequacy, and healthy food diversity need to be better understood. Through a cross-country comparison (Canada, US and India) of the determinants of dietary adequacy and diversity, with different policy programs aimed at enhancing food security in place, we can provide recommendations for effective strategies aimed at reducing food insecurity, in different contexts. Results suggest that multiple indicators need to be assessed to understand the multi-faceted nature of a household's food security status. Income plays a significant role in energy adequacy, while respondent age and family size play an important role in healthy food diversity. Assessing policy programs by effectiveness suggests that India may benefit from a cash transfer program instead of the traditional TPDS.

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1 Chapter 1: Introduction

1.1 Background

Inadequate nutrition is a pressing problem facing the poor in both developed and developing countries. It is estimated that more than 1 billion people lack sufficient dietary energy, and at least twice that number suffer from micronutrient deficiencies (Barrett, 2010). In 2000, member states of the United Nations committed to freeing "our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty," and to "making the right to development a reality for everyone" (IFPRI, 2003). This joint declaration also set out eight goals – the Millennium Development Goals (MDGs): (1) eradicate extreme poverty and hunger, (2) achieve universal primary education, (3) promote gender equality and empower women, (4) reduce child mortality, (5) improve maternal health, (6) combat HIV/AIDS, Malaria, and other diseases, (7) ensure environmental sustainability, and (8) global partnership for development. The targets for these goals are to be met by 2015, and encompass concerns of policy-makers and practitioners, from both developed and developing countries.

The 2008 food price crisis sparked renewed interest in food security. In a July 2009 joint statement, the Group of Eight (G8) heads declared that rising food prices and intensification of the food crisis called for a "more sustained, action-oriented and effective response to the current and future food insecurity" (G8, 2009, p. 1). For the first time since poverty trends began to be monitored, the absolute number of people living in extreme poverty fell in every developing region, the proportion of people living on less than $1.25 a day fell from 47 percent in 1990 to 24 percent in 2008 (United Nations, 2012). A possible result from the MDGs, 126 million fewer people were living on less than a dollar a day in 2001 compared to 1990, which reflects a drop in the share of poor people in the world's population from 28 to 21 percent. In addition, The Food and Agriculture Organization of the United Nations (FAO), has suggested that the number of undernourished, with reference to 2010-12, has fallen by 17 percent in the last decade.

This renewed interest in food security due to the changing nature of the global economy, however, requires a detailed analytical methodology aimed at identifying the food insecure to target interventions aimed at alleviating the deleterious side effects associated with being food insecure. The concepts of food security, food insecurity, and hunger, however, are multi-faceted and complex, and a thorough understanding of its different aspects is essential for directing any policy interventions. Ultimately, to be food insecure is a complex condition, and its multiple dimensions are better understood when presented through a suite of indicators; indicators that are able to effectively address different aspects of food insecurity (FAO, IFAD, and WFP, 2013).

1.1 Definitions

Discussions related to food insecurity and hunger have reflected the changing concerns of research scientists, policy-makers and practitioners over the last 50 years. In the 1960s, discussions tended to focus on the concept of hunger and food supplies. In developed countries, in particular, leaders were less likely to admit that hunger could exist where there were plentiful food supplies (Kennedy, 2003). Earlier concepts of food insecurity and hunger had been linked to clinical signs of malnutrition, and researchers felt a need to distinguish between clinically defined hunger and food insecurity, and hunger and food insecurity as commonly defined. At the 1996 World Food Summit, 182 nations agreed to define a food secure world as one "… in which most people are able, by themselves, to obtain the food they need for an active and healthy lifestyle, and where social safety nets ensure that those who lack resources still get enough to eat" (World Food Summit, 1996). From this basic definition, the WHO has identified three pillars on which food security depends:

> **Availability**: sufficient supplies of food available consistently
> **Access**: physical and economic access to food at all times
> **Acceptability**: appropriate use based on knowledge of basic nutrition

The definition does not simply represent an availability of foods that satiate hunger, but a diversity in diet that suggests accessibility and availability of culturally appropriate, nutritious, and healthy food. A major report supported by the American Institute of Nutrition, clarified the meaning of hunger from the scientific literature and established the links between food insecurity and hunger (Anderson, 1990). Within the report, food security, food insecurity, and hunger are defined as follows (Kennedy, 2003):

> **Food Security:** Access by all people at all times to enough food for an active, healthy life.
> **Food Insecurity:** Limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire foods in socially acceptable ways.
> **Hunger:** The uneasy or painful sensation caused by lack of food. Hunger is a potential consequence of food insecurity, although not necessarily.

1.2 Food Security and Health

Undernourishment and undernutrition can coexist. In some countries, undernutrition rates (i.e., indicated by the proportion of stunted children), are considerably higher than the prevalence of undernourishment (i.e., indicated by inadequacy of dietary energy supply) (FAO, IFAD, and WFP, 2013). FAO's most

recent estimates indicate that 842 million people (or 12 percent of the global population) were unable to meet their dietary energy requirements in 2011-13 (FAO, IFAD, and WFP, 2013). That is, around "one in eight people in the world are likely to have suffered from chronic hunger, not having enough food for an active and healthy life" (FAO, IFAD, and WFP 2013, 8). The vast majority of these hungry people, 827 million, live in developing regions, where the estimated prevalence of undernourishment is 14.3 percent (FAO, IFAD, and WFP 2013).

Two targets often referred to when assessing the current state of food security in the world are: the 1996 World Food Summit (WFS), which is to halve the number of hungry people, the other is the 2001 MDG hunger target, which is to halve the proportion of hungry people in the total population. Both targets use 1990 as the starting year and 2015 as the target year. Figure 1-1 illustrates the current trajectory of undernourishment according to both WFS and MDG. In order to meet the WFS target by 2015, the number of hungry people in developing regions would have to be reduced to 498 million – a goal which according to the FAO, is out of reach at a global level. The MDG target, however, could still be reached, but more efforts are need (FAO, IFAD, and WFP, 2013).

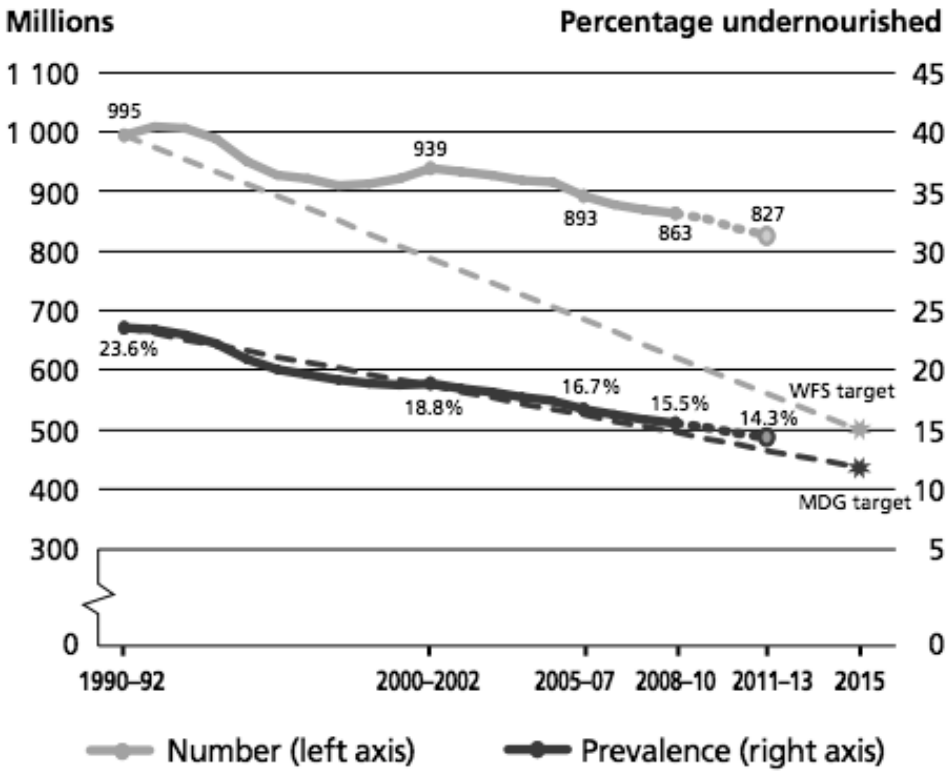


Figure 1-1: Undernourishment in the Developing Regions; Actual Progress and Target for MDG and WFS Targets

Source: *FAO, IFAD and WFP. 2013. The State of Food Insecurity in the World 2013. The multiple dimensions of food security. Rome, FAO.*

Examining food security in the context of undernourishment alone, however, does not capture the complex and multi-dimensional nature of the problem. As a standalone indicator, undernourishment as a measure dietary energy deprivation, does not fully capture the link between food security and health related outcomes that go beyond energy deprivation.

Ultimately, food insecure households in both developed and developing countries face hunger, nutrient deficiencies, increased incidence of chronic disease, and even death (Barrett, 2010; Frongillo, 2003; Kirkpatrick & Tarasuk, 2008; Rose-Jacobs, et al., 2008; Stuff, 2004; Vozoris & Tarasuk, 2003). Upon examination of the relationship between food insecurity and reduced physical, mental, and social health, Vozoris and Tarasuk found that individuals in food insecure households have significantly higher odds of reporting poor health, having poor functional health, restricted activity, multiple chronic conditions, suffer from major depression or distress, and have poor social health (Vozoris & Tarasuk, 2003). Food insecurity was found to be associated with developmental risks in infants and toddlers (Rose-Jacobs, et al., 2008). In addition, individuals in food insecure households reported with greater frequency the presence of coronary heart disease, diabetes, and high blood pressure (Stuff, 2004).

1.3 Research Problem

Effective food security policy is dependent on the measurement of food security status across populations. Without an understanding of the type and levels of food insecurity that persist across a population, it is impossible to target food security policy to ameliorate the deleterious side effects of that insecurity. In the United States there are policy programs, such as the Supplemental Nutrition Assistance Program (formerly called the National Food Stamp Program) aimed at food insecure, poor households (United States Department of Agriculture, 2013). In India, a Public Distribution System is in place to provide staples at low-cost to both above and below poverty line households (Government of India, 2013). In Canada, however, there is no comprehensive national program aimed at food insecure households.

In order to assess the effectiveness of public policy interventions (or lack of) aimed at food insecure households, the individual's socio-economic and demographic status and food security status need to be assessed. By understanding the demographic profile of the food insecure, it is possible determine the effect that current policy programs are having. Through an examination of the literature, it is possible to select food security indicators which will effectively allow for the assessment of (1) which households are characterized as food insecure and (2) which characteristics are similar or different across these food insecure households.

What constitutes 'food secure' can vary from culture to culture, and even household to household. Instruments have been developed in an effort to

determine food security status based on symptoms of food insecurity that are typical to most respondents. The food insecure tend to face similar symptoms such as worry about where their next meal is going to come from, reducing portion sizes, and skipping meals. In extreme situations, food insecure individuals may go hungry for an entire day. In addition, an individual may report no symptoms of food insecurity based on a qualitative assessment such as the United States Department of Agriculture (USDA) Household Food Security Survey Module (HFSSM), but given a caloric assessment may be consuming less than the recommended daily allowance. Similarly, an individual may be consuming calories in sufficient amounts, but given dietary recall assessments not be consuming an adequate variety of nutrients. As a result, numerous indicators would assist in painting a more detailed picture of an individual's food situation.

In India, poverty and malnutrition remain endemic. The seriousness of hunger levels is demonstrated by some staggering statistics: the percentage of children under the age of three who are underweight has been virtually unchanged between 1998/99 and 2005/06, hovering just under 50 percent. 75 percent of households have per capita calorie consumption lower than the minimum daily requirements (United Nations, p. Goal 1), and the IFPRI Global Hunger Index (GHI) designates Indian levels of hunger as 'alarming' given the fact that India scores lower on their scale than some Sub-Saharan African countries despite its higher GDP. The GHI is intended to comprehensively measure and track hunger on a global level, both by country and region. To reflect the exceedingly multi-dimensional nature of hunger, the GHI combines three indices (weighted equally) into one index number: (1) undernourishment: proportion of undernourished as a percentage of the population, (2) child underweight: proportion of children less than five years old who are underweight; either low weight for age, stunted growth, or both, and (3) child mortality: the mortality rate of children less than five years old (IFPRI, 2013).

In Canada and the United States, food insecurity is characterized by relatively low endemic levels of under-nutrition, but also by over-consumption of nutrient-deficient and energy-dense foods, demonstrated by rising levels of overweight and obesity (Frongillo, 2003). In 2011, more than 12 percent of Canadian households experienced some degree of food insecurity, according to a qualitative assessment of food security. During the same period, using an identical categorization of food insecurity, that number was almost fifteen percent for the United States, and has remained at the highest recorded level since 1995 when the first national food security survey was undertaken (Coleman-Jensen, Nord, Andrews, & Carlson, 2011; Tarasuk, Mitchell, & Dachner, 2013).

By comparing these selected indicators across the three countries, given their strikingly different policy programs aimed at enhancing food security status, and radically different socio-economic and demographic characteristics, we can provide recommendations for effective strategies aimed at reducing food insecurity, in different contexts.

1.4 Food Security Measurement

Traditionally, food security assessments were based on the per-capita availability of food at the national level. There are, however, three major reasons why the traditional assessment of food security using only national food balance sheets is not sufficient: (1) individual outcome indicators of food security reflect different aspects of the concept, (2) observational data reports the past, and (3) national-level indicators focus on availability, not access or acceptability (Barrett, 2010). First, each individual outcome indicator captures and neglects different aspects of food security intrinsic to the concept. Reliance on national food availability estimates, such as those produced by the FAO, tend to focus attention on food aid shipments and agricultural production strategies to increase food supplies. A shift in the accepted definition of food security has focused attention away from these national food supplies towards individual food access, due primarily to the concept of *entitlements,* for which individual-level data on hunger and physiological status is necessary (Sen, Poverty and Famines: An Essay on Entitlement and Deprivation, 1982). In fact, "the voluntary guidelines on the right to adequate food, unanimously agreed by all U.N. Food and Agriculture Organization (FAO) member states in 2004, was a response to lack of progress in individual-level indicators despite growth in aggregate food supplies and incomes" (Barrett, 2010, p. 826).

Second, observational data at the aggregate level report the past. Policy-makers, however, are generally more interested in the potential effects of policy interventions in the future. While understanding the past is important in predicting the future, ideal food security indicators would reflect the "forward-looking time series probabilities of satisfying the ((food) access criteria)" (Barrett, 2010, p. 826).

Third, national-level indicators lend themselves to addressing national food availability shortfalls, and not national access and acceptability concerns. In order for food security measures to inform public policy interventions, they must be "readily associated with targetable characteristics of vulnerable households and individuals and remediable causal factors that lead to food insecurity" (Barrett, 2010, p. 826). Research surrounding food security needs to, according to Barrett, revolve around the development of indicators that are comparable across countries while simultaneously appropriate for comprehensive monitoring at the household- and individual-level. In addition, policy interventions need to be targeted at these 'vulnerable' households and individuals.

Increasingly, policy-makers and practitioners have been searching for measurement techniques for food insecurity that are simple to use and easy to analyze and interpret (Kennedy, 2003). In Table 1-1, some commonly used indicators in food security analysis are presented based on a review by Carletto, Zezza, and Banerjee (2013). A short description of each indicator is given along with some strengths and weaknesses.

Table 1-1: Commonly Used Indicators of Food Security

Food Security Indicators	Description
Undernourishment (Quantitative)	A quantification of food security at the national level determined by capturing the average availability of food against requirements at the national level. • strengths: allows for frequent updated comparisons of deficiencies across countries and over time • weaknesses: large discrepancies found in results between researchers (Carletto, Zezza, & Banerjee, 2013)
Household Survey Food Consumption Data (Quantitative)	Quantities of food consumed (or purchased), which can be converted into energy with the use of appropriate conversion factors for comparison with energy requirements • strengths: can reflect individual Energy Adequacy precisely when anthropometric, activity, and demographic data is available • weaknesses: costly and not always feasible to collect such detailed information for all individuals
Dietary Diversity (Quantitative)	Reflects dietary quality and usually measured by summing up the total number of foods or food groups over a given reference period • strengths: easy and inexpensive data to collect • weaknesses: concerns about comparisons across studies since food groupings and reference periods vary
Food Consumption Scores (Quantitative)	A variant of dietary diversity, is a frequency of consumption weighted dietary diversity scores • strengths: Wiesmann et al. (2009) found that food frequency scores reflected dietary quality better than simple food group scores • weaknesses: there is much controversy for cut-off points reflecting diet quality states of 'poor', 'borderline', or 'adequate'
Household Food Security Access Scale (HFIAS) (Qualitative)	Adapted from the HFSSM, is a questionnaire which assesses subjective responses to food insecurity related symptoms. Measures (1) household access to food and (2) the degree of anxiety involved in acquiring food. • strengths: represents universal aspects of the experience of food insecurity • weaknesses: cross-cultural and language barriers may be hard to resolve on a global scale
Coping Strategy Index (CSI) (Qualitative)	Also built around the behavioural approach (as seen in the HFSSM AND HFIAS), recognizes that there are certain behaviours associated with being food insecure. • strengths: Christiaensen, Boisvert, & Hoddinott (2000) found that the CSI is a reliable indicator of dietary inadequacy and a good predictor of food vulnerability • weaknesses: penchant for generating false positives for food insecure individuals creates problems when targeting individuals for food aid, particularly in emergency situations
Non-Food Factors (Qualitative)	Based on information from large-scale living standard and health surveys, assesses factors such as: health and care inputs, feeding practices, and access to basic services such as clean water and

	sanitation. • strengths: many living standard and health surveys have been standardized for ease of cross-country comparison • weaknesses: not much consensus on the minimum number of questions required for adequate assessment

Source: Table adapted from discussion in (Carletto, Zezza, & Banerjee, 2013)

Based on the preceding review of indicators, and a review of the literature presented in Chapter 2, three indicators were chosen to reflect the multi-dimensional nature of food security. Energy Adequacy, Healthy Food Diversity, and a qualitative assessment of food security based on the HFSSM module were selected as three indicators of food security status.

Table 1-2: Selected Indicators of Food Security

Type of Indicator	Indicator	Strengths	Weaknesses
Quantitative	Energy Adequacy (24 – hour recall)	- addresses adequate consumption based on individual characteristics including anthropometry, activity level, and demographic characteristics	- no indication of diet quality
Quantitative	Healthy Food Diversity (24 – hour recall)	- effectively indicates food quality	- subjective food group assessment - no indication of quantity of consumption
Qualitative	HFSSM (Survey – based)	- reflects common symptoms of food insecurity similar across individuals and households	- cultural appropriate-ness - only addresses income-based food insecurity

Source: Table adapted from information presented in Chapter 2

1.5 Coping Strategies

As assessment of individual or household coping strategies to symptoms of food insecurity, either through an indicator such as the Coping Strategies Index (Table 1-1) or another alternative, have often been used as an alternative to the consumption-based indicators selected for the assessment of food security status in Table 1-2. A wide range of indicators are categorized as 'coping strategies', from short-term dietary changes, reducing or rationing consumption, altering household composition, altering intra-household distribution of food, depleting

food stores, increased use of credit for consumption purposes, increased reliance on wild food, short-term alterations in crop and livestock production patterns, mortgaging and sale of assets, and distress migration (Maxwell, 1996).

Examining food security from a consumption-perspective can be tricky, according to Maxwell (1996), in that financially-constrained individuals balance competing needs for asset preservation, and may choose to go hungry up to a point to meet other objectives (Maxwell, 1996, p. 293). Thus, inferring food insecurity from a purely consumption-based perspective may neglect to recognize its root causes. There are, as well, a number of drawbacks in using 'coping strategies' in food security assessments (Davies, 1993): 1) 'coping strategies' tends to be used as a catch-all referring both to coping strategies used as fall-back mechanisms when habitual food entitlements are disrupted; and coping strategies as outcomes of fundamental and irreversible changes in local livelihood systems, 2) coping strategies imply that people somehow 'get by' when, in fact, coping strategies indicate that things are getting worse, and 3) since coping strategies are by definition nutritionally unsustainable, they are bound to be economically and environmentally unsustainable as well. As a result, while coping strategies can be an effective indicator of food security where consumption-based data is not available, it is important to note the distinction between 'coping' and 'failure to cope' (Dreze & Sen, 1989).

1.6 Objectives

Using three national data sets (i.e., Canada, US and India), food insecure households will be identified. The identification of these households, however, will require a specific understanding of the individual- and household- level characteristics that are associated with food insecurity across the three countries. Ultimately, the goal of this research is to assist in the development of policy interventions aimed at food insecure households. This will be done by achieving the following objectives:

> (Objective 1): To examine the link between different indicators of food security including energy adequacy, healthy food diversity, and household food security status (based on a qualitative food security assessment), where available.
>
> (Objective 2): To assess the effect that different individual- and household- characteristics have on the indicators in (Objective 1), and to what degree the effects are similar or different across the three countries.
>
> (Objective 3): To extrapolate the link between healthy food diversity and energy adequacy and qualitative food security status, and to discuss what can be expected where qualitative food security data is not available.

(Objective 4): To assess which households are 'food insecure' according to all three food security indicators, and discuss the characteristics associated with falling into this 'vulnerable group'.

(Objective 5): To compare the individual determinants of food security across countries to provide recommendations about existing policy programs.

Analysis will be undertaken through the utilization of three national data sets: India, Canada and the US. For India, a survey undertaken in 2004-05 for rural populations by the National Nutrition Monitoring Bureau (NNMB) will be utilized. For the U.S. and Canada, the National Health and Nutrition Examination Survey (NHANES 2007/08) and the Canadian Communities Health Survey Cycle 2.2. (2004) will be utilized to compare, at a specific point in time, energy adequacy, healthy food diversity, and qualitative food security with the HFSSM.

1.7 Outline

A detailed discussion of the background and changing definitions of food security, in addition to empirical measurement methods used traditionally in the literature will be presented in Chapter 2. The empirical methodology utilized will be discussed in Chapter 3, including a detailed description of the data sets analyzed. Results of the analysis will be presented in Chapter 4, and discussion and concluding remarks presented in Chapter 5.

2 Chapter 2: Literature Review

2.1 Introduction

In Chapter 2, a review of the literature will be presented. In order to examine the link between different indicators of food security including energy adequacy, healthy food diversity, and household food security status (Objective 1), a thorough understanding of the current definitions of food security is required. A background discussion providing historical context of food security definitions within the literature will be provided in Section 1. In addition, within Section 1, the predominant definition of food security will be presented.

Within Section 2, a discussion of the outcome indicators of food security: availability, access, and acceptability will be presented, with sub-sections designated towards a discussion of the definitions of these outcome indicators and their empirical measurement methodology. In addition, different measurement techniques for food security will be presented here.

2.2 Section 1

2.2.1 Food Security

2.2.1.1 Background

The changing definitions in the food security literature have reflected the changing concerns of policy makers, academics, and practitioners since the 1970s. Originally, food security analyses tended to focus on national and global food supplies. The roots of this concern can be primarily traced to the World Food Crisis of 1972-74, which exposed the weaknesses of the global food supply system (Heady & Fan, 2010). As a result, food security, as it was interpreted in the 1970s, was defined by the United Nations Report of the World Food Conference in 1975 as "availability at all times of adequate world supplies of basic foodstuff, to sustain a steady expansion of food consumption…and to offset fluctuations in production and prices and more succinctly that "food security represents the ability of a country or the world at large to supply the food needs of all its people at all times, now and in the future" (Smith, Pointing, & Maxwell, 1993).

It was not until the early 1980s that questions about the access to food at the household and individual level gained importance. The surge of interest during this period can be attributed primarily to three factors (Smith, Pointing, & Maxwell, 1993, p. 6):

(1) "The impact of the African Famine of 1984-85
(2) A concern with deteriorating basic needs during structural adjustment
(3) And the fruits of an intellectual progression which stretched from the multi-sectoral nutrition planning in the 1970s through entitlement theory

in the early 1980s, to household food security in the second half of the decade"

It was argued that concepts of food security had to be revised to include the household and individual level, and that it is "not until we discuss food security at the individual level that it incorporates distributive and nutritional aspects. At this level the focus on the balance of aggregate supply and demand for food is replaced with the notion of individual food needs" (Fones-Sundell & Brasch, 1989, p. 10).

The M.S. Swaminathan Research Foundation (MSSRF), however, points to another development during the 1960s and 1970s that promoted the development of food security research within the specific context of India: the 'Green Revolution' (MSSRF, 2008). The Green Revolution was characterized not only by technological innovation leading to massive increases in agricultural production, but by a whole set of supportive policies implemented by the government of India. These policies included investment in agricultural research and development; provision of extension services; implementation of a public distribution system for food grains such as rice and wheat; and provision of institution credit and agricultural inputs at subsidized prices (MSSRF, 2008, p. 25). The success of these policies in increasing food production directed attention away from national food supplies towards questions of economic access to food at the individual and household level during the 1980s.

Prior to the 1980s, the popular belief that famine was simply a shortage of food, known as the Food Availability Decline approach (FAD) was the dominant approach to examining famines (Sen, 1982). It was not until this view was challenged by Amartya Sen in his influential work "Poverty and Famines: An Essay on Entitlement and Deprivation" that this paradigm in the literature shifted (MSSRF, 2008). Sen pointed to the Bengali famine of 1943, among other contemporary famines in Asia and Africa, which he maintained did not result from a shortage of food. Instead he concluded that their root cause lay not in there not *being* enough food to go around, but in people not *having* enough food to eat. This statement formed what came to be known as the 'entitlement approach' to starvation and famine—an approach that "concentrates on the ability of people to command food through the legal means available in the society, including the use of production possibilities, trade opportunities, entitlements vis-à-vis the state, and other methods of acquiring food" (Sen, 1982, p. 41). In terms of the definition of food security, a person's entitlement reflects their 'access', to commodity bundles, including food items (Osmani, 1993). This access, be it economic or physical, represents the legal means through which an individual can command food. The entitlement approach has extended beyond its initial concern with famine. In particular, Dreze and Sen applied the approach to shed "light on the policy issues relating to famine relief and the more widespread problem of combating endemic hunger" (Osmani, 1993, p. 1).

The conceptualization of food security in the 1980s reflects the dominance of Sen's entitlement theory and a focus on individual and household food security status (Benson 1986, Chisholm 1982, Corbett 1988). The interest in how individuals and households acquire food, however, has a longer history rooted in nutrition planning (Smith, Pointing, & Maxwell, 1993). Food security itself is regarded as a necessary but not sufficient condition for adequate household nutrition. As a result, in the 1990s, significant efforts were made to identify the nutrition requirements of individuals in an effort to promote balanced and healthy diets in an attempt to ensure overall food security (MSSRF, 2008). A household being characterized as food secure, however, does not necessarily imply adequate nourishment and diet quality. In addition to having nutritional food items available and accessible, a household must have:

- "Sufficient knowledge and skills to acquire, prepare and consume a nutritionally adequate diet, including those to meet the needs of young children;
- Access to health services and a healthy environment to ensure effective biological utilization of the foods consumed; and
- Time and motivation to make the best use of their resources to provide adequate family/household care and feeding practices" (FAO, 2000)

The term 'nutritional security' represents the "condition of having access to all the food, health, social, economic and environmental factors necessary to achieve nutritional well-being, in accordance with the prevailing cultural context" (MSSRF, 2008, p. 5). There is an apparently large difference between the concept of food security and nutrition security, but they remain closely linked (Smith, Pointing, & Maxwell, 1993). Nutritional security requires simultaneous access to a multitude of health, social, economic, and environmental factors that the acceptable definitions of food security do not.

Food insecurity can be either chronic or transitory. Chronic food insecurity is defined as a "long-term or persistent inability to meet minimum food consumption requirements" whereas transitory food insecurity is characterized by a "short-term or temporary inability to meet food consumption requirements, indicating a capacity to recover" (Smith, Pointing, & Maxwell, 1993).

An important starting point for the discussion of food security planning is to question why independent analyses of food security need to be conducted. As Robert Hindle from the World Bank posited: how does food security analysis differ from a spectrum of alternatives, from simple agricultural sector reviews to general development strategies? (Smith, Pointing, & Maxwell, 1993)
The first answer justifies a focus on food security because it directs attention towards a fundamental need of the poorest and most vulnerable groups. The question of "whether people have enough food is politically highly sensitive in all but the most totalitarian societies. And it is a matter of life and death to the poorest and economically most vulnerable people in any country" (Dearden & Cassidy, 1990, p. 1). Within this conceptualization, food insecurity acts as a proxy for poverty, and the use of different food security and nutrition indicators provide

convenient methods of measuring changes in impoverishment levels; this focus on food security therefore ensures that the needs of the impoverished are not neglected during the formation of pertinent policy (Smith, Pointing, & Maxwell, 1993).

The second answer, provided by Kennes (Smith, Pointing, & Maxwell, 1993), accepts the moral case for focusing on hunger as a proxy for poverty, but proposes a more integrated approach to tackling hunger. Kennes points out that the World Food Crisis of 1972-74 stimulated increased aid flows and investments in agricultural and rural development, but these were not successful in improving the basic trends in the food situation. He concluded that food security analysis provides new or better-justified policy interventions that would not otherwise be considered.

Nonetheless, the case for improved measurement and greater attention towards food security analysis can be made simply examining the statistics: more than 1 billion are estimated to be lacking in sufficient dietary energy availability, and twice that number are expected to suffer from micronutrient deficiencies as of 2010. The 2008 global food price crisis sparked a renewed interest in food security research, due in part to the eruption of riots in more than two dozen countries (Barrett, 2010).

2.2.2 Definition

Today, food security research is concerned not only with the physical availability and economic and physical access to food stocks, but reflects an increasing interest in the acceptability of culturally appropriate food and distribution systems as well. The most common and widely used definition of food security was derived by the FAO in 1996 at the Rome Declaration on World Food Security. This definition states that a nation can be considered food secure 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 and healthy lifestyle" (Reutlinger, 1985).

The three pillars that this conceptualization commonly rests on, using notable terms, are:

1) Availability: sufficient supplies of food available consistently
2) Access: physical and economic access to food at all times
3) Absorption: appropriate use based on knowledge of basic nutrition as well as utilization

The terms are hierarchical in nature, with food availability being necessary but not sufficient to ensure food access, which is, then, a necessary but not sufficient condition to ensure food acceptability (Barrett 2010). In other words, while adequate availability is necessary, it does not ensure that individuals or households have 'access to sufficient, safe, and nutritious food'. Community

resources, natural resources, capital resources, credit, and human resources are all essential to ensure that food is available. The second pillar, food access, is most closely related to Sen's concept of entitlement. According to Barrett, "access reflects the demand side of food security, as manifest in uneven inter- and intra-household food distribution and in the sociocultural limits on what foods are consistent with prevailing tastes and values within a community" (Barrett 2010, p.1). Access is, in itself, a multidimensional concept and its measurement requires a more complex approach than with food availability. Food access represents both physical and economic access, including but not limited to food production, market purchasing capabilities, transfers, loans, and remittances, and the ability to forage and/or gather. The third pillar, food acceptability (or food utilization), represents the ability to biologically absorb the food consumed. This can be related to several factors such as nutrition knowledge and practices and safe and sanitary physical and environmental conditions (Barrett, 2010; MSSRF, 2008).

2.3 Section 2

2.3.1 Outcome Indicators of Food Security

2.3.1.1 Availability

Food availability will be assessed using both: 1) national food balance sheets and 2) individual Energy Adequacy (EA). National food balance sheets, retrieved from the Food and Agriculture Organization, will be used to assess national-level food availability. Individual Energy Adequacy will be assessed using caloric intake information from a 24-hour recall.

2.3.1.1.1 Food Balance Sheets

Information pertaining to food availability generally comes from national, regional and sub-regional food balance sheets. These are obtained from the Food and Agriculture Organizations balance sheet database for individual countries and regions (Babu & Rajasekaran, 1991). Food balance sheets provide a "comprehensive picture of the pattern of a country's food supply during a specified reference period" (FAO, 2001, p. 1). These provided the first attempts to record national-level food supplies date back to World War I, and provided a major source of data for a systematic international comparison of food consumption data at the request of the League of Nations. (FAO, 2001) In 1948, at its Fourth Session in Washington, the FAO recommended that governments develop their own food balance sheets, and would assist governments that found it difficult to do so with the *Handbook for the Preparation of Food Balance Sheets* (1949). In 1957, for methodological reasons, it was decided to shift from annual food balance sheets to three-year average food balance sheets instead. By 1977, it was possible to publish food balance sheets for 162 developed and developing countries, and for the first time, information for "all countries, continents, economic classes and regions and the world, long-term series of *per-caput* food

supplies in terms of calories, protein and fat by major food groups" was available (FAO, 2001, p. 2).

For each food balance sheet, information regarding each food item – "i.e. each primary commodity and a number of processed commodities potentially available for human consumption – the sources of supply and its utilization" was available (FAO, 2001, p. 2). The *supply* during the reference period is given by the total quantity of each foodstuff produced in a given country plus the total quantity imported. The *utilization* is the distinction made between quantities exported, fed to livestock, used as seed, processed for both food and non-use, wastage from storage and transportation, and food supplies that are available for consumption at the retail level. These food balance sheets are useful for detailed examination of the food and agricultural situation in a country as well as for "developing projections of future food supply needs or the future demand for food, in setting targets for agricultural production and trade and for establishing relationships between national food supplies, famine and malnutrition as well as evaluating national food and nutrition policies" (FAO, 2001, p. 3). While availability paints a picture of the national food availability situation, it does not lend itself favourably to targeting of specific policies. It is not possible to identify which households are food insecure, only whether or not, average, there are sufficient quantities of food available at the national level using this method.

2.3.1.1.2 Energy Intake

2.3.1.1.2.1 Conceptual Discussion

Daily energy intake is defined as the energy obtained from food during a 24-hour period, measured in kilocalories (kcal) that is available through cellular respiration. From the policy maker's viewpoint, assuring adequate energy intake in a population is important due to its strong linkage with both human health and economic productivity (Babatunde, Adejobi, & Fakayode, 2010).

2.3.1.1.2.2 Empirical Measurement

2.3.1.1.2.2.1 24-hour Recall

Dietary intake for the nutritional assessment component of both the NHANES and CCHS survey is assessed through a 24-hour dietary recall interview for all participants, regardless of age. Interviews are conducted in person by trained dietary interviewers, fluent in both Spanish and English for the NHANES and French and English for the CCHS.

For the NHANES survey, each interview is conducted in a private room in the Mobile Examination Center (MEC). A standard set of measurement tools are utilized to help respondents report the dimensions and volume of the food items consumed. The same set of measuring guides has been used since the 2002 survey cycle, and are not intended to represent any particular food, but are designed to

help respondents estimate portion sizes. The measuring guides are given to the interviewees, and in order to obtain a more comprehensive picture of typical dietary patterns of the interviewees, a follow-up dietary interview is conducted by phone, 3 to 10 days after the initial interview. Demographic data includes both socio-economic characteristics and personal information. Information including, but not limited to, gender, age, race, marital status, education, citizenship, and family structure is contained in the data set (CDC/National Center for Health Statistics, 2012).

For the CCHS data set, the 24-hour recall method was based on the USDA Automated Multiple Pass Method (AMPM), an automated questionnaire designed to maximize opportunities for remembering and reporting foods eaten in the last 24 hours (Health Canada, 2006). The five steps in the AMPM in CCHS 2.2. are (Health Canada, 2006): (1) quick list: list all foods and beverages consumed the day before the survey (midnight to midnight), (2) forgotten foods: a series of questions are asked to prompt recall of commonly forgotten foods suck as snack foods or alcoholic beverages, (3) time and occasion: time each item recorded was eaten, and what eating occasion would be called (i.e., snack, brunch, dinner), (4) detail cycle: specific descriptions of foods are obtained which included preparation methods, food additions, amounts consumed, where the meal was prepared (food models are used to describe the size or amount consumed), and (5) final review: probe for missed foods or details about foods.

There are slight differences in methods used for the NHANES and CCHS. For instance, CCHS 2.2. included a review of food categories to reflect the Canadian food supply, and incorporated metric measures. In addition, Step 4 in CCHS 2.2. was modified to exclude where the meal or snack was obtained, as preliminary testing found it to be too repetitive (Health Canada, 2006). Nothing about how data collected in India?

2.3.1.2 Access

Food access represents both physical access to food in the market place and economic access to food at the household level (Babu & Rajasekaran, 1991). Physical access to food is determined by the existence of infrastructure at the regional and national level, while economic access to food is determined by the purchasing power of the household, including the existing level of food prices (which could also depend on physical access to food) (Thompson & Metz, 1998). As Sen pointed out with his *entitlement approach*, shifting the focus of food security analysis from the national aggregate level, as demonstrated by examining food availability, towards household- and individual-level analyses is essential for a thorough understanding of food issues.

According to a 1995 USAID paper, *Food Aid and Food Security Policy*, the primary cause of food insecurity is "the continued lack of economic opportunity to produce adequate amounts of food or to obtain sufficient income to purchase

adequate amounts of food" (USAID, 1995). There are numerous ways to assess food access (see Table 2: Title II FFP Generic Indicator List in *Indicators of Food Access*, FAO for a comprehensive list). Among those, dietary diversity can represent food access at the individual- and household- level and allows for the assessment of food security status across countries.

2.3.1.2.1 Dietary Diversity

2.3.1.2.1.1 Conceptual Discussion

The International Conference on Nutrition promoted food-based dietary guidelines as an important approach for nutritional improvement and a healthy lifestyle (Drescher, Thiele, & Mensink, 2007). International dietary guidelines consistently promote dietary diversity because humans require consistent consumption of more than 40 essential nutrients which can only be contained by consuming a wide range of food items (Royo-Bordonada, et al., 2003).

American nutritionists have taken a leading role in dietary diversity studies, and dietary variety has been a fundamental concept in American dietary guidelines since the early 1900s (Kant, Schatzkin, Graudbard, & Schairer, 2000; Drescher, Thiele, & Mensink, 2007). Table 2-1 highlights how the promotion of dietary diversity has varied in the USDA's dietary guidelines over time. Over a 15-year time period the primary message of the USDA was for individuals to consume a variety of foods. It was not until 2000, that 'healthier' foods were promoted more readily. By 2005 the USDA was promoting 'nutrient-dense' foods and beverages, while discouraging the consumption of foods high in saturated and trans fats, cholesterol, sugars, salt, and alcohol (Table 2-1).

Table 2-1: Promotion of Dietary Diversity by the USDA over time

Edition Year	Wording
1980	Eat a variety of foods.
1985	Eat a variety of foods.
1990	Eat a variety of foods.
1995	Eat a variety of foods.
2000	Let the pyramid guide your food choice. Choose a variety of grains daily, especially whole grains. Choose a variety of fruits and vegetables daily.
2005	Consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit the intake of saturated and trans fats, cholesterol, added sugars, salt, and alcohol.

Table Source: (Drescher, Thiele, & Mensink, 2007)

Canadian Food Guides have varied significantly from 1942 (Table 2-2), when they were referred to as Canada's Official Food Rules, to 2007, when the

official Canada's Food Guide label was first used. The title changes over the years reflected changes in the evolution of the philosophy of the food guide (Health Canada, 2007). Canada's Official Food Rules in 1942 worked under the tagline: Canada at war cannot afford to ignore the power that is obtainable by eating the right foods (Pett, 1942). The 1942 guide identified the consumption of six food groups (Milk; Fruit; Vegetables; Cereals and Breads; Meat, Fish, etc; and Eggs). The creation of a guide that recommended dietary diversity, by promoting adequate consumption of different types of foods, was prompted by the recognition of policy-makers that Canadians needed guidance to make appropriate dietary choices. Removing the term 'official' in 1944, the Canadian Council on Nutrition made numerous changes to the previous document. The consumption of milk was promoted, however, the scarcity of milk during this time period prompted the Department of Agriculture to object to this recommendation (Health Canada, 2007). Other changes included the removal of kidney and heart from the recommendations, cheese and eggs were incorporated into the Meat and Fish group, and butter was mentioned in the Bread and Cereals Group.

Table 2-2: Promotion of Dietary Diversity by Health Canada Over Time

Edition Year	Wording
1942	Eat from six food groups (implied variety)
1944	Eat from six food groups with specified amounts, eat more if possible
1949	Eat from six food groups every day, have at least three meals a day
1961	Eat from six food groups every day, have at least three meals a day
1977	Eat a variety of foods from four food groups every day
1982	Eat a variety of foods from four food groups every day
1992	Enjoy a variety of foods from four food groups; choose lower-fat foods more often
2007	Enjoy a variety of foods from the four food groups

In 1961, the title language softened from 'rules' to 'guide'. For the first time, the Milk group included specified intakes for pregnant women. The Meat and Fish group clarified the role of meat alternatives, such as eggs, cheese, beans, or peas. 1977 was the first time that the consumption of a 'variety' of items was inserted into the document. The tag line for the guide was "Eat a variety of foods from each group every day", a phrase that persisted in food guides until the 1990s (Health Canada, 2007). Historic changes accompanied the 1992 version of the document. The title was changed to Canada's Food Guide to Healthy Eating, reflecting the overarching goal of the Guide. The new guide embraced a total diet approach to choosing foods, which had not been done before. Servings based on age, activity level, gender, and other physiological conditions were presented. The

Other Foods category was included, as well, including foods and beverages that did not fit into any of the other four food groups. The most recent guide, referred to as Eating Well with Canada's Food Guide was published in 2011 and promotes an active and healthy lifestyle, including recommendations on daily activity along with servings sizes based on individual characteristics. In addition, the Eating Well guide suggests eating a 'variety' of foods from the four food groups, promoting dietary diversity.

In the Indian context, the first edition of 'Dietary Guidelines' was published in 1998. The massive economic transitions, however, that took place in the country during the 90s in India changed the lifestyles of people in both rural and urban areas. The shift from 'traditional' to 'modern' foods, changed cooking practices, and the increased consumption of processed and ready-to-eat foods have affected people's perceptions as well as their dietary behavior (Indian Council of Medical Research, 2010). The National Institute of Nutrition, working under the guide of the Indian Council of Medical Research, contends that "irrational preference for energy-dense foods and those with high sugar and salt content pose a serious health risk to the people, especially children" (Indian Council of Medical Research, 2010, ii).

The need for adoption of healthy dietary guidelines was prompted by the institute's belief that rising numbers of overweight and obese people, and the rapid rise in chronic non-communicable diseases necessitates nutritional education intervention on a massive scale. The most recent set of guidelines for Indians, published in 2010, emphasize the promotion of health and prevention of disease among all age groups. There are 10 overarching goals of the guidelines: (1) eat a variety of foods to ensure a balanced diet, (2) ensure provision of extra food and healthcare to pregnant and lactating women, (3) promote exclusive breastfeeding for six months and encourage breastfeeding 'til two years, (4) feed home based semi-solid foods to the infant after six months, (5) ensure adequate and appropriate diets for children and adolescents both in health and sickness, (6) eat plenty of vegetables and fruits, (7) ensure moderate use of edible oils and animal foods and very less use of ghee/butter/vanaspati, (8) overeating should be avoided to prevent overweight and obesity, (9) exercise regularly and be physically active to maintain ideal body weight, and (10) ensure the use of safe and clean foods (Indian Council of Medical Research, 2010, 10).

Lack of dietary diversity is considered a significant problem in the developing world, where diets tend to consist of starchy staples and lack in fruits and vegetables or animal source fats (Ruel, 2003). These plant-based diets have less micro- and macro-nutrients than their developed country counter-parts, and the micronutrients that they do contain are not easily absorbed by the body (Ruel, 2003). Indian food guidelines tend to emphasize that vegetarians can derive almost of all of the required nutrients typically available in eggs, flesh foods, and fish from cereals, pulses, vegetables, fruits and milk-based diets.

2.3.1.2.1.2 Empirical Measurement

Dietary diversity is a qualitative measure of food consumption that "reflects household access to a wide variety of foods, and is also a proxy of the nutrient adequacy of the diet for individuals" (FAO, 2011, p. 28). Assessments of diet quality have traditionally been done through the analysis of specific-nutrient intake. Nutrient level indicators, however, do not accurately reflect total dietary behaviour (Dubois & Ligon, 2010). Consumers purchase food items, and not single nutrients, and a dietary quality indicator needs to reflect this behaviour. Drescher (2007) proposes the use of a Healthy Food Diversity Index to reflect dietary quality, partly due to its ability to take complex diets into account. Through a review of over 50 studies, mainly based in the United States, Drescher and Goddard found that food diversity is strongly correlated with dietary quality and nutrient adequacy, and this finding is consistent among developed and developing countries (Drescher & Goddard). Many studies, then, use assessment of dietary diversity as a proxy for nutrient adequacy (Ruel, 2003).

Numerous studies have calculated dietary diversity scores using the 24-hour recall method using the Food Group Score (FGS) methodology outlined by Kant et al (1991) (Lo 2011; Savy 2006; Azadbakht 2010; Azadbakht 2011). Others have utilized the survey instrument designed by the United States Agency for International Development for the Household Dietary Diversity Score (HDDS) and the Individual Dietary Diversity Score (IDDS) (Savy 2006; Thorne-Lyman 2009; Martin-Prevel 2012; Kennedy 2010; Becquey 2010). While a few have used the newly-developed HFD score, which will be used in this analysis (Drescher 2007; Claesson 2012; Yadavendra 2009; Jayawardena 2013).

To verify whether the HFD-index was able to reflect a healthy diet, Drescher et al (2007) conducted Pearson's correlation analyses between HFD and nutrient supply and biochemical parameters using the German National Health Interview and Examination Survey from 1998. The study found that HFD was positively and significantly associated with most nutrient supplies, including but not limited to: vitamin A, vitamin D, vitamin E, vitamin K, thiamine, riboflavin, vitamin C, potassium, calcium and iron while being negatively associated with fat and sodium intake. In addition, HFD was more strongly correlated with nutrient intakes than other types of count or share indices. Ultimately, they conclude that HFD is an accurate reflection of both dietary quality and nutrient adequacy.

2.3.1.2.2 Household Food Security Survey Module (HFSSM)

2.3.1.2.2.1 Conceptual Discussion

The HFSSM is chosen as an indicator of food access, representing whether or not a household has sufficient physical and economic access to food at all times. Assessing household food insecurity has presented a challenge due to the complex and multi-faceted nature of this phenomenon. The U.S. food security

measurement project began in 1992 to develop a standard measure of food insecurity and hunger for the United States, to be used at national, state, and local levels under assignment from the Ten-Year Comprehensive Plan for the National Nutrition Monitoring and Related Research Program established by Congress in 1990. (Bickel, Nord, Price, Hamilton, & Cook, 2000) By the mid 1990s the United States Department of Agriculture (USDA) had developed an instrument for the rapid assessment of food security: the Household Food Security Survey Module (HFSSM). In April 1995 the U.S. Census Bureau included the HFSSM as an addition to the Current Population Survey (CPS).

Numerous research studies have confirmed the validity of the HFSSM as an "easy to use and analyze method for measuring household food insecurity in different populations living in the U.S" (Melgar-Quinonez, Nord, Perez-Escamilla, & Segall-Correa, 2008, p. 28). The questions are outlined in Table 2-3 of this section. The first question is generally a 'screener' and used to shorten the questionnaire if respondents felt they always had enough to eat. Subsequent questions attempt to identify typical incidents of food insecurity such as worry, economic constraints to purchasing specific desired foods, reducing the size of meals for adults and children, and ultimately skipping entire meals. Given the inclusion of the module in studies with diverse designs, sizes, and purpose, the module has demonstrated its suitability to evaluate the perceptions of individuals on their food security status. (Melgar-Quinonez, Nord, Perez-Escamilla, & Segall-Correa, 2008)

The HFSSM is used in its entirety for CCHS cycle 2.2, and subsequent survey cycles which exclude the nutrition component as well. While the HFSSM is widely recognized as the best available instrument for assessing food insecurity at the household-level, there are certain limitations (Tarasuk, 2001). The HFSSM does not capture frequency or duration of food insecurity, only whether or not it occurred during the past 12 months. In addition, the food insecurity assessed by the module reflects only income-based food insecurity. That is, economic constraints to consumption are reflected by the questionnaire, but other constraints are not.

Table 2-3: Household Food Security Survey Module (HFSSM)

	Questions (Reference Period: Last 12 Months)	Responses
1	Which situation best describes the food eaten in your household in the past 12 months?	i. always enough to eat ii. enough to eat but not the foods desired iii. sometimes did not have enough iv. often did not have enough
2	You and others worried that food would run out before you got money to buy more?	i. often true ii. sometimes true iii. never true
3	The food that you and other bought just didn't last and	i. often true ii.

	there wasn't any money to get more?	sometimes true iii. never true
4	You and others couldn't afford to eat balanced meals?	i. often true ii. sometimes true iii. never true
5	You and other adults relied on only a few kinds of low cost food to feed to your child/ren because you were running out of money to buy food?	i. often true ii. sometimes true iii. never true
6	You and other adults couldn't feed your child/ren because you were running out of money to buy food?	i. often true ii. sometimes true iii. never true
7	You and other adults couldn't feed your child/ren a balanced meal because you couldn't afford it?	i. often true ii. sometimes true iii. never true
8	Your child/ren was not eating enough because you and other adults just couldn't afford enough food?	i. often true ii. sometimes true iii. never true
9	You and other adults cut the size of your meals or skip meals because there wasn't enough money for food?	i. yes ii. no
10	How often did (8) happen?	i. almost every month ii. some months but not every month iii. only 1 or 2 months
11	Did you personally ever eat less than you felt you should because there wasn't enough money to buy food?	i. often true ii. sometimes true iii. never true
12	Were you personally ever hungry but didn't eat because you couldn't afford enough food?	i. often true ii. sometimes true iii. never true
13	Did you personally lose weight because you didn't have enough money for food?	i. often true ii. sometimes true iii. never true
	Did you or other adults not eat for a whole day because there wasn't enough money for food?	i. yes ii. no
15	How often did (14) happen?	i. almost every month ii. some months but not every month iii. only 1 or 2 months
16	Did you or other adults ever cut the size of any child's meals because there wasn't enough money for food?	i. often true ii. sometimes true iii. never true
17	Did any child ever skip meals because there wasn't enough money for food?	i. often true ii. sometimes true iii. never true
18	Was any child ever hungry but you just couldn't afford food?	i. often true ii. sometimes true iii. never true
19	Did any child ever not eat for a whole day because there wasn't enough money for food?	i. often true ii. sometimes true iii. never true

Source: Appendix A: Canadian Communities Health Survey: Household Food Security Status Module (2004)

2.3.1.2.2.2 Empirical Measurement

Determination of the Food Security Status Level or categorization of households into 'food secure' and 'food insecure' is done according to the number of affirmative responses to the module. For households with children, there are 18 potential responses. For households without children, there are 10 potential responses. A food secure household with children would respond affirmatively to fewer than three questions in the module – this is the same for households without children. Households can be classified as either food secure, food insecure without hunger, moderately food insecure with hunger, or severely food insecure with hunger.

2.3.1.3 Acceptability

Food acceptability represents culturally acceptable and appropriate food and distribution systems, in that the food that is available (or affordable) for consumption respects individual's cultural traditions. Acceptability has been assessed using both focus groups and questionnaires, in an attempt to determine whether food items consumed (or provided) were acceptable for consumption (Centre for Studies in Food Security, 2014). This information was not available for this analysis.

2.4 Conclusion

2.4.1 Qualitative vs. Quantitative Indicators

Mixed-method studies, which employ both qualitative and quantitative indicators are valued in addressing nutrition and food security related concerns (Coates, Wilde, Webb, Rogers, & Houser, 2006). The trade-off between quantitative and qualitative indicators can be assessed using cost-benefit analyses. That is, often, quantitative indicators such as calorie intake and nutrient adequacy are either too expensive or infeasible to use, and alternative qualitative indicators, such as dietary diversity scales and self-reported assessment of food security status, would be more feasible (Vargas & Penny, 2010).

There are advantages and disadvantages to both types of indicators, results from qualitative analyses require less time for analysis, but staff with special skills for interpreting qualitative information would be essential. By contrast, quantitative results require analysis by staff with statistical skills as well as large sample sizes that increase the power of statistical tests of association (IFPRI, 1997). Ultimately, it is often argued that complementary use of both qualitative and quantitative approaches "provides a greater range of insights and perspectives and permits triangulation or the confirmation of findings by different methods,

which improves the overall validity of results, and makes the study of greater use to the constituencies to which it was intended to be addressed" (IFPRI, 1997).

Ultimately, the results from an IFPRI study in 1997 that assessed food security using numerous quantitative and qualitative indicators found that there was a lack of 'overlap' between the two types of indicators. The primary explanation for this result proposed was that single indicators were tested quantitatively, such as Energy Adequacy or share of food expenditure, within the qualitative work, however, respondents tended to identify a series of reasons for their food insecurity. Villagers within selected field sites were asked to identify households in their community that constantly struggled to feed their family members, and for what reasons they believed these households were food insecure. Villagers tended to list a series of reasons and not one single explanation for their food security. As a result, the IFPRI study suggested that more overlap might be found between the quantitative and qualitative indicators if combinations of indicators were tested in the quantitative analysis (IFPRI, 1997, p. 75).

Many organizations opt for qualitative instead of quantitative measures of dietary intake for food security assessment. Quantitative measures use data collected at the individual level to determine dietary and nutrient intakes, which are then compared to individual nutrient requirements. Qualitative measures of food consumption such as self-reported food security status are more attractive to policy makers because the information required is less time consuming and costly than quantitative dietary intake methods. Quantitative survey methods are, in particular, more expensive to implement due to their cost, logistics, and respondent burden, among others (Kennedy 2010). With both quantitative and qualitative methods, dietary patterns and consumption of specific food items, depending on the intention of the study, can be identified.

Quantitative indicators, in our case, the HFD-index and Energy Adequacy, will be used in conjunction with the HFSSM, a qualitative indicator, where available. Two types of indicators will be used to paint a more comprehensive picture of the food security status of respondents, and ultimately assess the different aspects of food security that each indicator reflects. A discussion paper published through the United Nations University by Migotto, Davis, Carletto, & Beegle (2006) used data sets from Albania, Indonesia, Madagascar, and Nepal to assess the external validitiy of subjective food security measures (such as the HFSSM) with standard quantitative indicators (such as calorie consumption, dietary diversity, and anthropometry). Ultimately, Migotto et. al found, using simple descriptive statistics, correlational analyses, contingency tables, and multivariate regression, that the qualitative indicator is poorly correlated with standard quantitative indicators, and while more 'subjective' indicators "may provide insight on the vulnerability dimension of food insecurity, they are too blunt an indicator for insecurity targeting" (Migotto, Davis, Carletto, & Beegle, 2006, p. 16).

2.4.2 Concluding Remarks

The conceptual definition of food security rests on three generally agreed upon pillars: food availability, food access, and food acceptability. Availability entails sufficient supplies of food at all times, access entails both physical and economic access to food, whereas acceptability requires appropriate use based on knowledge of basic nutrition as well as adequate absorption of nutrients. There are numerous methods to assess these three pillars to get at the totality of what a food secure household or individual looks like. The indicators that were chosen for this analysis have been highlighted in the preceding section, along with different methods of measurement. Food availability will be assessed using national food balance sheets, developed by the FAO. Physical and economic access to food will be assessed through the HFD, and where available, the USAID HFSSM. Acceptability will be assessed using Energy Adequacy.

Within the following chapter, empirical modeling utilized for this analysis will be discussed. Estimation of the selected data sets will be done using ordinary least squares, simultaneous equations, seemingly unrelated regressions, instrumental variables, and various econometric tests; as a result, a review of these methods will be presented. In addition, in Chapter 3 we will outline the method of variable creation for HFD, CA, and qualitative food security status employed.

3 Chapter 3: Methods

3.1 Conceptual Model

Food security is composed of numerous different elements. Unlike preliminary discussions into the world food situation, in which food availability was the sole determinant of food security status; contemporary research employs a more comprehensive and multi-faceted approach. For many food programs aimed at the household and individual level, tight budgets and constrained resources prevent the assessment of all of these different elements. As a result, decision and policy-makers need to rely on information collected for some, but not all, aspects of food security status required for the comprehensive assessment that the contemporary definition encompasses. The link between these different elements, however, if strong and well understood, can effectively provide the comprehensive picture of a given food situation that a policy maker would require. In addition, the link between these different elements and other household- and individual-level socio-demographic characteristics can provide essential information, from a public policy perspective.

As discussed in the literature review, food security consists of three pillars: availability, access, and acceptability, which, if fulfilled, result in the consumption of food both sufficient in quantity and quality. Various different indicators have been used to assess the different facets of food insecurity, for "e.g. simple derived measures such as assets or nutritional status; indicators based on food availability, food expenditure, or food consumption; healthy food diversity scores at the household level; food insecurity experience-based indicators using coping strategies and behaviors; and household food insecurity scales" (Becquey et al 2010, p. 2234).

The Food and Agriculture Organization (FAO) and the World Food Programme (WFP) both use dietary diversity to inform food security analysis. The FAO uses the HDDS based on guidelines produced by the Food and Nutrition Technical Assistance Project. The WFP, on the other hand, uses a Food Consumption Score (FCS). Both the HDDS and the FCS have been validated for use in different countries as proxy measures of household energy intake, per capita. (Kennedy 2010; Hoddinott & Yohannes 2002; Wiesmann 2009) The HFD index that will be employed is simply an extension of the dietary diversity concept used for the computation of the HDDS and FCS.

Ultimately, the object of interest is the well being of individuals and households, which is measured by their consumption of food. Food is a basic need and sufficient intake is a necessary condition for all other dimensions of well being, including education, health, and security (Cockburn 2009). In addition, in most developing countries food consumption comprises the majority of household expenditures, and very often exceeds three quarters of it (Deaton 1987).

Energy Adequacy will be employed as one measure of individual well being, along with healthy food diversity and self-reported food security. Energy Adequacy is the ratio of caloric intake to caloric requirements. Calorie intake (C_i) is measured using the 24-hour recall of food intake. Calorie requirements for the NHANES and CCHS samples are determined using Dietary Reference Intakes (DRI) by the National Academy of Sciences. Calorie requirements for the NNMB samples are based on Recommended Daily Allowance (RDA) outlined by the National Nutrition Monitoring Bureau (India). Both the DRIs and RDA are for healthy populations, available disaggregated by age, gender, pregnancy status, and activity level (Bouis and Haddad, 1989).

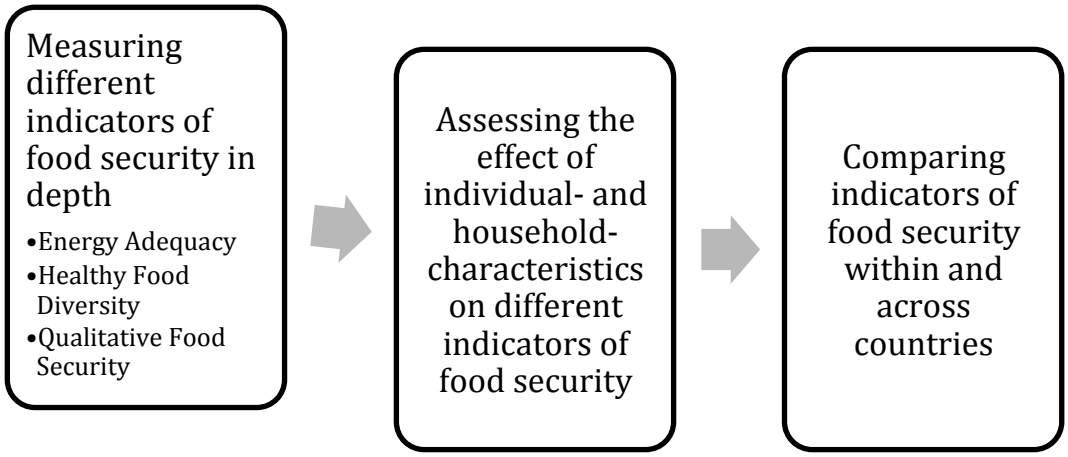


Figure 3-1: Assessment Methodology Flow Chart

The discussion in this chapter will flow as visually depicted in Figure 3-1. First, the measurement of the selected indicators of food security will be discussed; in this case: Energy Adequacy, the HFD-index, and self-reported food security based on the HFSSM. Second, statistical methods employed to assess the effect of individual- and household- socio-demographic characteristics on the different indicators of food security will be discussed. Third, the methodology utilized to compare and contrast different indicators of food security within and across countries will be discussed.

3.2 Measuring Food Security

The following section will be split up according to the three outcome indicators of food security status: Energy Adequacy, healthy food diversity, and adult and child food security status. A conceptual discussion of the indicators was

presented in Chapter 2, and a strictly methodological discussion will be presented here.

3.2.1 Energy Adequacy

Dietary standards, which are referred to by many different acronyms – Recommended Dietary Allowances (RDA), Recommended Nutrient Intakes (RNI), Recommended Dietary Intake (RDI), Safe Intake of Nutrients, are the "average amounts of essential nutrients estimated, on the basis of available scientific knowledge, to be sufficiently high to meet the physiological needs of practically all healthy persons in a group with specific characteristics" (Indian Council of Medical Research, 2010, p. 8). RDI values are "intended to serve as a guide for good nutrition and provide the scientific basis for the development of food guidelines…" (Institute of Medicine of the National Academies, 2011). These RDI values will be utilized in the assessment of Energy Adequacy, as the caloric requirement of the individual, R_i.

Energy Adequacy is calculated as the ratio of individual calorie intake, divided by the calorie requirement of the individual. Energy Adequacy will be calculated using the following formula (Bouis and Haddad, 1989):
C_i = caloric intake of individual i
R_i = calorie requirement of individual i
ϕ_i = Energy Adequacy of individual i

$$\phi_i = \frac{C_i}{R_i}$$

The unit of energy (calories) is Kilocalories (kCal), and is defined as the heat required to raise the temperature of one kilogram of water by 1°C from 14.5°C to 15.5°C (Indian Council of Medical Research, 2010). For Canada and the US, internationally accepted guidelines for the calculation of Estimated Energy Requirements (EER) are determined using the equations outlined by the National Academy of Sciences and outlined in Table 3-1. These EER formulas were developed by the National Academy of Sciences in 2005, and represent the average dietary intake that is required to maintain energy balance, given height, weight, and activity level of the individual. This definition of EER does not represent the consumption of a 'healthy' food basket, but instead reflects the consumption of energy adequate to maintain an energy balance. In order to accurately determine the exact EER of respondents in our sample, height, weight, and physical activity status were required. For both the Canadian and U.S. data sets, EER will be calculated based on the specific characteristics for each individual using the equations outlined in Table 3-1.

Table 3-1: Dietary Reference Intakes and Estimated Energy Requirements (EER)

Infants and Young Children	
Estimated Energy Requirement (kcal/day) = Total Energy Expenditure + Energy Deposition	
0 - 3 months	EER = (89 * WEIGHT[KG] - 100) + 175
4 - 6 months	EER = (89 * WEIGHT[KG] - 100) + 56
7 - 12 months	EER = (89 * WEIGHT[KG] - 100) + 22
13 - 35 months	EER = (89 * WEIGHT[KG] - 100) + 20
Children and Adolescents 3 - 18 Years	
Estimated Energy Requirement (kcal/day) = Total Energy Expenditure + Energy Deposition	
Boys	
3 - 8 Years	EER = 88.5 - (61.9 * AGE[Y]) + PA * {(26.7 * WEIGHT[KG]) + (903 * HEIGHT[M])} + 20
9 - 18 Years	EER = 88.5 - (61.9 * AGE[Y]) + PA * {(26.7 * WEIGHT[KG]) + (903 * HEIGHT[M])} + 25
Girls	
3 - 8 Years	EER = 135.3 - (30.8 * AGE[Y]) + PA * {(10.0 * WEIGHT[KG]) + (934 * HEIGHT[M])} + 20
9 - 18 Years	EER = 135.3 - (30.8 * AGE[Y]) + PA * {(10.0 * WEIGHT[KG]) + (934 * HEIGHT[M])} + 25
Adults 19 Years and Older	
Estimated Energy Requirement (kcal/day) = Total Energy Expenditure	
Men	EER = 662 - (9.53 * AGE[Y]) + PA * {(15.91 * WEIGHT[KG]) + (539.6 * HEIGHT[M])}
Women	EER = 354 - (6.91 * AGE[Y]) + PA * {{9.36 * WEIGHT[KG]) + (726 * HEIGHT[M])}
Pregnancy	
Estimated Energy Requirement (kcal/day) = Non-pregnant EER + Pregnancy Energy Deposition	
1st trimester	EER = NON-PREGNANT EER + 0
2nd trimester	EER = NON-PREGNANT EER + 340
3rd trimester	EER = NON-PREGNANT EER + 452
Lactation	
Estimated Energy Requirement (kcal/day) = Non-Pregnant EER + Milk Energy Output - Weight Loss	
0 - 6 Months Postpartum	EER = NON-PREGNANT EER + 500 - 170
7 - 12 Months Postpartum	EER = NON-PREGNANT EER + 400 - 0

Source: *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients),* National Academy of Sciences (2001)

The energy requirements outlined in Table 3-1 have been estimated on a large number of subjects, mostly in the European and North American context. The EER equations require information about the physical activity level of respondents. That is, in order to determine the caloric requirements of individuals, it is necessary to know how much energy they expend in both occupational and

non-occupational activities. Ultimately, the EER equations in Table 3-1 can be reduced to the following equation: $EER = Predicted\ BMR * PAL$, where BMR is the Basal Metabolic Rate is the daily energy expended at rest, and PAL is the physical activity coefficient (discussed in 3.2.1.1). A study of BMR done on Indian subjects found that BMR for Indians tended to be approximately 5 percent lower than for BMR in developed countries (Indian Council of Medical Research, 2010). As a result, ICMR (and its subsidiary, the National Institute of Nutrition), proposed a set of RDIs different than those utilized by their international counterparts. The RDIs for Indians were determined by a panel of experts at the ICMR, and represent 'healthy' body weights for adults and children, depending on age, physiological status, and sex (Table 3-2).

Table 3-2: National Nutrition Monitoring Bureau Recommended Dietary Intakes

Summary of Recommended Daily Intake of Energy for Indians - 2010			
	Physical Activity Level	Body Weight (KG)	RDI Energy (kCal)
Men	Sedentary	60	2320
	Moderate		2730
	Heavy		3490
Women	Sedentary	55	1900
	Moderate		2230
	Heavy		2850
	Pregnant		350
	Lactating 0 – 6 mos.		600
	Lactating 6 – 12 mos.		520
Infants	0 to 6	5.4	92 kCal/kg/day
	6 to 12	8.4	80 kCal/kg/day
Children	1to 3	12.9	1060
	4 to 6	18	1350
	7 to 9	25.1	1690
Boys	10 to 12	34.3	2190
Girls		35	2010
Boys	13 to 15	47.6	2750
Girls		46.6	2330
Boys	16 to 17	55.4	3020
Girls		52.1	2440

The difference in assessment of RDIs between international and Indian standards results in estimated energy requirements, which given the same height, weight, age, physical activity level, and sex, that are different between countries. The methodology utilized for the Canadian and U.S. data would, given a sample

person, result in RDIs greater than that for an Indian subject. The resulting difference in RDIs between the two methodologies is outlined in Table 3-3, with the correlation between RDIs given both methodologies ranging from 0.6 to 0.79.

Table 3-3: Comparison of Sample BMR; International and India

	Age (Years)	Recommended Intake Sample Person (International)	Recommended Intake Sample Person (India)	Correlation Coefficient between International and Indian Recommendations
Male	18 - 30	1447.2 kCal	1370 kCal	0.65
	30 - 60	1448 kCal	1378 kCal	0.6
	>=60	1172.7 kCal	1093 kCal	0.79
Female	8 - 30	1226 kCal	1171 kCal	0.72
	0 - 60	1250 kCal	1203 kCal	0.7
	>=60	1113.5 kCal	1065 kCal	0.74

Source: Adapted from Table 4.8 in (Indian Council of Medical Research, 2010): Equations for prediction of BMR

3.2.1.1 Physical Activity Level

Physical activity level was characterized using responses to the physical activity questionnaire (PAQ) in the NHANES data set and is based on the Global Physical Activity Questionnaire (GPAQ) which pertains to questions regarding daily activities, leisure time activities, and sedentary activities. All survey participants which were over 2 years of age were eligible to participate. Proxy respondents answered questions for 2 – 11 year olds, and respondents 2 to 11 and 16 years of age or older were asked before their physical examination at home, using the Computer-Assisted Personal Interviewing-CAPI (interviewer administered) system. Respondents between 12 and 15 years were asked as part of the Mobile Examination Center (MEC) interview. The following coefficients were used for the categorization of respondents into activity levels based on responses to physical activity questions.

Table 3-4: Physical Activity Coefficients (PA Values) for use in EER Equations

Physical Activity Coefficients (PA Values) for use in EER Equations				
	Sedentary	**Low Active**	**Active**	**Very Active**
	Typical daily living activities (e.g., hosuehold tasks, walking to the bus)	**Typical daily living activities plus 30 - 60 minutes of daily moderate activity (e.g., walking at 5 - 7 km/h)**	**Typical daily living activities PLUS At least 60 minutes of daily moderate activity**	**Typical daily living activities PLUS An additional 60 minutes of vigorous activity or 120 minutes of moderate activity**
Boys 3 - 18 y	1	1.13	1.26	1.42
Girls 3 - 18 y	1	1.16	1.31	1.56
Men 19 y +	1	1.11	1.25	1.48
Women 19 y +	1	1.12	1.27	1.45

Source: *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients),* National Academy of Sciences (2005)

For the CCHS data set, physical activity status was a variable available within the data set, and calculated using similar criteria to the NHANES by Statistics Canada (Statistics Canada, 2004). For the NNMB data set, physical activity level was pre-determined by the National Institute of Nutrition using occupation of the respondent.

3.2.2 Healthy Food Diversity Index

The HFD-Index is an extension of the Berry Index developed by Drescher et. al. in 2007. Numerous economic food diversity studies utilize the Berry-Index to assess dietary diversity (Drescher, Thiele, & Mensink, 2007). The index is defined as:

$$BI = 1 - \sum s_i^2$$

where s_i is the share of product i in the total amount (kCal) of food consumed. The lower bound of the index is 0, and the upper bound is $1 - \frac{1}{n}$ whose limit value approaches 1 if the number of foods (n) increases. A value of $BI = 0$ results when an individual consumes only 1 food group, and the maximum, $BI = 1 - \frac{1}{n}$ refers to a situation in which an individual consumes all food groups in equal shares. The Healthy Food Diversity Index is an extension of the Berry Index, and is used to incorporate a more nutritional perspective into the index. The upper bound of the BI is not necessarily a favourable condition, it implies that individuals are consuming all food groups in equal quantities – instead, we would prefer an index that attaches appropriate weights to 'healthier' food groups. An approach is utilized by Drescher (2007) that attaches weights to consumption based on the nutritional recommendations for a 'balanced' diet.

The HFD is calculated using the following formula (Drescher 2007):

$$HFD = \left(1 - \sum_{i=1}^{n} s_i^2\right)\left(\sum_{i=1}^{n} hf_i * s_i\right)$$

where s_i is the share of food i on total quantities and hf_i is the health factor for food group i based on food guides for each country.

Table 3-5: Canadian Communities Health Survey Health Factors

	TEENS 14 - 18			
	Female	Health Factor	Male	Health Factor
Fruits and Vegetables	7	0.38	8	1
Grain Products	6	0.32	7	0.88
Milk and Milk Products	3.5	0.19	3.5	0.44
Meat and Meat Alternatives	2	0.11	3	0.38
Total	18.5	1	21.5	2.69
	ADULTS 19 - 50			
	Female	Health Factor	Male	Health Factor
Fruits and Vegetables	7.5	1.15	9	1.13
Grain Products	6.5	1	8	1
Milk and Milk Products	2	0.31	2	0.25
Meat and Meat Alternatives	2	0.31	3	0.38
Total	18	2.77	22	2.75
	ADULTS 51+			
	Female	Health Factor	Male	Health Factor
Fruits and Vegetables	7	1.08	7	0.88
Grain Products	6	0.92	7	0.88
Milk and Milk Products	3	0.46	3	0.38
Meat and Meat Alternatives	2	0.31	3	0.38
Total	18	2.77	20	2.5

Canadian health factors were disaggregated based on age and gender, with three different categories based on the ranges 14—18, 19—50, and over 51 years

of age (Table 3-5). Indian and U.S. Health Factors were similar, with the Indian food category of 'legumes and pulses' being listed instead of 'meat, fish, and eggs'; the latter category, for the NNMB being contained within 'milk and milk products' (Table 3-6 and Table 3-7).

Table 3-6: National Nutrition Monitoring Bureau Health Factors

Indian Food Group	Recommended Serving	Mean Servings	% of Servings	Health Factor
(1) Milk and Milk Products	2 to 3	2.5	12%	0.12
(2) Legumes, Pulses	2 to 3	2.5	12%	0.12
(3) Vegetables	3 to 5	4	20%	0.2
(4) Fruits	2 to 4	3	15%	0.15
(5) Cereals	6 to 11	8.5	41%	0.41
Total Servings		20.5	100%	
*Table Adapted for Indian Food Groups from (Drescher & Goddard)				
Source: *Dietary Guidelines for Indians,* (Indian Council of Medical Research, 2010)				

Table 3-7: National Health and Nutrition Examination Survey Health Factors

USDA FG	USDA Food Code	Recommended Servings	Mean Servings	% of Servings	Health Factor
Milk and Milk Products	1	2 to 3	2.5	12%	0.12
Meat, Fish, Eggs, and alternates	2, 3, 4	2 to 3	2.5	12%	0.12
Vegetables	7	3 to 5	4	20%	0.2
Fruits	6	2 to 4	3	15%	0.15
Breads and Cereals	5	6 to 11	8.5	41%	0.41
Total Servings			20.5	100%	

3.2.3 Adult Food Security Status

Adult Food Security Status (ADFS) is a "0" to "10" continuous variable that is calculated using affirmative responses to adult food security questions from the HFSSM. The specific questions of the HFSSM are presented in Table 2-3: Household Food Security Survey Module (HFSSM) along with their associated value.

Table 3-8: Adult Food Security Status

Variable	Potential Affirmative Response	Value Assigned	
FSD032A	1,2	1	HH Worried run out of food
FSD032B	1,2	1	HH Food didn't last
FSD032C	1,2	1	HH Couldn't afford balanced meals
FSD041	1	1	HH Adults cut size or skip meals
FSD052	1,2,3	1	HH How often did this happen
FSD061	1	1	HH Eat less than should
FSD071	1	1	HH Hungry, but didn't eat
FSD081	1	1	HH Lost weight, no money for food
FSD092	1	1	HH Adults not eat whole day
FSD102	1,2,3	1	HH How often adults not eat for day
Total		10	

Source: National Health and Nutrition Examination Survey: HFSSM

3.2.4 Child Food Security Status

Child Food Security Status (CDFS) is a continuous "0" to "8" variable calculated using affirmative responses to child food security questions. The questions outlined in Table 3-9 were used in the calculation of the variable:

Table 3-9: Child Food Security Status

Variable	Potential Affirmative Response	Value Assigned	
FSD032D	1,2	1	HH Relied on low-cost food for child
FSD032E	1,2	1	HH Couldn't feed child balanced meal
FSD032F	1,2	1	HH Child not eating enough
FSD111	1	1	HH Cut size of child meals
FSD122	1	1	HH Child skip meals
FSD132	1,2,3	1	HH How often child skip meals
FSD141	1	1	HH Child hungry in last 12 months
FSD146	1	1	HH Child not eat whole day
Total		8	

Source: National Health and Nutrition Examination Survey: HFSSM

3.2.5 Household Food Security Status

Together the ADFS and CDFS reflect the self-reported food security status at the household level. Statistics Canada and the Center for Disease Control use the same methodology for the classification of households into three categories: (1) food secure, (2) moderately food insecure, and (3) severely food insecure. Classification is based on affirmative responses to the HFSSM (Table 3-10).

Table 3-10: Household Food Security Categorization

Food Security Status		
Category Labels	Category Description	
	10-item Adult Food Security Scale	8-item Child Food Security Scale
Food Secure	no, or one, indication of difficulty with income-related food access; 0 or 1 affirmed responses	no, or one, indication of difficulty with income-related food access; 0 or 1 affirmed responses
Food Insecure, Moderate	indication of compromise in quality and/or quantity of food consumed; 2 to 5 affirmed responses	indication of compromise in quality and/or quantity of food consumed; 2 to 4 affirmed responses
Food Insecure, Severe	indication of reduced food intake and disrupted eating patterns; >=6 affirmed responses	indication of reduced food intake and disrupted eating patterns; >= 5 affirmed responses

3.3 Links between demographics and food security

In order to effectively target policy at the most vulnerable groups, or the groups for which the policy will have the greatest impact, it is essential to know the characteristics that describe these groups. Knowing the particular demographics that represent food insecure households enhances policy analysis.

3.3.1 Outline

Ultimately, ten models will be estimated across three data sets to assess the links between the outlined demographics and different measures of food security status.

Table 3-11: National Nutrition Monitoring Bureau Conceptual Model

Model (1)		Model (2)	
Log-Transformed Healthy Food Diversity	Community	Log-Transformed Energy Adequacy	Community
	Family Size		Family Size
	Income		Income
	Education		Education
	Marital Status		Marital Status
	House Type		House Type
	Family Type		Family Type
	Water Source		Water Source
	Gender		
	Age		
	Physical Activity Level		

Table 3-11, Table 3-12, and Table 3-13 list the food security indicators and individual and household characteristics utilized for this analysis. The NNMB analysis will consist of two models, one estimating the effect of individual- and household- level characteristics on healthy food diversity and one estimating their effect on Energy Adequacy. The NHANES and CCHS analyses will consist of four models each, estimating the effect of individual- and household- level characteristics on adult and child food insecurity, in addition to healthy food diversity and Energy Adequacy.

Table 3-12: National Health and Nutrition Examination Survey: Conceptual Models (3) and (4)

Model (3)		Model (4)		Model (5) and (6)	
Log-Transformed Healthy Food Diversity	Income	Log-Transformed Energy Adequacy	Income	Adult (5) and Child (6) Food Insecurity Score	Income
	Physical Activity Level		WIC		Physical Activity Level
	Gender		Food Stamp		Gender

	WIC		Emergency Food		WIC
	Food Stamp		Education		Food Stamp
	Emergency Food		Marital Status		Emergency Food
	Education		Household Size		Education
	Marital Status				Marital Status
	Age				Age
	Household Size				Household Size

Table 3-13: Canadian Communities Health Survey Conceptual Model

Model (7)		**Model (8)**		**Model (9) and (10)**	
Log-Transformed Healthy Food Diversity	Income	Log-Transformed Energy Adequacy	Income	Adult (9) and Child (10) Food Insecurity Score	Income
	Physical Activity Level		Education		Physical Activity Level
	Gender		Marital Status		Gender
	Education		Household Size		Education
	Marital Status		Home Ownership		Marital Status
	Age				Age
	Household Size				Household Size
	Home Ownership				Home Ownership

The estimation methods utilized for models (1) through (10) are outlined in Table 3-14. Models (1) and (2) were estimations with HFD and EA as dependent variables, for the NNMB data set. For Model (1), log-transformed HFD was initially estimated using Ordinary Least Squares Regression methods. After performing a series of regression diagnostic tests, it appeared that while the model followed an approximate normal distribution, did not have omitted variable bias or multicollinearity issues, heteroskedasticity was present, and thus, re-estimated with heteroskedasticity-consistent (robust) standard errors.

For Model (2) EA was originally estimated using ordinary least squares. Regression diagnostics demonstrated that while Model (2) followed an approximately normal distribution with no presence of multicollinearity, an omitted variables bias and heteroskedasticity were present. As a result, the model was re-estimated with a log-transformed Energy Adequacy dependent variable. Ultimately, due to the presence of income endogeneity in the traditional calorie intake-income model, instrumental variables regressions were run using the new log-transformed Energy Adequacy. In order to identify possible instruments the literature was consulted, and correlational analyses were implemented. The presence of a sanitary latrine, electrification, and a separate kitchen were all correlated with income and identified as possible instrumental variables. Income was instrumented and sanitary latrine used as an instrumental variable. Ultimately, all three variables were chosen for the final IV regression in Model (2).

Endogeneity was tested for at the 5% S.L. and as such we can reject the null hypothesis that the variables are exogenous, and thus endogeneity is present. Additionally, first-stage regression summary statistics suggest that we can reject the null that the instruments are weak. At the 10% s.l. using the Sargan test for over-identifying restrictions, we can reject the null that the error term is correlated with the instruments, suggesting that the chosen instrumental variables are exogenous thereby encouraging the need for an IV regression.

Models (3) – (6) were estimations with HFD, EA, ADFS, and CDFS as dependent variables for the NHANES data set. Initially, all 4 models were estimated as Seemingly Unrelated Regressions, under the assumption that estimation of the 4 models as a system would contribute to estimation efficiency. The generation of a Breusch-Pagan test of independence chi-squared suggests that the residuals are not independent, and there are efficiency gains from estimating as a system. HFD and EA were estimated as log-transformed variables. Regression diagnostic results from Model (3) suggested a non-normality, heteroskedasticity, and omitted variables problem. In order to correct for non-normality age, income, and household size were squared and re-estimated. This did not correct for non-normality in the model.

Initial diagnostics for Model (4) suggested a heteroskedasticity and omitted variables problem. Models (5) and (6) appeared to have a heteroskedasticity, but no omitted variables or non-normality problem. Data limitations prevented correcting for the omitted variables bias. A likely contributor to this is the exclusion of food price data in the model. Food consumption is an economic variable, and price is invariably a major contributing factor to the quantity and variety (an indicator of quality) of food consumed by an individual. If the demographics data set was more expansive, it may have been possible to run an IV regression, with a variable that takes food prices into account. Ultimately the system of equations, models (3) – (6) was estimated with Robust Standard Errors (RSE), to correct for the presence of heteroskedasticity.

Models (7) – (10), estimations with HFD, EA, ADFS, and CDFS as dependent variables for the CCHS data set were originally estimated as a system, similar to Models (3) – (6). Results from the Breusch-Pagan test for independence suggested that there were no gains from estimating the models as a system. As a result, Models (7) – (10) were estimated as independent equations. HFD and EA were estimated as log-transformed variables. Models (7) and (8) appeared to have an omitted variables bias, with only model (7) also having a problem with heteroskedasticity. Models (9) and (10) had no omitted variables bias, but a problem with heteroskedasticity, as well. Ultimately, independent equations were estimated with OLS. Because CCHS uses a multi-stage survey design, the bootstrap re-sampling method is suggested for use in the CCHS. As a result, Models (7) – (10) were estimated using OLS with Bootstrap Standard Errors.

Descriptions of the estimation methodologies, including the regression diagnostic tests, are provided in the rest of Chapter 3. Ordinary Least Squares, Seemingly Unrelated Regressions, and Instrumental Variables regression techniques will be discussed. In addition to tests for non-normality, omitted variables bias, multicollinearity, and heteroskedasticity. In addition, elasticities will be generated in order to compare coefficients across countries, and a summary of elasticity-generating methodology will be provided as well.

Table 3-14: Estimation Methods

Model #	Final Estimation Methods	Data Set
Model (1)	Ordinary Least Squares with Heteroskedasticity Consistent Standard Errors	NNMB
Model (2)	Instrumental Variables Regression with Robust Standard Errors	NNMB
Model (3)	Seemingly Unrelated Regression with Robust Standard Errors	NHANES
Model (4)	Seemingly Unrelated Regression with Robust Standard Errors	NHANES
Model (5)	Seemingly Unrelated Regression with Robust Standard Errors	NHANES
Model (6)	Seemingly Unrelated Regression with Robust Standard Errors	NHANES
Model (7)	Ordinary Least Squares with Bootstrap Standard Errors	CCHS
Model (8)	Ordinary Least Squares with Bootstrap Standard Errors	CCHS
Model (9)	Ordinary Least Squares with Bootstrap Standard Errors	CCHS
Model (10)	Ordinary Least Squares with Bootstrap Standard Errors	CCHS

3.3.1.1 Ordinary Least Squares

The classic linear regression model (CLR) consists of five basic assumptions about how observations are generated (Kennedy 2010 6ed):

(1) The dependent variable can be calculated as a linear function of a set of independent variables, plus a disturbance term.
(2) The expected value of the disturbance term is zero, that is, the mean of the distribution from which the disturbance term is drawn is zero
(3) The disturbance terms have the same variance and are uncorrelated
(4) The observations of the independent variable can be considered fixed in repeated samples
(5) There is no exact linear relationship between independent variables and the number of observations is greater than the number of independent variables.

Assuming a multivariate analysis, the corresponding mathematical equations are as follows[1]:

(1a) $Y = X\beta + \varepsilon$
(2a) $E\varepsilon = 0$
(3a) $E\varepsilon\varepsilon' = \sigma^2 I$
(4a) X fixed in repeated samples
(5a) Rank of $X = K \leq N$

When these assumptions are met, the OLS estimator produces consistent and efficient estimates.

3.3.1.2 Simultaneous Equations

Given a system of simultaneous equations, all of the endogenous (dependent) variables in a model are random variables. A change in any disturbance term changes all of the endogenous variables, because they are determined *simultaneously* (Kennedy 2010, p. 171). In a system of equations, at least one equation will have an endogenous variable as an independent variable. As a result, this endogenous variable cannot be considered fixed in repeated samples and assumption 4 of the CLR model is violated. As a result of this violation, OLS is not the most efficient estimation technique that can be utilized. A popular method for the estimation of a system of equations is the Seemingly Unrelated Regression (SUR) technique.

3.3.1.3 Seemingly Unrelated Regressions

A seemingly unrelated regression system is comprised of a series of equations linked by the fact that their disturbance terms are highly correlated (Zellner 1962). One way to write the SUR model, given by Moon (2008) is in a form of multivariate regression with parameter restrictions (Moon 2008). For this, define $X_t = [x_{1t}, x_{2t}, \dots, x_{Nt}]$ and $A(\beta) = diag(\beta, \dots, \beta_N)$ to be a $(L \times N)$ block diagonal coefficient matrix. The SUR model, then, can be written as:

$$Y_t = A(\beta)X_t + U_t$$

And the coefficient $A(\beta)$ satisfies:

$$vec\big(A(\beta)\big) = G\beta$$

[1] The mathematical terminology is as follows: Y is a vector of observations on the dependent variable; X is a matrix of observations on the independent variables; ε is a vector of disturbances, or the disturbance term; σ^2 is the variance of the disturbances; I is the identity matrix; K is the number of independent variables; N is the number of observations. (Kennedy 2010 6ed, Table 3.1.)

According to Srivastava (1991), it is assumed that

$$E(u_i) = 0, \qquad E\left(u_i u_j'\right) = \sigma_{ij} I_T, \qquad i, j = 1,2, \dots, M,$$

so that

$$E(U) = 0, \;\; E(UU') = (\sum \otimes I_T)$$

where σ_{ij} is the $(i,j)th$ element of the $M \times M$ matrix Σ.
The least squares estimator of β is given by

$$b = (X'X)^{-1}X'y,$$

which is an unbiased estimator with a variance-covariance matrix:

$$V(b) = \; E(b - \beta)(b - \beta)' = (X'X)^{-1}X'(\Sigma \otimes I_T)X(X'X)^{-1}$$

If the disturbance terms are correlated, however, the estimator b is still unbiased – however, it is not BLUE (the Best Linear Unbiased Estimator). The estimator b ignores the correlated nature of disturbances across the equations and therefore a more appropriate estimator is the generalized least squares (GLS) estimator:

$$b_G = [X'(\Sigma^{-1} \otimes I_T)X]^{-1}X'(\Sigma^{-1} \otimes I_T)y,$$

The estimator b_G, then, is unbiased with variance-covariance matrix given as follows:

$$V(b_G) = E(b_G - \; \beta)(b_G - \; \beta)' = [X'(\Sigma^{-1} \otimes I_T)X]^{-1} = \frac{1}{T}\Omega$$

Zellner (1962) proposed two feasible versions of the GLS estimator (Srivastava 1991)

$$\tilde{\beta} = [X'\left(\tilde{\Sigma}^{-1} \otimes I_T\right)X]^{-1}X'\left(\tilde{\Sigma}^{-1} \otimes I_T\right)y,$$
$$\hat{\beta} = [X'\left(\hat{\Sigma}^{-1} \otimes I_T\right)X]^{-1}X'\left(\hat{\Sigma}^{-1} \otimes I_T\right)y,$$

By multiplying a single equation by the transpose of a matrix of observations on *all* of the exogenous variables in the system, "applying generalized least squares (GLS) creates 2 stage least squares (2SLS) estimates" (Kennedy 2010, p. 180).

The generalized least squares estimation procedure includes two stages (Kennedy 2010, p.180):
stage 1: calculate the 2SLS estimates of the identified equations
stage 2: use the 2SLS estimates to estimate the structural equations' errors, and then use these to estimate the contemporaneous variance-covariance matric of the structural equations' errors

SUR regression techniques, instead of independent equations with different functional forms, have been utilized because fewer observations can be required to obtain reliable functions (Smith 2000). The popularity of SUR techniques is due primarily to its "applicability to a large class of modeling and testing problems" along with the associated relative ease of estimation (Fiebig 2003).

3.3.1.4 Instrumental Variables Regression

The third assumption of the CLR model is that the disturbance terms have the same variance and are uncorrelated with the regressors in the equation. When that assumption is violated, we have an 'endogeneity' problem. When we have an endogenous regressor, we can use an Instrumental Variable (IV) procedure to produce a consistent estimator (Kennedy 2010, 141). To use an IV estimator we must find an instrument that is both uncorrelated with the disturbance term, and highly correlated with the endogenous regressor. Multiple instruments can be utilized for the IV procedure and the resulting equation is said to be 'over-identified'. In the case of over-identification, two-stage least squares (2SLS) is the usual estimation alternative (Greene 2000, 682). A thorough derivation of the 2SLS estimator is provided in Greene 2000 (p. 682 – 684). Ultimately, the 2SLS name stems from the two regressions in the procedure (IBM Statistics SPSS Manual, 2011):
(1) stage 1: obtain OLS predictions from the estimated values of the problematic predictor, and (2) use those values to estimate a linear regression model of the dependent variable.

3.3.1.5 Bootstrap Standard Errors

Bootstrap Standard Errors (BSE) is used to determine the sampling properties of empirical estimators using the sample data, rather than broad theoretical results (Greene 2000). This technique was developed by Efron (1979), and is recommended for CCHS analysis. According to Ader et al (2008) bootstrap procedure is recommended when the theoretical distribution of a statistic of interest is complicated or unknown. As a result, we will use bootstrap standard errors for the CCHS analysis. It was not necessary to use BSE for the NHANES or NNMB analyses due to analytical requirements of the organization. As a result, Robust Standard Errors were used for those samples instead.

3.3.1.6 Econometric Tests

The following tests will be implemented to check that the data meets the assumptions required for the regression: (1) normality, (2) heteroskedasticity, (3) multicolinearity, and (4) test for omitted variables.

3.3.1.6.1 Normality

Normality in the data will be tested for using a visual k-density plot. K-density plots will be generated and plotted against their normal distribution. Any deviation of the k-density from the normal implies non-normality in the data (UCLA Statistical Consulting Group).

3.3.1.6.2 Heteroskedasticity

Heteroskedascity can pose potential problems for inferences based on least squares estimation and it is rare for one to determine the exact nature of the heteroskedasticity. Ordinary Least Squares is nonetheless a consistent estimator of $\boldsymbol{\beta}$ even in the presence of heteroskedasticity (Green 1997, p. 508).

Heteroskedasticity does, however, have the potential to bias standard errors, thereby biasing the inference of hypothesis tests. For a thorough review of heteroskedasticity, see Green (2000) Chapter 12. A test was devised by (White, 1980) to test for the presence of heteroskedascity, even when the exact nature is unknown:

The correct (non-heteroskedastic) covariance matrix for the least squares estimator is (Green 2000):

$$Var[\mathbf{b}] = \sigma^2[\mathbf{X}'\mathbf{X}]^{-1}[\mathbf{X}'\mathbf{\Omega}\mathbf{X}][\mathbf{X}'\mathbf{X}]^{-1}$$

, which can be estimated by:

$$Est.Var[\mathbf{b}] = [\mathbf{X}'\mathbf{X}]^{-1}\left[\sum_{i=1}^{n} e_i^2 x_i x'_i\right][\mathbf{X}'\mathbf{X}]^{-1}$$

The conventional estimator, then, is

$$\mathrm{V} = s^2[\mathbf{X}'\mathbf{X}]^{-1}$$

If there is no heteroskedasticity then the conventional estimator will give a consistent estimator of $\mathrm{Var}[\mathbf{b}]$, but if there is heteroskedasticity present, then it will not. As a result of this operation, White devised a statistical test by obtaining nR^2 in the regression of e_i^2 on a constant and all unique variables in $\mathbf{x} \otimes \mathbf{x}$.

According to Greene (2000), the White test is extremely general and while it may identify the presence of heteroskedasticity, it does not offer solutions to correct for it. The White test statistic is asymptotically distributed with a chi-squared distribution and $\mathrm{P} - 1$ degrees of freedom, where P is the number of regressors in the regression, including the constant (Green 2000, p. 508).

3.3.1.6.3 Multicollinearity

According to the Gauss-Markov theorem, the least squares estimator has the smallest variance (Greene 2000). If two predictor variables within a multiple regression equation are highly correlated, it is not possible to separate the individual effects of the components, and a multicollinearity problem is said to exist. As the degree of multicollinearity increases, standard errors may become inflated as coefficient estimates become increasingly unstable. See Greene (2000) pp. 255 for a detailed discussion of the multicollinearity problem. In order to detect the multicollinearity problem within this data, a variance inflation factor (VIF) test was utilized. A VIF greater than ten suggests a multicollinearity problem in the model (UCLA Statistical Consulting Group, 2012).

3.3.1.6.4 Omitted Variables Test

A model specification error can occur when relevant variables are omitted from the model (UCLA Statistical Consulting Group, 2012). If we omit relevant variables, estimates of both β_1 and σ^2 are biased and inconsistent (Green 2000). To test for the omitted variable bias, a regression specification error test (RESET) will be applied (UCLA Statistical Consulting Group, 2012).

3.3.1.6.5 Elasticities

Estimation procedures and model specifications for models across countries were selected based on the regression diagnostic results presented in Chapter 3.3.1. Both the Healthy Food Diversity Index and Energy Adequacy were log-transformed, which changed the boundaries of the dependent variable to a lower bound of $-\infty$ and $+\infty$. The log transformation was done using the same methodology as Drescher (2007) as outlined by Greene (1997):

$$THFD = \ln\left(\frac{HFD}{(1-HFD)}\right) \text{ and } TCA = \ln\left(\frac{CA}{(1-CA)}\right)$$

Descriptive statistics including means and correlations are presented using the non-log transformed variable. ADFS and CDFS were not transformed, and estimated as continuous variables. As a result, the nature of the variable specifications resulted in two types of models, 'level-level' and 'log-level'. Models in which HFD and EA are the dependent variables would be considered log-level, or semi-log, equations. Models in which ADFS and CDFS are the dependent variables, would be considered level-level equations. Again, assuming the following notation for functional form will be assumed:

$$Y = X\beta + \varepsilon$$

Coefficient interpretations for both model types are presented in Table 3-15. When elasticities are discussed, the equations outlined in Table 3-15 will be used for their calculation. The use of elasticities during this analysis will allow for the unit-less comparison of coefficients across the three data sets.

Table 3-15: Elasticities

Model	Dependent Variable	Independent Variable	Interpretation	Elasticity
$Level - Level$	Y	x	$\Delta Y = \beta_1 \Delta x$	$\varepsilon_{LL} = \beta_1 * \frac{\bar{x}}{\bar{Y}}$
$Level - Log$	Y	$Log(x)$	$\Delta Y = \frac{\beta_1}{(100\% * \Delta x)}$	
$Log - Level$	$Log(Y)$	x	$\%\Delta Y = 100 * \frac{\beta_1}{\Delta x}$	$\varepsilon_{LGL} = \beta_1 * \bar{x}$
$Log - Log$	$Log(Y)$	$Log(x)$	$\%\Delta Y = \square_1 \%\Delta x$	

Source: Table adapted from Table 2.3. *Introductory Econometrics: A Modern Approach,* Jeffrey M. Wooldridge. 5th ed 2012. p.44

3.4 Linking Measures of Food Security

Ultimately, the link between different measures of food security, in our case, the HFD-index, EA, and self-reported food security will be developed through contrasting and comparing the results of models (1) – (10). First, regression results will be presented in Chapter 4 that highlight the key differences how demographics affect each outcome indicator different. Second, comparisons between indicators, and across countries will be presented in Chapter 5. In Chapter 5.4., individuals that can be characterized as food insecure according to all three indicators of food security will be discussed.

3.5 Conclusion

In Chapter 3 the conceptual model was presented and an outline of the methodology utilized for measuring food security, using different indicators, assessing the linkages between demographics and food security indicators, and determining the relationship between different measures of food security status was discussed. The results of the analysis outlined in Chapter 3 will be presented in Chapter 4.

4 Chapter 4: Results

Energy Adequacy (EA), the Healthy Food Diversity Index (HFD), adult food security status (ADFS), and child food security status (CDFS), where available, were regressed on a series of household and individual-level demographics for the NHANES, CCHS, and NNMB data sets. Because the information was collected by three different statistical organizations, the information available is not identical across the three data sets. In the following section, the results from multivariate regression analysis will be presented. Results will be separated by indicators, while similarities and differences between them will be presented in the final discussion chapter.

4.1

Three data sets were utilized for this analysis: (1) National Health and Nutrition Examination Survey (NHANES) for the United States from 2007/2008, (2) Canadian Communities Health Survey (CCHS) for Canada for 2004/2005, and (2) National Nutrition Monitoring Bureau (NNMB) Survey for Rural Populations for India 2004/2005. Both rural and urban populations are included in the CCHS and NHANES data set, while the NNMB is restricted to rural populations.

4.1.1 National Health and Nutrition Examination Survey

The NHANES program began in the early 1960s, when a series of surveys was conducted focusing on selected health topics or population groups. Since 1999, the survey has become a continuous program, with data collected every two years. The survey examines a nationally representative sample of 5, 000 persons a year and findings from the survey are used to determine the prevalence of major diseases (including the risk factors for major diseases) (CDC, 2013). The data set used was retrieved from the Center for Disease Control (CDC). Questionnaires and other associated files are publicly available on their Website. Data was retrieved for the 2007/2008 survey, as that was the most recent cycle for which food security information was available. The additional component containing food security questionnaire responses was released for the 2009/2010 cycle in March, 2013.

4.1.2 Canadian Communities Health Survey

Cycle 2.2. of the CCHS was developed to collect focused nutritional information pertaining to the population. It was the first national nutrition data to be collected since Nutrition Canada survey in 1970-1972 (Health Canada, 2012). This cross-sectional survey provides food intake information, food group and nutrient consumption, use of nutrition supplements, physical activity, Body Mass Index, and household food security at the national and provincial level. The data were collected in 2004, and the survey was composed of two parts: a general

health questionnaire and a 24-hour dietary recall. The target population of the survey was all individuals 0 or above, living in private dwellings in the ten Canadian provinces and reflects about 98 percent of the population in those ten provinces.

The CCHS was assessed at the Research Data Center (RDC). Data pertaining to the 24-hour dietary recall, physical activity levels, and anthropometric measurements are not publicly available. Access to the data was approved by Statistics Canada, and output was examined and approved for vetting by the RDC analyst at the University of Alberta.

4.1.3 National Nutrition Monitoring Bureau

NNMB data was accessed and analyzed at the National Institute of Nutrition, a division of the Indian Council of Medical Research in Hyderabad, Andhra Pradesh, India in March 2013. Data analysis was conducted with the support of an NIN biostatistician, Dr. N. Balakrishna. The NNMB survey for rural populations was collected once over 2004/2005.

4.2 Variable Descriptions

Descriptions of each variable are presented in Appendix 1 along with their corresponding values by data set. Not all variables were available across all three data sets. For example, total land owned, community, type of house, electrification, separate kitchen, type of cooking fuel, source of drinking water, and presence of a sanitary latrine were specific to the NNMB data set. Whether or not a household received WIC, Food Stamps, or accessed an emergency food source were policy variables specific to the NHANES data set. Physical activity level, marital status, gender, education, age, and household size were available for all three data sets, although their values differ slightly.

EA, HFD, and where available, ADFS and CDFS were the dependent variables in the models estimated. EA and HFD were, for all regressions, log-transformed to TEA and THFD. ADFS and CDFS were kept in their original forms.

Income was a continuous variable for all three data sets, in CDN dollars for the CCHS data set, in Rupees for the Indian data set, and in USD for the NHANES data set. Physical activity was a categorical variable with 3 levels for the CCHS and NNMB data sets, with corresponding levels of sedentary, moderate, and active. Physical activity was a categorical variable with 4 levels for the NHANES data set, with corresponding levels of sedentary, low active, active, and very active. Gender was either male or female, for all three data sets. Education was a categorical variable for the NHANES and CCHS data sets, and continuous for the NNMB. This was done because the proportion of respondents in the NNMB data set with education levels beyond secondary was significantly

limited. Marital status was a categorical variable for all three data sets. NHANES marital status categories were married, widowed, divorced, separated, never married, or living with partner. CCHS marital status categories were married, common-law, widowed, divorced, separated, or single. NNMB marital status categories were married, un-married, or widowed or divorced. Age and household size were continuous variables for all three data sets. Respondent age could range from 12 to 80, 12 to 150, or 12 to 99, for the NHANES, CCHS, or NNMB data sets, respectively.

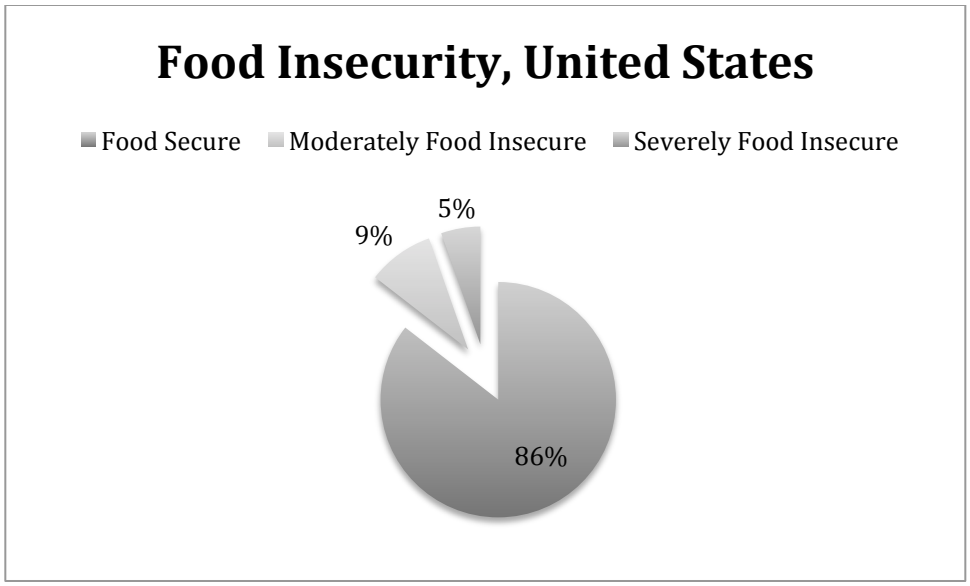
For variables that are only available for the NNMB data set, total land owned was reported as a continuous variable, in acres. Community was a categorical variable that represented respondent's membership to a government identified disadvantaged community. Membership to one of these communities reflects access to policy schemes that are not available to those not considered advantaged. The 4 categories for community are Scheduled Tribe (ST), Schedule Caste (SC), Backward Caste (BC), and Other (which would include Mostly Backward Caste and non-disadvantaged populations). There are three house types that characterize the type of house variable. A 'kutcha' house would be one made of either mud thatched wall, or a mud thatched roof, or both. A 'semi-pucca' house would have either a brick or stone wall with either a tin or thatched roof. A 'pucca' house would not have any mud used in its construction and a solid (either asbestos and tile or reinforced concrete (RCC)) roof. There are three possible family types for the NNMB analysis, nuclear, extended or joint. Electrification, sanitary latrine, and separate kitchen are dummy variables which indicate the presence of these three amenities. There are four possible sources of drinking water: open well, tube well, tap, and either pond/stream/lake.

4.3 Non-Parametric Statistics

4.3.1 Descriptive Statistics

4.3.1.1 United States

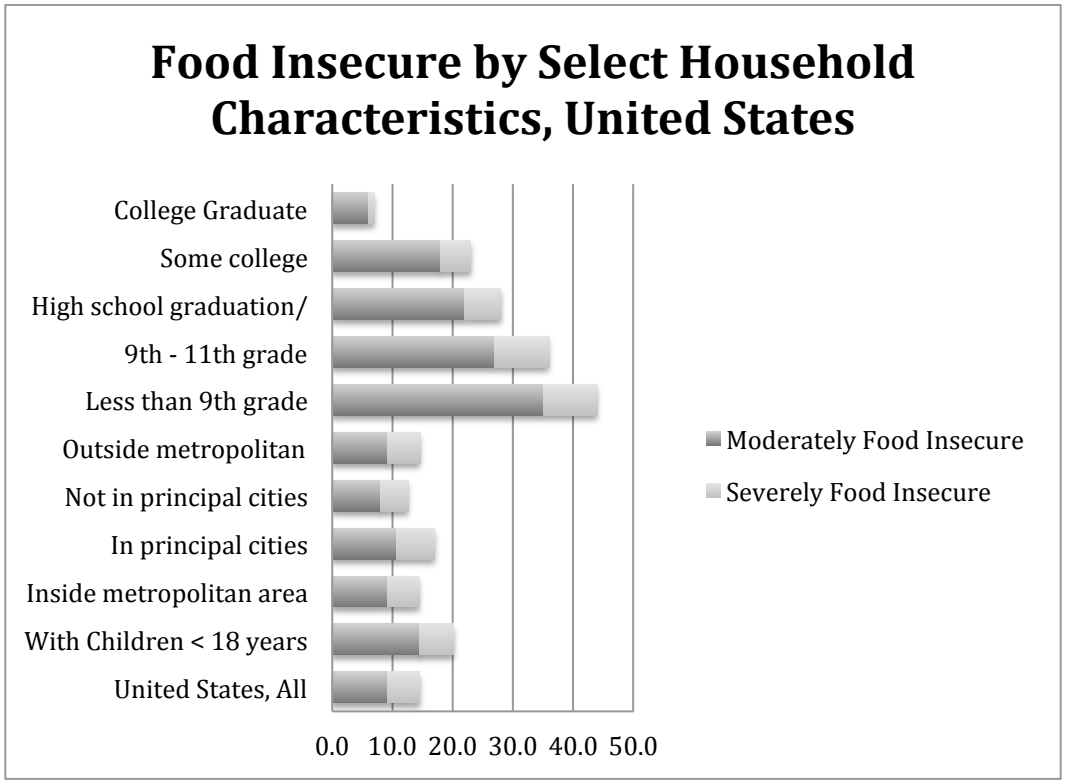
Years after the onset of the financial and economic crisis, hunger remains high in the United States. This level of hunger continued until 2010, according to the most recent government report (with the latest statistics), released in September 2011 (Coleman-Jensen, Nord, Andrews, & Carlson, 2011). Using the household food security classifications outlined in Table 3-10, in 2010, 17.2 million households (or one in seven households) were food insecure, the highest number ever recorded in the United States (Coleman-Jensen, Nord, Andrews, & Carlson, 2011). Of these 17.2 million households, 9 percent were moderately food insecure, while 5 percent were severely food insecure.



Source: Table Adapted from (Coleman-Jensen, Nord, Andrews, & Carlson, 2011)

Figure 4-1: Food Insecurity, United States

By examining respondents by education level, it is observed that lower education level tend to be associated with greater food insecurity (Figure 4-1). 20 percent of respondents that were either moderately or severely food secure had children less than 18 years of age.

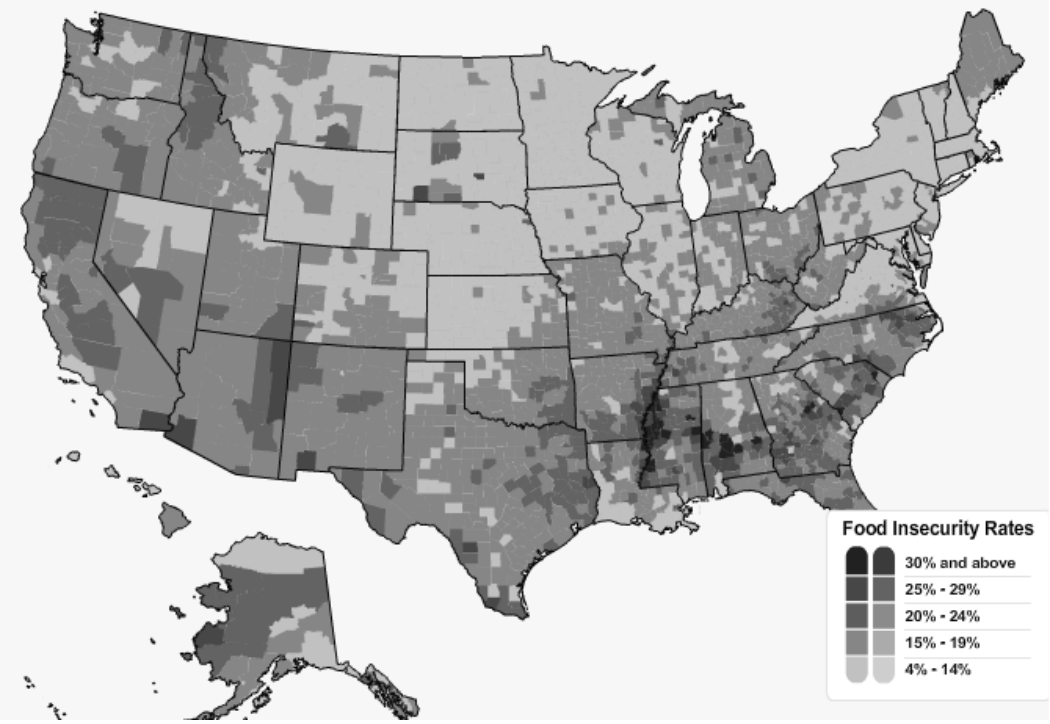


Source: Table Adapted from (Coleman-Jensen, Nord, Andrews, & Carlson, 2011)

Figure 4-2: Food Insecure by Select Household Characteristics, United States

Children were insecure for at least one time during the year in 9.8 percent of households with children. In one percent of households with children, one or more of the children experienced the most severe condition of food insecurity, with levels of food intake below levels considered adequate by caregivers (Coleman-Jensen, Nord, Andrews, & Carlson, 2011, p. 6). Food insecure children are more likely to reside in rural communities, with rural food insecure children making up two-thirds of counties with high rates of child food insecurity (Feeding America, 2013).

Figure 4-2 highlights the distribution of children facing varying degrees of food insecurity. The density of respondents is greatest for states with a heavy proportion of rural residents, with three in ten children in New Mexico, Arizona, Oregon, and D.C. facing food insecurity, in addition to one in four children in Georgia, Florida, Arkansas, Nevada, Texas, South Carolina, Mississippi, North Carolina, California, Alabama, Ohio, Oklahoma, and Tennessee (Feeding America, 2013).



Source: Feeding America (2013)

Figure 4-3: Child Food Insecurity in the United States (2011)

Given publicly available data, the 2007-08 cycle was the most recent data set available, which included both dietary intake, anthropometric assessments, and the HFSSM. This NHANES sample consists of 3709 respondents. Over half the sample (57 percent) is male. Approximately 92 percent of the sample had not received food stamps or WIC benefits within the last 12 months, while 86 percent of the sample did not access food from any food bank, food pantry, soup kitchen, or church within the last 12 months. Only 9 percent of respondents report

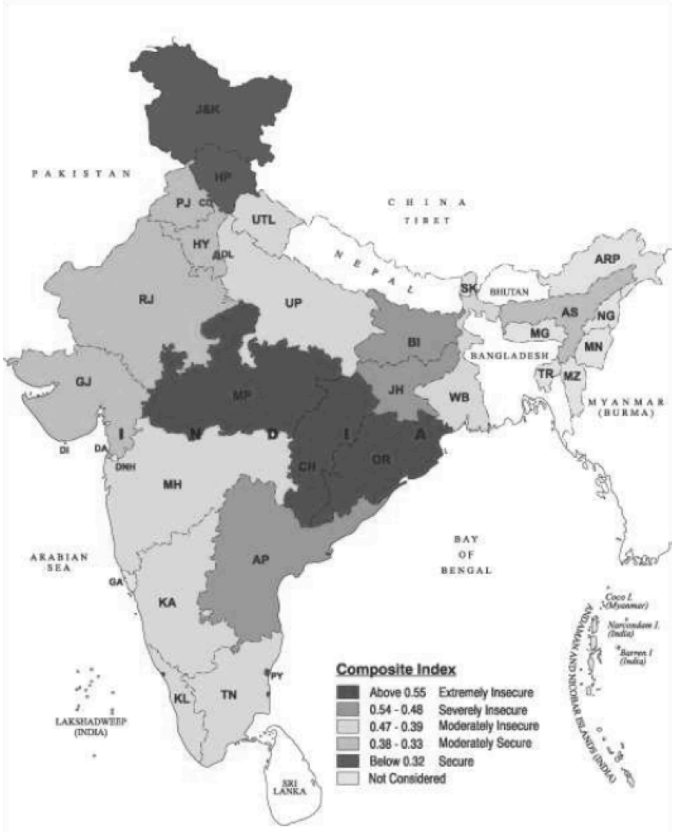
education level as less than 9th grade. 15 percent of respondents are, or have, completed between 9th and 11th grade. 25 percent of individuals have at least a high school diploma or equivalent. 29 and 22 percent, respectively, have some college education or a college or equivalent degree. The majority of respondents (62 percent) are married. 11 percent are divorced, 14 percent are single, 6 percent are widowed, and 7 percent are living with a partner.

Mean Energy Adequacy (Appendix 2) is approximately 0.768. Energy Adequacy appears to be positively associated with education, with the greatest average EA corresponding to college graduates. Respondents living with partners tended to have greater EA than all other marital statuses (Appendix 3). The Healthy Food Diversity Index (HFD) averages a score of 0.141 within this sample, with a minimum of 0 (implying no food diversity) and a maximum of 0.193 (implying the greatest food diversity within the sample). Average HFD appears to be higher for females, relative to males. Education appears to be a positive contributor to HFD, with college graduates having a greater HFD relative to all other education levels. Widowed and married respondents have the highest HFD relative to divorced, living with partner, or single respondents.

4.3.1.2 India

The proportion of India's population living below the poverty line amounts to more than 300 million people, with approximately 30 percent of India's rural population living in poverty. While this statistic is startling, poverty has been declining in recent years. Government of India estimates suggests that poverty declined from 37.2 percent in 2004-05 to 29.8 percent in 2009-10. Rural poverty fell from 41.8 percent to 33.8 percent, and urban poverty fell from 25.7 percent to 20.9 percent over the same period (World Bank 2012). Figure 4-4 and Figure 4-5 depict the distribution of respondents based on their food insecurity, according to rural and urban geographic locations. Comparing both Figures suggests that food insecurity is far more severe across rural populations.

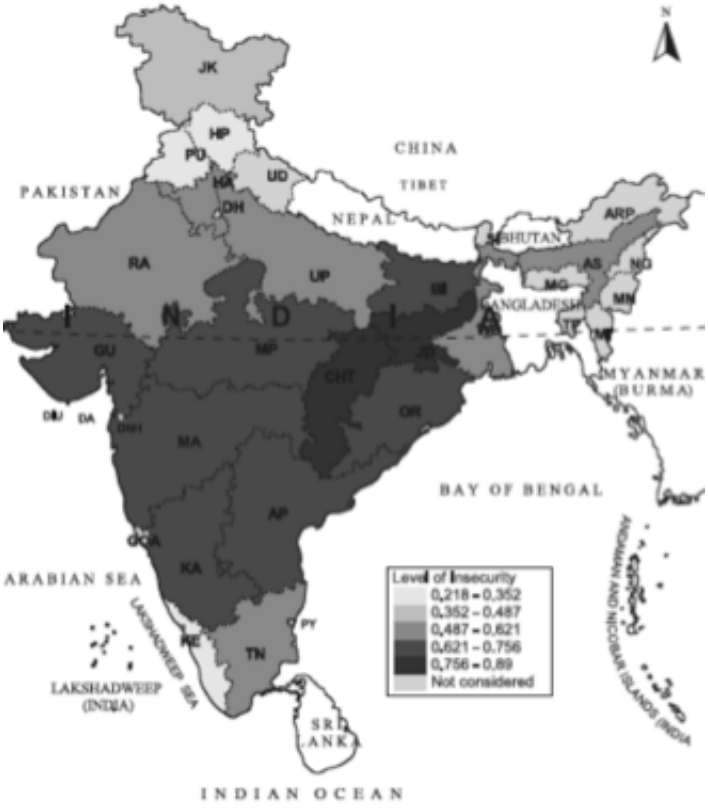
Urban India (1990-2000)



Source: *Food Insecurity Atlas of Urban India* M.S. Swaminathan Research Foundation and World Food Programme. Chennai. 2002.

Figure 4-4: Food Insecurity Map: Urban India

Rural India (1990-2000)



Source: *Report on the State of Food Insecurity in Rural India* M.S. Swaminathan Research Foundation and World Food Programme. Chennai. 2008.

Figure 4-5: Food Insecurity Map: Rural India

The categorization of individuals as food insecure for was done by creating a composite index using data assembled from independent data sets from as early as 1991 and as late as 2001. The maps themselves do not pertain to any specific year, but represent both urban and rural food insecurity over a 10-year period as estimated by the M.S. Swaminathan Research Foundation in 2008. The composite index was created by aggregating values from 6 separate indices and is presented in Table 4-1.

Table 4-1: Indicators Utilized for Food Security Assessment and Creation of Composite Index

Urban	**Rural**
Food Affordability Index	Percentage of population consuming less than 1890 KCAL/cu/day
Livelihood Access Index	% of rural households without access to safe drinking water
Housing Index	% of rural household not having access to toilet on premises
Discrimination Index	% of rural women with anaemia
Sanitation and Health Index	% of rural women with CED
Nutritional Outcome Index	% of rural children with anaemia
	% of rural children stunted

Source: *Food Security Atlas: Urban India* (2002) & *Food Security Atlas: Rural India* (2008); MSSRF and WFP

The selected data set that will be discussed here is the National Nutrition Monitoring Bureau survey for rural populations (2007-08). Based on a review of analyses in the past, it is to be expected that food insecurity would be more severe for respondents in our data set, than for a similar survey done for urban populations. The selected sample for the NNMB data set consists of 22 157 individuals and does not include any respondents under the age of 12. This was done solely for comparative purposes with the NHANES and CCHS data sets, which do not collect physical activity information on respondents less than 12 years of age, with physical activity level being essential information for the calculation of recommended dietary intake. With reference to age, no particular age group dominates the sample. An overwhelming majority of respondents fall into ‘sedentary’ and ‘moderate’ physical activity levels, with only 53 respondents engaging in physical activities that would be characterize their activity level as ‘heavy’. The majority of respondents tend to fall into ‘Backward Caste’ and ‘Other’ community groupings. Using education as a categorical variable for the purposes of descriptive statistics, only 1245 respondents report that the head of the household holds a college degree, while the majority of respondents report fall between 5 to 8 and 9 to 12 years of education. 6767 respondents live in households in which the head is illiterate. These education levels are specific to the head of the households, and unlike NHANES and CCHS data sets, do not

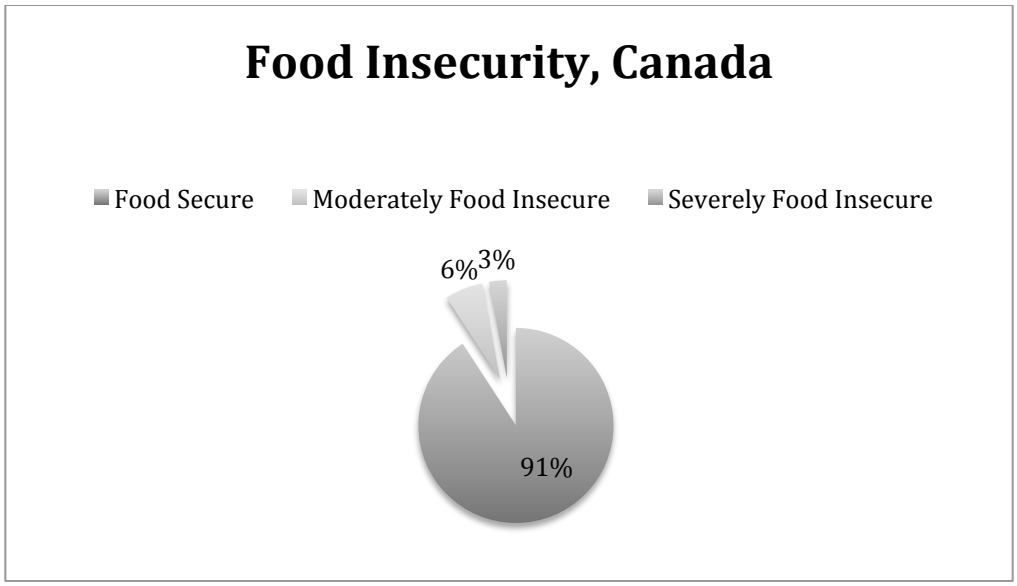
indicate the highest level of education attained at the household level. In addition, a majority of respondents reporting per-capita income >= 1500 Rs. annually, reside in nuclear families larger than 5 members.

With regards to household amenities, data that is only available for the NNMB data set, only 6309 respondents report the presence sanitary latrine. 16 240 and 17 248 report electrification and a separate kitchen from the rest of the home, respectively. The majority of respondents live in 'semi-pucca' homes. Respondents report different sources of water including open well, tube well, and tap, with very few, only 370 respondents reporting their main source of drinking water is a pond or stream. Occupation wise there do not appear to be any overwhelming majorities. In terms of land ownership, 10 115 of the respondents are landless, with very few having over 10 acres, only 1 604. The sample is approximately evenly split between males and females.

Taking a look at some of the descriptive statistics on (Table 3-5) for the continuous variables in the sample, we see that average Energy Adequacy is approximately 0.81. That is, on average, respondents within the sample are consuming 81 percent of their recommended daily calorie intake. This value ranges from 10 percent to 258 percent, with the low-range respondent consuming only 10 percent of their recommended daily calorie intake, and an upper-range respondent consuming 2.58 times more calories in a day than is recommended. The average age of respondents in the sample is 34 years, average annual household income is 40 091.30 Rs., assessing income distribution per month.

4.3.1.3 Canada

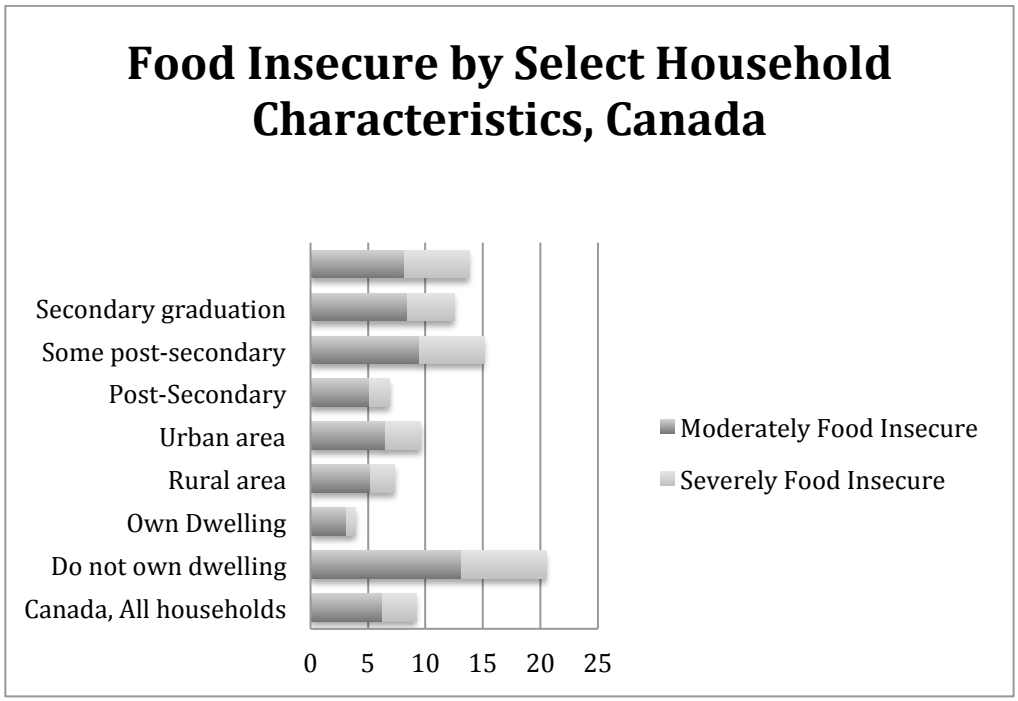
In 2004, 1.1 million households (or 9.2 percent) were either moderately or severely food insecure according to the household food security categorization discussed in Table 3-10. In these households, either an adult or a child faced symptoms of food insecurity assessed through the HFSSM. The most recent estimates available for Canada suggest that food insecurity issues in Canada have lessened, with 2007 – 2008 estimates suggesting that 7.7 percent, or 961 000 individuals, were either moderately or severely food insecure during that time (Statistics Canada, 2012). This is even higher in vulnerable populations: two-thirds of households whose major source of income was social assistance were food insecure, female long-parents, low-income, aboriginal, and home renters were also more likely to be food insecure (Tarasuk, Mitchell, & Dachner, 2013).



Source: Table adapted from (Statistics Canada, 2012)

Figure 4-6: Food Insecurity (2004), Canada

Examining food insecurity by select household characteristics, it is observed that households with lower education levels, similar to the United States but less pronounced, are more likely to be either moderately or severely food insecure. Those residing in urban areas are more likely to be food insecure as well. Home owner, or respondents that own the dwelling that they reside in are, overwhelmingly, more likely to be both moderately or severely food insecure.



Source: Table adapted from (Statistics Canada, 2012)

Figure 4-7: Food Insecure by Select Household Characteristics, Canada

Examining the results by province, according to a 2007 Health Canada report, it is observed that residents in Yukon Territory, Northwest Territories, Nunavut, Manitoba, Ontario, Newfoundland, Prince Edward Island, New Brunswick, and Nova Scotia have food insecurity greater than the Canadian average (Figure 4-7). Residents in Alberta, Saskatchewan, and Quebec are the only three provinces with food insecurity levels below average.

Source: (Statistics Canada, 2012)

Figure 4-8: Food Insecurity Map of Canada (2007-08)

The selected data set for the following analysis, CCHS 2.2 (2004) was chosen because it is the most recent time nutrition intake data was collected at the national level. The selected sample consists of 35107 respondents, with an average Energy Adequacy of 0.758. The mean value for the HFD index is 0.153. EA and HFD are expectedly positively associated, with a significant pairwise correlation coefficient of 0.180 Examining average HFD and EA by select demographics, it is observed that both average HFD and EA tend to rise with rising education levels. Home owners are more likely to have greater HFD, while non—home owners are likely to have greater EA. Women tend to have lower HFD but greater EA, relative to men (Table 4-3).

The following frequencies and descriptive statistics were calculated using the CCHS cycle 2.2 Public Use Micro Datafile (PUMF). Most respondents reported

their health as either 'good' or 'very good', only 830 respondents reported 'poor' health compared to 5289 that reported 'excellent' health. The average age within the sample was 32 years old. The average sample household had 2.5 members and an annual household income of 49 000 CDN dollars. Adult and child food security status were highly positively correlated with a significant coefficient of 0.48. Older age was positively associated with adult and child food security. Larger household size was negatively associated with adult food insecurity, but positively associated with child food insecurity.

4.3.2 ANOVA

In order to determine whether mean values of EA and HFD varied significantly between groups for categorical variables, Analysis of Variance tests were implemented and the results are presented below. Ultimately, ANOVA tests were implemented to assess whether or not between group differences between demographics variables were statistically significant, and present for both HFD and EA.

4.3.2.1 United States

ANOVA results suggest between group differences of EA based on physical activity categorizations, marital status, and education level. That is, mean Energy Adequacy varied across groups within these categories. Between-group variation of means for HFD appears to exist based on categories of marital status, education, household size, and whether or not the respondent had accessed emergency food within the last 12 months (Appendix 5).

4.3.2.2 India

Between-group results show similarly significant variations in mean EA with physical activity level, head of household occupation, gender, and the presence of a separate kitchen or electrification. Between-group variation for HFD appears to be statistically significant by state, physical activity level, community, head of household occupation, gender, house-type, electrification, and the presence of a separate kitchen (Appendix 6).

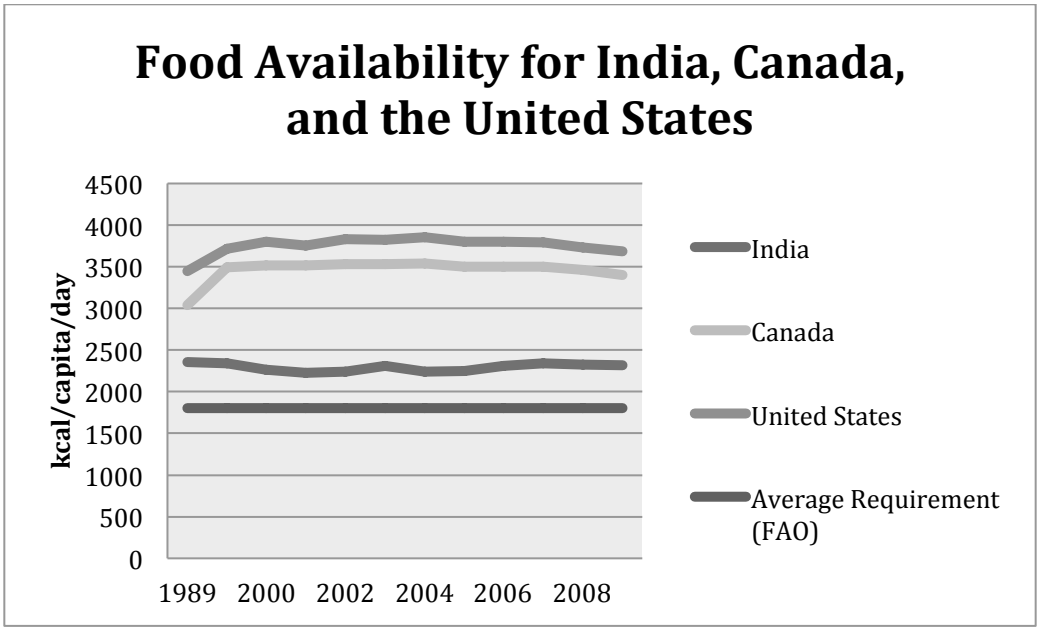
4.3.2.3 Canada

ANOVA results for the CCHS suggest that between-group differences of EA are few, with only differences in adequacy across physical activity levels. Differences between groups for HFD, however, are more significant with variation in the index between education levels, by home ownership, physical activity level, income, and gender (Appendix 7).

4.4 Results: Food Security Indicators

4.4.1 Food Availability

According to the FAO, the average minimum energy requirement per person is approximately 1800 kcal per day. While the exact energy requirement is dependent on age, height, weight, activity level, and physiological conditions such as illness, pregnancy, and lactation an approximate will be used to assess food availability (FAO, 2012). These exact particulars were used to assess Energy Adequacy. Figure 4-9 depicts the average food supply availability, in kcal, as retrieved from FAOSTAT (FAOSTAT, 2012).



Source: FAOSTAT: 1989 – 2009 Food Supply Grand Total (kcal/capita/day)

Figure 4-9: Food Availability for India, Canada, and the United States

Typical assessments relying on measurements of food supply, based on Figure 4-9, would suggest per capita availability of food in sufficient quantities such that no one *should* be consuming less than the average minimum energy requirement.

4.4.2 Energy Adequacy

Linkages between demographic characteristics at the individual and household level and Energy Adequacy will be presented in this section. Statistically significant results will be discussed, and final comparisons across countries will be provided in Chapter 5.

4.4.2.1 United States

From the SUR estimation with Robust Standard Errors, with log-transformed Energy Adequacy as the dependent variable for the analysis it is observed that income, education status less than 9th grade, being married, or widowed are all statistically significant. Income appears to have a significant and positive effect on EA. Falling into the 'less 9th grade' category has a negative effect on EA. Being either married or widowed, relative to single, has a negative effect on EA.

4.4.2.2 India

From the OLS estimation with Robust Standard Errors, with log-transformed Energy Adequacy as the dependent variable, it is observed that Scheduled Caste and Backward Caste communities have greater EA than other communities. Those in kuccha and semi-pucca houses had lower EA than individuals residing in pucca houses. Members of joint families had higher EA than nuclear families. Individuals in households whose main source of drinking water was either an open well or a tube well appear to have greater EA than those that drank tap water. Un-married respondents appeared to have less EA than married respondents. Belonging to a larger family, as well, was associated with lower EA (Table 4-2).

Table 4-2: National Nutrition Monitoring Bureau Regressions; Healthy Food Diversity Index

THFD	Coef.	Sig	TEA	Coef.	Sig
Schedule Tribe	-0.455	***	Schedule Tribe	-0.058	**
	(0.026)			(0.031)	
Scheduled Caste	-0.302	***	Scheduled Caste	0.042	
	(0.019)			(0.026)	
Backward Caste	-0.145	***	Backward Caste	0.052	**
	(0.015)			(0.022)	
Kutcha	-0.176	***	Kutcha	-0.185	***
	(0.021)			(0.030)	
Semi-Pucca	-0.128	***	Semi-Pucca	-0.278	***
	(0.017)			(0.025)	
Extended	0.036	**	Extended	0.01	
	(0.018)			(0.023)	
Joint	0.098	***	Joint	0.111	***
	(0.02)			(0.026)	
Open Well	0.014		Open Well	0.109	***
	(0.018)			(0.022)	
Tube Well	-0.261	***	Tube Well	0.193	***
	(0.015)			(0.020)	
Pond/Tank	0.009		Pond/Tank	0.004	

	(0.051)			(0.068)	
Female	0.035	***	Female		
	(0.014)				
Un-Married	0.08	**	Un-Married	-0.089	*
	(0.035)			(0.045)	
Widowed or Divorced	0.081		Widowed or Divorced	0.025	
	(0.052)			(0.074)	
Sedentary	0.196	***	Sedentary		
	(0.015)				
Heavy	-0.059		Heavy		
	(0.144)				
Age (Years)	0.002	***	Age (Years)		
	(0.000)				
Family Size	-0.071	***	Family Size	-0.036	***
	(0.005)			(0.006)	
Total Income	0.000	***	Total Income	0.000	
	(0.000)			(0.000)	
Total Land	-0.008	***	Total Land	0.002	
	(0.002)			(0.002)	
Head Education	0.028	***	Head Education	0.005	**
	(0.002)			(0.002)	
Constant	-2.929		Constant	1.401	
R-Square	0.162		R-Square	0.027	

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

4.4.2.3 Canada

CCHS regression results estimated using Bootstrap Standard Errors (BSE), with log-transformed Energy Adequacy as the dependent variable, it is observed that income has a positive effect on EA. Widowed, never married, and common-law respondents have greater Energy Adequacy than married respondents. Being divorced or separated has a negative effect on the Energy Adequacy of the respondent. Respondents residing in households in which the highest education level achieved was secondary school graduation are associated with lower EA (Table 4-3) than other education levels.

Table 4-3: Canadian Communities Health Survey Regression Results with Bootstrap Standard Errors

THFD	Coef.	Significance	TEA	Coef.	Significance
Less than secondary	-0.007	**	Less than secondary	-0.078	--

	(0.004)			(0.073)	
Secondary Graduate	-0.015	--	Secondary Graduate	-0.139	***
	(0.012)			(0.056)	
Some post-secondary	0.032	***	Some post-secondary	-0.008	--
	(0.005)			(0.045)	
Home Owner	0.047	***	Home Owner	0.026	--
	(0.007)			(0.055)	
Active	0.040	***	Single	0.055	--
	(0.016)			(0.052)	
Moderate Active	-0.003	--	Divorced	-0.137	***
	(0.009)			(0.054)	
Single	0.018	--	Separated	-0.170	**
	(0.015)			(0.087)	
Divorced	-0.048	***	Widowed	0.319	***
	(0.001)			(0.094)	
Separated	-0.020	***	Common-Law	0.179	**
	(0.004)			(0.103)	
Widowed	0.018	*	Income	0.000	***
	(0.011)			(0.000)	
Common-Law	0.079	***	Household Size	0.076	***
	(0.017)			(0.032)	
income	0.000	--	Constant	0.223	***
Age	0.001	--	R-squared	0.024	

	(0.001)				
Male	0.063	***			
	(0.005)				
Household Size	-0.009	***			
	(0.004)				
Constant	-1.885	***			
R-squared	0.013				

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

4.4.3 Healthy Food Diversity Index

Linkages between demographic characteristics at the individual and household level and the Healthy Food Diversity Index will be presented in this section. Statistically significant results will be discussed, and final comparisons across countries will be provided in Chapter 5.

4.4.3.1 United States

From the SUR estimation with Robust Standard Errors, with log-transformed Healthy Food Diversity as the dependent variable, age appears to have a positive effect on HFD, suggesting that older individuals are more likely to consume a more diverse diet. Gender is negative and significant, suggesting that men consume a less diverse diet than women. In terms of policy programs, individuals that accessed food from an emergency source, were more likely to consume a less diverse food basket (Table 4-4).

Table 4-4: National Health and Nutrition Examination Survey Regression Results; Simultaneous Estimation with Robust Standard Errors

THFD	Coef.	Sig	TEA	Coef.	Sig
Age (Years)	0.002	***	Household Size	0.001	--
	(0.001)				
				(0.005)	
Household Size	0.010	--	Income	0.000	**
	(0.006)			(0.000	
Income	0.000	--	Less than 9th Grade	-0.054	**
	(0.000)			(0.027)	

Male	-0.046	***	9 - 11th Grade	0.017	--
	(0.016)			(0.026)	
Less than 9th Grade	-0.015	--	High School Graduate/GED	-0.030	--
	(0.033)			(0.019)	
9 - 11th Grade	-0.015	--	Some College or AA Degree	-0.009	--
	(0.031)			(0.017)	
High School Graduate/GED	-0.010	--	Married	-0.050	**
	(0.024)			(0.022)	
Some College or AA Degree	-0.014	--	Widowed	-0.059	**
	(0.023)			(0.030)	
Married	0.006	--	Divorced	-0.039	--
	(0.024)			(0.030)	
Widowed	0.029	--	Separated	-0.022	--
	(0.037)			(0.042)	
Divorced	-0.026	--	Living With Partner	0.031	--
	(0.033)			(0.035)	
Separated	-0.001	--	Emergency Food Access	-0.004	--
	(0.040)			(0.026)	
Living With Partner	-0.011	--	Food Stamp Beneficiary	0.048	--
	(0.033)			(0.034)	
Sedentary	0.026	--	Women, Child, and infants Beneficiary	0.014	--
	(0.026)			(0.028)	
Low Active	0.024	--	Constant	0.786	***
	(0.020)				
Emergency Food Access	-0.081	***			
	(0.029)				
Food Stamp Beneficiary	-0.045	---			
	(0.037)				
Women, Child, and infants Beneficiary	0.033	---			
	(0.031)				
Constant	-1.94	***			

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

4.4.3.2 India

From the IV regression with Robust Standard Errors, and log-transformed HFD as the dependent variable, it is observed that STs, SCs, and BCs have a lower HFD than other communities, with STs, SCs, and BCs consuming less than other communities. Individuals residing in kutcha and semi-pucca houses are consuming less than those in a pucca house. Extended and joint families have a higher HFD than nuclear families. Additionally, females have a higher HFD than males. The only source of drinking water with a significant effect on HFD is the use of a tube well. Respondents whose main source of drinking water was relative to tap water drinkers, a tube well, had lower HFD. Sedentary activity respondents had greater HFD than moderate activity respondents.

Increases in both age and income are associated with greater HFD although the effects are very small in magnitude. Those belonging to larger families had lower HFD, while those from households with higher head of household education levels had greater HFD. Somewhat contrary to expectation, increases in total household land owned were associated with lower HFD (Table 4-2).

4.4.3.3 Canada

Increased physical activity level appears to have a positive effect on HFD. Belonging to the 'moderately active' categorization has a negative effect on a respondent's healthy food diversity, while belonging to the 'active' categorization has a positive effect on HFD. Residing in a household in which the highest education level is 'less than secondary graduation' has a negative effect on HFD, while unsurprisingly, belonging to a household in which the highest education level is at least 'some post-secondary' has a positive effect on healthy food diversity. Widowed, never married, and common-law respondents have greater HFD, with divorced and separated respondents having less. In addition, Home ownership was associated with greater healthy food diversity (Table 4-3).

4.4.4 Adult Food Security Status

The HFSSM was available for both the CCHS and NHANES samples, and regression results for those estimations are provided below. Adult and Child Food Security Status were estimated as a system, using SUR regression techniques, along with log-transformed EA and HFD for the NHANES data set. OLS regression techniques with Bootstrap Standard Errors were utilized for independent equations for Adult and Child Food Security Status for the CCHS data set.

4.4.4.1 United States

Age and income are both negative and significant variables within this estimation. Older adults face less food insecurity along with respondents from wealthier households. Income in magnitude, however, is less than 0.0001 and while statistically significant not in terms of practicality. Larger households are more likely to face food insecurity. With regards to education status, individuals in the lowest (less than 9th grade) and second lowest (9th – 11th grade) education categories tend to be more food insecure. Married respondents were more food secure, while divorced and respondents living with partners faced increased likelihood of food insecurity. Individuals with activity levels classified as 'low active' and 'active' were, relative to 'very active' individuals, more likely to face food insecurity, suggesting that activity level factors into adult self-reported food security status. In terms of policy programs, the WIC benefit program did not have any significant effect on reporting symptoms of food insecurity. Both food stamp beneficiaries and those that accessed emergency food faced an increased likelihood of food insecurity. This is an important finding, especially considering the magnitude of the coefficients involved. Food stamp beneficiaries were more likely to respond affirmatively to 3 food security questions within the HFSSM. In percentage terms, this translates to a 30 percent increase in the severity of adult food insecurity. Individuals that accessed emergency food at some point in the 12 months prior to the administration of the HFSSM, faced a 17 percent increase in the severity of adult food insecurity. (Table 4-5)

Table 4-5: National Health and Nutrition Examination Survey Regression Results; Simultaneous Equations with Robust Standard Errors

ADFS	Coef.	Sig	CDFS	Coef.	Sig
Age (Years)	-0.008	***	Age (Years)	-0.001	**
	(0.002)			(0.001)	
Household Size	0.235	***	Household Size	0.017	**
	(0.030)			(0.009)	
Income	-0.000	***	Income	-1.17E-06	***
	(1.13E-0.6)			(3.58E-07)	
Male	0.074	--	Male	0.003	--
	(0.064)			(0.018)	
Less than 9th Grade	0.475	***	Less than 9th Grade	0.040	--
	(0.163)			(0.044)	
9 - 11th Grade	0.260	**	9 - 11th Grade	-0.022	--
	(0.111)			(0.029)	
High School Graduate/GED	0.037	--	High School Graduate/GED	-0.013	--
	(0.077			(0.019)	
Some College or AA Degree	0.186	***	Some College or AA Degree	-0.005	--
	(0.071)			(0.016)	

Married	-0.157	-	Married	-0.021	--
	(0.104)			(0.029)	
Widowed	-0.057	--	Widowed	-0.023	--
	(0.156)			(0.033)	
Divorced	0.524	***	Divorced	0.069	*
	(0.156)			(0.041)	
Separated	0.096	--	Separated	0.010	--
	(0.230)			(0.089)	
Living With Partner	0.386	**	Living With Partner	0.051	--
	(0.176)			(0.058)	
Sedentary	0.064	--	Sedentary	-0.019	--
	(0.109)			(0.034)	
Low Active	-0.131	*	Low Active	-0.063	***
	(0.077)			(0.017)	
Active	-0.091	--	Active	-0.042	**
	(0.082)			(0.020)	
Emergency Food Access	0.829	***	Emergency Food Access	-0.005	--
	(0.154)			(0.043)	
Food Stamp Beneficiary	2.30	***	Food Stamp Beneficiary	0.533	***
	0.212)			(0.074)	
Women, Child, and infants Beneficiary	0.029	--	Women, Child, and infants Beneficiary	0.015	--
	(0.184)			(0.059)	
Constant	0.855	***	Constant	0.134	**

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

4.4.4.2 Canada

From the OLS regression with Bootstrap Standard errors, income was a significant contributor to adult food security status, with greater income being associated with a lower food security score. Older adults face less food insecurity, expectedly. Residing in a household in which the highest education level is either 'less than secondary', 'secondary graduate' or 'some post-secondary', relative to 'post-secondary graduate' has a negative effect on food security. That is, adults from *less-educated* households are more likely to respond affirmatively to HFSSM questions. Being either widowed or never married has a positive effect on adult food security status, while being divorced or separated has a negative effect, suggesting greater food insecurity for respondents belonging to split households. In addition, larger households are more likely to face food insecurity. (Table 4-6)

Table 4-6: Canadian Communities Health Survey Regression Results; Ordinary Least Squares with Bootstrap Standard Errors

ADFS	Coef.	Significance	CDFS	Coef.	Significance
Less than secondary	0.109	***	Less than secondary	0.034	--
	(0.042)			(0.032)	
Secondary Graduate	0.095	***	Secondary Graduate	0.025	***
	(0.003)			(0.003)	
Some post-secondary	0.199	***	Some post-secondary	0.014	--
	(0.023)			(0.008)	
Home Owner	-0.476	***	Home Owner	-0.086	--
	(0.094)			(0.059)	
Active	0.008	--	Active	-0.015	***
	(0.027)			(0.004)	
Moderate Active	0.024	--	Moderate Active	0.030	***
	(0.022)			(0.001)	
Single	-0.097	***	Single	-0.062	*
	(0.004)			(0.034)	
Divorced	0.321	***	Divorced	-0.030	--
	(0.093)			(0.022)	
Separated	0.320	***	Separated	0.008	--
	(0.095)			(0.020)	
Widowed	-0.354	***	Widowed	0.016	--
	(0.041)			(0.031)	
Common-Law	0.032	--	Common-Law	-0.048	***
	(0.052)			(0.012)	
Income	0.000	***	Income	0.000	***
	(0.000)			(0.000)	
Age	-0.009	**	Age	-0.003	***
	(0.004)			(0.001)	
Male	-0.019	***	Male	0.012	--
	(0.004)			(0.008)	
Household Size	0.045	**	Household Size	0.068	***
	(0.023)			(0.008)	
Constant	2.137	***	Constant	0.334	**
R-squared	0.131		R-square	0.080	

*** significant at the 1% s.l, ** significant at the 5% s.l, * significant at the 10% s.l.

4.4.5 Child Food Security Status

4.4.5.1 United States

From the SUR estimation with RSE, age, household size, and income are all significant, similar to adult food security. Older children tend to report less food insecurity and children from larger households tend to report more food insecurity. it is not possible for children less than 10 to necessarily have a 'marital status' different from single, the marital status of the proxy-respondent does have an effect on the food security status of the child. Married, divorced, separated, and individuals living with partners, relative to single, face an increase in child food insecurity. In terms of severity, we can rank the regression coefficients in terms of magnitude of negative effect food security as: divorced, separated, living with partner, and married. That is, children residing in divorced households face more severe food insecurity, relative to separated, living with partner, married, and single households. With regards to the effect of different policy programs on the child food insecurity score, accessing emergency food and receiving food stamps at the household level during the preceding 12 months, has a negative effect on child food security, but with a significantly lower magnitude than adult food security. (Table 4-5)

4.4.5.2 Canada

Given the OLS estimation with BSE, household income has a positive effect on child food security status, with higher income households less likely to respond affirmatively to HFSSM questions. Older children, and children from smaller households are less likely to face food insecurity. (Table 4-6)

4.5 Conclusions

Within the preceding chapter, the results from descriptive statistics and linear regression techniques that were implemented on three data sets: NHANES from the United States, NNMB from India, and the CCHS from Canada are presented. Both non-parametric and parametric methods were utilized for the analysis. Non-parametric statistics consisted of means, frequencies, and ANOVA. Parametric methods included multiple linear regression techniques, including OLS, SUR, and IV regressions.

Levels of hunger across the United States, India, and Canada remain high. One in seven U.S. households was categorized as food insecure in 2010, the highest number ever recorded. In Canada, using the same measurement criteria, one in ten households was food insecure. While the level of food insecurity lessened from 2004 in Canada, from 9.2 percent to 7.7. percent, the figure remains high for a country with the relative standard of living of Canada. While similar standards of comparison were not available for the Indian data, due to the unavailability of the HFSSM, it is reported that poverty in India (i.e., the

proportion of the population living below the poverty line), is approximately 29.8 percent.

The disparity between food security in urban populations and rural populations is pronounced across all three countries. In the United States, food insecure children were more likely to reside in rural communities, with rural food insecure children making up two-thirds of the counties with high rates of child food insecurity. According to recent World Bank estimates, approximately 30 percent of India's rural population is living below the poverty, compared to 21 percent of India's urban population living below the poverty line. The result is different Canadians, however, with 6.5 percent of Canada's urban population reporting food insecurity, and 5.2 percent Canada's rural population reporting food insecurity.

As discussed in Chapter 2, traditional assessments of food security consisted of national balance sheets, and a simple of measurement of whether or not there was enough food available at the national level, and not necessarily whether or not households and individuals had access to that food, or whether it was acceptable for their consumption. This traditional assessment, done for the United States, India, and Canada, using publically available FAO data and under the assumption that the average caloric requirement for each person was 1800 kCal per day, suggested that all three countries have food available in sufficient quantities at the national level to fulfill the average daily requirement of each individual. Over the last 10 years, both U.S. and Canadian national caloric availability ranged between 3000 to 4000 kCal per capita per day. In India, this range hovered between 2200 and 2400 kCal per capita per day, which while significantly lower than the U.S. and Canada, is still above the base level of average caloric requirement.

The regression results presented in Chapter 4 highlighted the link between select demographic characteristics and Energy Adequacy, Healthy Food Diversity, and where available, Adult and Child Food Security Status across the United States, India, and Canada. Different regression techniques were utilized based on the requirements of each data set, and each variable, and the rationale behind these selections is presented in the model specification section of Chapter 3. EA and HFD were log-transformed for all regression models, across all three countries. ADFS and CDFS were not transformed, and kept as a count index of affirmative responses to the HFSSM. SUR regression techniques with RSE were utilized for U.S. estimation of EA, HFD, ADFS and CDFS. OLS with RSE was utilized with HFD as a dependent variable, and IV regression with RSE was utilized with EA as a dependent variable for the Indian data set. OLS with BSE was utilized for Canadian estimation for EA, HFD, ADFS, and CDFS.

Further comparison of the results discussed in Chapter 4, along with their cross-country comparison will be presented in Chapter 5. In 5.1., EA, and HFD will be compared across countries. In 5.2., differences and similarities between

the effects of demographic variables on EA, HFD, ADFS and CDFS, across countries, will be presented. In 5.3., new regression results will be presented in order to contribute to the prediction of qualitative food security status, where that data is not available. In 5.4., households will be identified as food insecure, based on the three indicators of food security used throughout this research. Descriptive statistics will be presented that highlight the difference between this 'vulnerable group', the group which is food insecure according to all three indicators, and the food secure group. In 5.4., food policy schemes will be discussed, and policy recommendations will be made.

5 Chapter 5: Conclusion

The preceding analysis was separated into four chapters. The first chapter presented an introduction to the topic, and discussed the reason for and importance of discussing food security issues. The research problem was presented, and the final objectives of the analysis were discussed. In Chapter 2 (Section 1), a review of the literature as it relates to the definition of food security was presented. In Chapter 2 (Section 2), a review of the outcome indicators of food security was presented and three indicators ultimately chosen to reflect the multi-dimensional nature of food security: Energy Adequacy, healthy food diversity-index, and qualitative food security status. In Chapter 3, the measurement and empirical classification of the three indicators of food security was discussed, along with the conceptual model for the analysis.

Results from the analysis were presented in Chapter 4, distinguished by outcome indicator and country. The following conclusions of this research (Chapter 5) will be discussed as they relate to the 5 objectives outlined in Chapter 1 of this document. Limitations will be discussed briefly in the following chapter, in addition to the concluding remarks.

5.1 Comparisons Between Indicators

> **(Objective 1):** Examine the link between different indicators of food security including Energy Adequacy, healthy food diversity, and household food security status (based on a qualitative food security assessment), where available.

In order to paint a comprehensive picture of the food security situation of an individual or household, the different aspects of being 'food secure' need to be examined. A review of the literature found that food security is a complex and multi-faceted concept. Definitions of what a food secure world looks like have varied and shifted, with the academic and policy focus shifting from an examination of how much food is available to whether or not an individual has physical and economic access to food, along with the cultural acceptability and appropriateness of the food that is available and accessible.

As a result, the outcome indicators that were chosen for this analysis: Energy Adequacy (EA), representing food acceptability (and utilization), the Healthy Food Diversity Index (HFD), representing food access, and a qualitative assessment of food security status using the Household Food Security Survey Module (HFSSM) work together to paint a comprehensive picture of the food security situation of our respondents. In addition to an examination of food availability at the national level using food balance sheets, we found that a thorough understanding of an individual or household's food security status is not possible without a series of indicators that probe all three pillars of food security: availability, accessibility, and absorption. Examining mean EA, it is observed that

Energy Adequacy was highest for rural Indian populations, with NNMB respondents consuming 81 percent of their recommended daily intake. CCHS and NHANES respondents consumed 76 and 77 percent, respectively, of their daily-recommended caloric intake (Figure 5-1). This result is likely due to the lower recommended dietary intakes suggested by India's National Nutrition Monitoring Bureau. It is likely that re-calculation of Energy Adequacy using the same guidelines as the NHANES and CCHS data sets, would result in a lower EA for NNMB respondents than what is presented here.

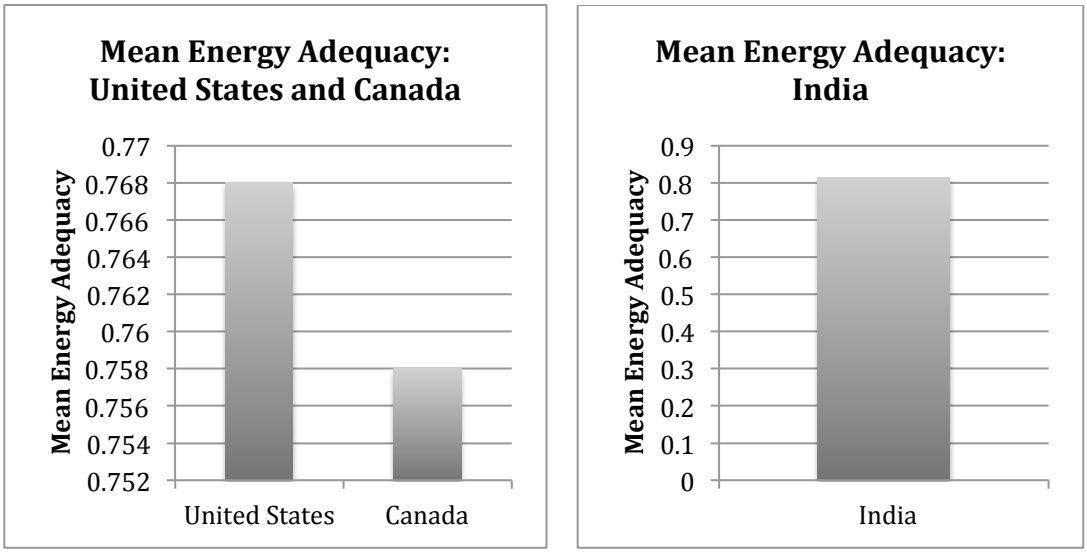


Figure 5-1: Average Energy Adequacy by Country

From examining EA by percentiles (Figure 5-2), it is observed that the lowest 10th percentile of both the CCHS and NHANES data sets is consuming approximately 0.3, or 30%, of their recommended intake. The 90th percentile, for both data sets, is consuming greater than 1.00, or 100%, of their recommended daily intake.

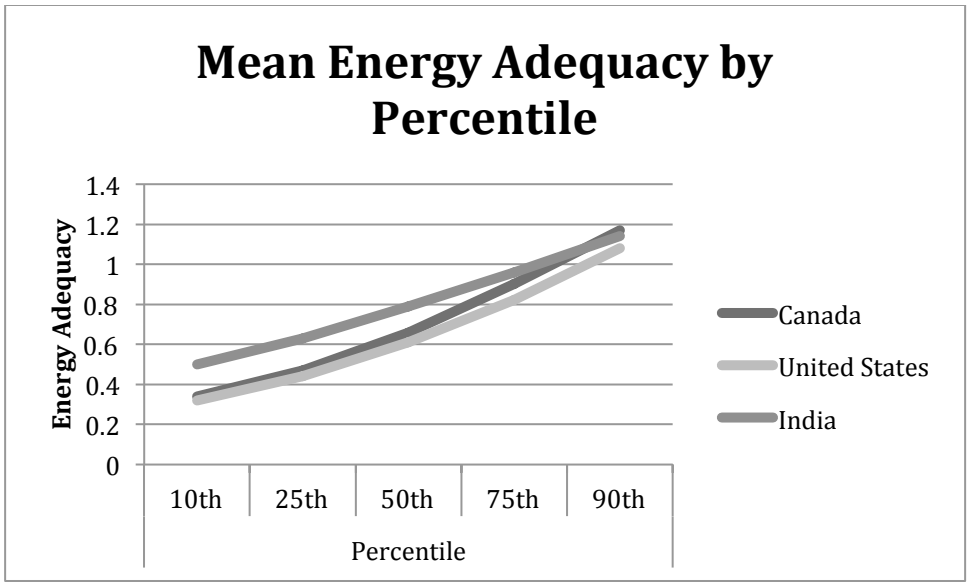


Figure 5-2: Mean Energy Adequacy by Percentile

HFD was, as anticipated, highest for NHANES and CCHS respondents, at 0.141 and 0.153, respectively. HFD for rural Indian populations was found to be 0.059, significantly lower than both the CCHS and NHANES. This result empirically reinforces our conclusion from objective 1, specifically that without examining both the Energy Adequacy and dietary diversity of food consumed, we would not fully understand the whole food picture of each household.

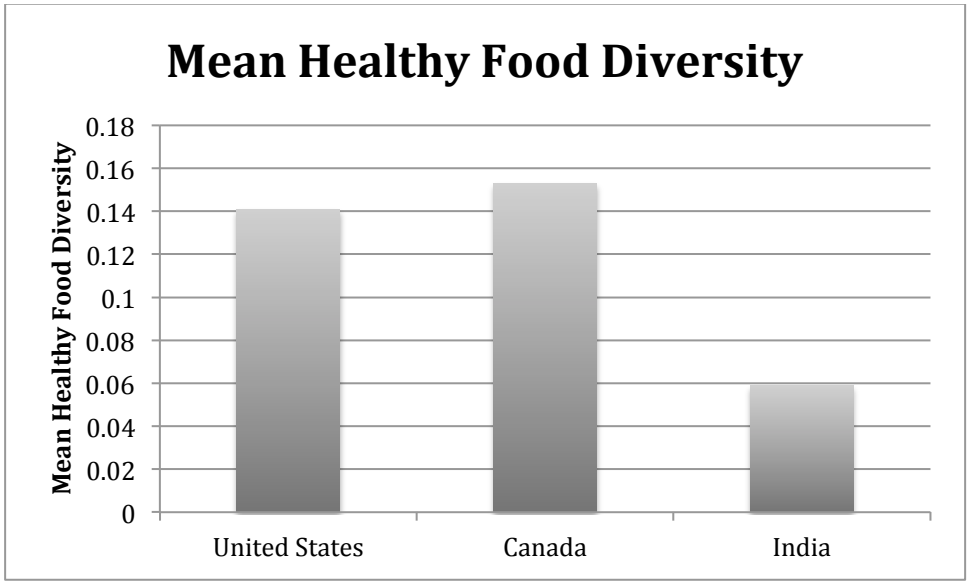


Figure 5-3: Healthy Food Diversity Index by Country

Assessing food security through healthy food diversity paints a different picture than that suggested by examining Energy Adequacy alone. Average HFD for Indians is significantly lower than for Canadian and U.S. respondents (Figure

5-3). Examining the results by percentile further suggest that Indians have lower HFD than Canadians consistently across percentiles (Figure 5-4).

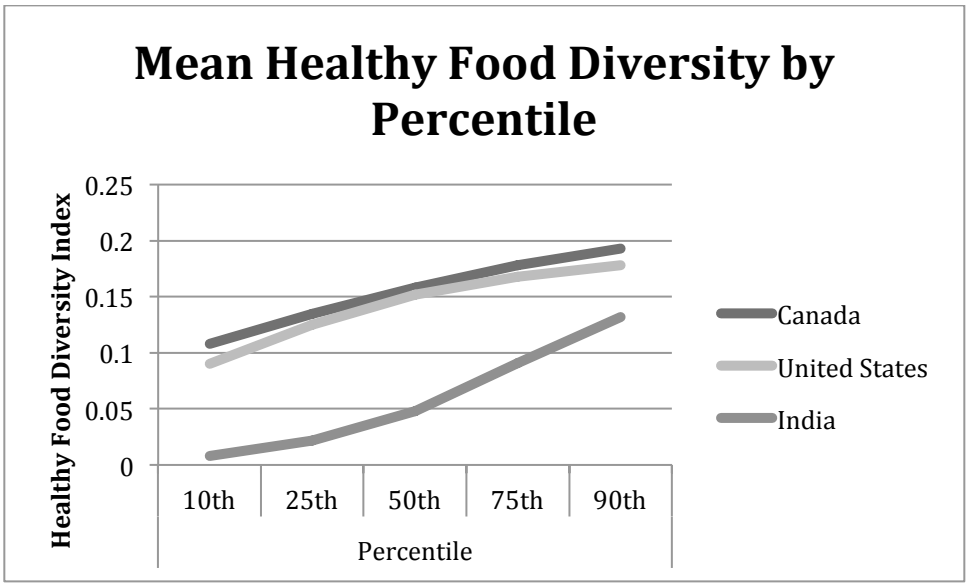


Figure 5-4: Mean Healthy Food Diversity by Percentile

5.2 Demographics and Food Security

(Objective 2): Assess the effect that different individual- and household- characteristics have on the indicators in (Objective 1), and to what degree the effects are similar or different across the three countries.

The effects of different individual- and household-level characteristics were assessed using multiple linear regression techniques, along with ANOVA and other descriptive statistics. Three data sets were analyzed: NHANES (United States), NNMB (India), and CCHS (Canada). While data collection methods varied across the three sets, both the CCHS and NHANES utilized the HFSSM for a qualitative assessment of food security status.

In Table 5-1, positive and negative effects of the individual and household characteristics on the three chosen indicators of food security are presented. It is observed that household income is a positive contributor to EA across all three countries. Family size appears to be a negative contributor to HFD for both India and Canada. Age appears to positively contribute to HFD for both India and the United States, while having no significant effect for Canadian respondents.

Table 5-1: Positive and Negative Effects of Individual and Household Characteristics on Energy Adequacy, Healthy Food Diversity, and Qualitative Food Security Status

	India		Canada		United States	
	Positive	Negative	Positive	Negative	Positive	Negative
Energy Adequacy	Joint Family, Open Well Water Source, Tube Well Water Source, **Household Income**, Head of Household Education	Scheduled Tribe, Kutcha Home, Semi-Pucca Home, Un-Married, Family Size	Widowed, Common-Law, **Household Income**	Secondary Graduate, Divorced, Separated, Family Size	**Household Income**	Less than 9th Grade Education, Widowed
Healthy Food Diversity-Index	Extended Family, Joint Family, Female, Un-Married, Sedentary Activity, ***Age***, Total Household Income, Head of Household Education	Scheduled Tribe, Scheduled Caste, Backward Caste, Kutcha Home, Semi-Pucca Home, Tube Well Water Source, ***Family Size***	Some Post-Secondary Education, Home Ownership, Active Physical Activity Level, Common-Law, Male	Less than Secondary Education, Divorced, Separated, ***Family Size***	***Age***	Male, Accessed Emergency Food in the Last 12 Months
Adult Food Insecurity			**Less than Secondary Education, Secondary Graduate, Some Post-Secondary, Divorced**, Separated, Widowed, Income	Home Ownership, Single, Widowed, **Age**, Male	Family Size, **Less than 9th Grade, 9th-11th Grade, Some College, Divorced,** Living with Partner, Emergency Food Accessed in Last 12 Months, Food Stamps Received in Last 12 Months	**Age**

Child Food Insecurity			Secondary Graduate, Medium Activity Level, **Family Size**, Male, Income	High Activity Level, Single, Common-Law, **Age**	**Family Size**, Divorced, Food Stamps Received in Last 12 Months	**Age**, Low Activity Level, Medium Activity Level

Lower education levels appear to be significant contributors to adult food insecurity status across both Canada and the United States. That is, lower education levels were more likely to report with greater frequency, more symptoms of food insecurity at the adult level. Age was a negative and significant contributor to adult food insecurity aswell, suggesting that older individuals are less likely to report symptoms of adult food insecurity (Table 5-1).

In terms of child food insecurity, family size appears to be a significant contributor across both Canada and the United States, suggesting that larger families are more likely to report, with greater frequency, symptoms of child food insecurity. In addition, age was a negative and significant contributor to child food insecurity (along with adult food insecurity), with older respondents less likely to report symptoms of child food insecurity (Table 5-1).

5.3 When Qualitative Food Security is Unavailable

(Objective 3): Extrapolating the effect that healthy food diversity and Energy Adequacy have on household food security status, and discussing what we can expect where qualitative food security data is not available.

In order to determine the effect that healthy food diversity and Energy Adequacy have on household (adult and child) food security status, Pearson correlation coefficients were generated to assess the statistical association between different indicators of food security. Results for associations between EA, HFD, ADFS, and CDFS are presented in Table 5-2 and Table 5-3, for the United States and Canada. Correlations between EA and HFD are presented in Table 5-4, for India.

Table 5-2: Pearson Correlation Coefficients: United States

	Healthy Food Diversity Index	Energy Adequacy	Adult Food Security Status	Child Food Security Status
Healthy Food Diversity Index	1			
Energy Adequacy	0.09***	1		
Adult Food Security Status	-0.11***	0.02	1	
Child Food Security Status	-0.06***	0.01	0.58***	1

*** significant at the 1% s.l., ** significant at the 5% s.l., * significant at the 10% s.l.

Similar results were found across all three countries. Qualitative Adult and Child food security status, were positively and strongly associated with each other, with correlation coefficients of 0.58 for the U.S., and 0.51 for Canada. Adult and Child food security were not significantly associated with EA for both countries, suggesting that EA and qualitative food security are not statistically dependent on each other. The link between qualitative food security and HFD was significant and negative for both countries, suggesting the higher levels of food insecurity at the adult and child level are associated with lower levels of healthy food diversity. A result that reinforces the importance of including HFD in food security analyses.

Table 5-3: Pearson Correlation Coefficients: Canada

	Healthy Food Diversity Index	Energy Adequacy	Adult Food Security Status	Child Food Security Status
Healthy Food Diversity Index	1			
Energy Adequacy	0.18***	1		
Adult Food Security Status	-0.05***	-0.02*	1	
Child Food Security Status	-0.01***	-0.004	0.51***	1

*** significant at the 1% s.l., ** significant at the 5% s.l., * significant at the 10% s.l.

Across all three countries, EA and HFD were positively associated. With magnitudes of 0.09, 0.18, and 0.02 for the United States, Canada, and India, respectively. In magnitude, the association between EA and HFD is the strongest in Canada, and the weakest in India.

Table 5-4: Pearson Correlation Coefficients: India

		Healthy Food Diversity Index
Healthy Food Diversity Index	Coefficient	1
Energy Adequacy	Coefficient	0.023**

*** significant at the 1% s.l., ** significant at the 5% s.l., * significant at the 10% s.l.

Ultimately, the results from the correlation coefficients suggests that a similar association between qualitative food security status, for both adults and child, can be predicted given the similar statistical association between EA and HFD. To further explore this result, new regression results examining the link between EA and HFD and Adult and Child Food Security were proposed and their results are provided in Table 5-5 and Table 5-6.

Table 5-5: Link Between Dependent Variables; Canadian Communities Health Survey

Adult Food Insecurity Score	Observed Coefficient	Bootstrap S.E.	Significance
Energy Adequacy	-0.047	0.059	
Healthy Food Diversity	-0.353	0.265	
Constant	-0.174	0.339	
R-Square	0.023		
Child Food Insecurity Score			
Energy Adequacy	-0.008	0.011	
Healthy Food Diversity	-0.099	0.031	***
Constant	-0.104	0.053	
R-Square	0.008		

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

HFD and EA do not appear to have any significant effect on adult food security status for CCHS respondents suggesting that the Adult Food Insecurity Score reflects information not necessarily discernible from examining the healthy food diversity and Energy Adequacy of a respondent. That is, if we were to solely examine food consumption, without access to a more qualitative assessment of a household's food situation, we would miss a piece of the food security puzzle. Additionally, healthy food diversity does appear to be significant for child food security; a result asserting that increases in the HFD index are associated with greater food security.

Table 5-6: Link Between Dependent Variables; National Health and Nutrition Examination Survey

Adult Food Insecurity Score	Observed Coefficient	S.E.	Significance
Energy Adequacy	0.213	0.090	***
Healthy Food Diversity	-0.363	0.073	***
Constant	0.071	0.160	
R-Square	0.008		
Child Food Insecurity Score			
Energy Adequacy	0.055	0.037	
Healthy Food Diversity	-0.076	0.030	***
Constant	0.049	0.066	
R-Square	0.002		

*** significant at the 1% s.l., ** significant at the 5% s.l., * significant at the 10% s.l.

An examination of the link between HFD, EA, adult, and child food insecurity suggest that greater Energy Adequacy is associated with greater food insecurity for adults. That is, the higher the daily intake of calories, relative to caloric requirements, the more likely a respondent would report symptoms of food insecurity. A possible explanation for this result is that economic constraints on food consumption lead to the consumption of less healthy, more processed, food items. In fact, many studies report a positive association between the prevalence of obesity (the over-consumption of calories and nutrients) and food insecurity (Dinour, Bergen, & Yeh, 2007) (Adams, Grummer-Strawn, & Chavez, 2003) (Wilde & Peterman, 2006) (Martin & Ferris, 2007). In addition, the consumption of healthier foods appears to be associated with greater food security as well.

5.4 Vulnerable Groups

> **(Objective 5):** Assess which households are 'food insecure' according to all three food security indicators, and discuss the characteristics associated with falling into this 'vulnerable group' across countries.

The preceding discussion has been about what aspect of food security the three measures, Energy Adequacy, healthy food diversity, and qualitative food security status reflect. It has not been discussed, however, whether or not we can identify households based on these measures as either food secure or insecure. Ultimately, using how the three measures are interrelated it is possible to identify groups that are the most vulnerable in terms of their total energy consumption, their consumption of healthy foods, and their self-reported food security status. By identifying individuals that are calorie deficient, consuming an unhealthy food basket, and experiencing symptoms of food insecurity, and assessing their demographics, we can identify the most vulnerable groups in a population and ultimately tailor policies to alleviate their symptoms of food insecurity.

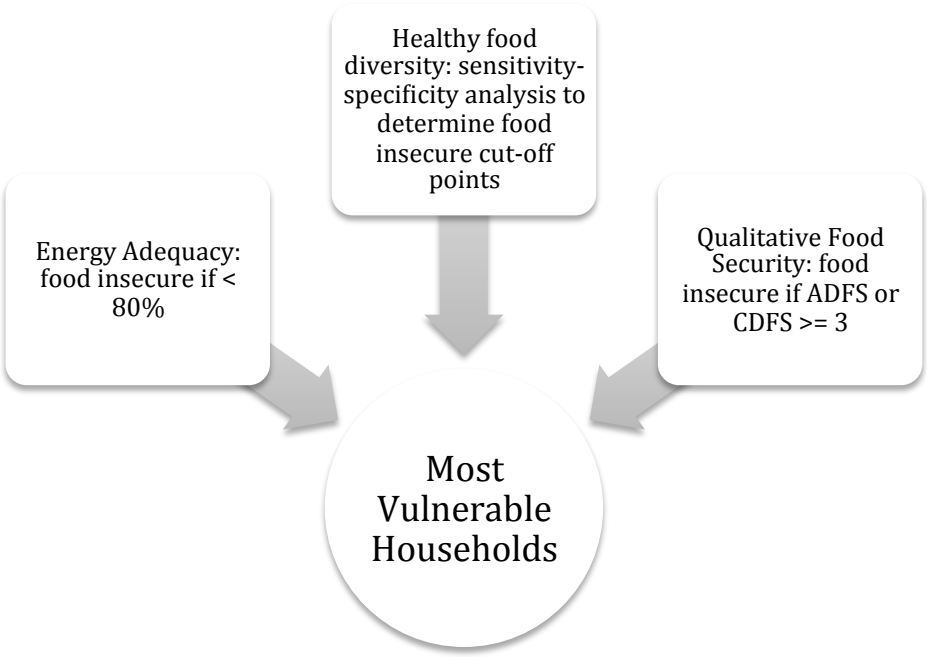


Figure 5-5: Conceptual Framework for Identification of Most Vulnerable Groups

Cutoff points for the three measures were determined using the following criteria:

(1) Energy Adequacy: using the cutoff points used by Daniel Maxwell in his book Urban Livelihoods and Food and Nutrition Security in Greater Accra, Ghana (less than 80 percent Energy Adequacy is classified as food insecure) (Maxwell, Ahiadeke, Levin, Armar-Klemesu, Zakariah, & Lamptey, 1999)

(2) healthy food diversity: determined specifically within each sample using sensitivity-specificity analysis to determine cut-off points (Hatloy, Torheim, & Oshaug, 1998)

(3) qualitative food security status: using the criteria outlined for the use of the HFSSM; an ADFS or CDFS score >=3 is food insecure (CDC/National Center for Health Statistics, 2012)

Results comparing descriptive statistics for income and age between the most vulnerable group, or the group that is food insecure, according to all three measures are presented in Table 5-7. With respect to the CCHS, 0.84 percent of the sample would fall into the most vulnerable group according to all three categories. For the NHANES and NNMB samples, approximately 6 percent and 34 percent of the sample would fall into the most vulnerable category, which for India excludes the qualitative measure of food security status.

Table 5-7: Vulnerable Group Descriptive Statistics

	Income			
		CCHS	NHANES	NNMB
Most Vulnerable Group	Mean	27977.18	27505.92	32952.54
	SD	18507.67	1040.09	393.19
	N	260	422	7602
Total Sample	Mean	49469.42	47182.13	40082.89
	SD	24642.16	396.06	308.23
	N	31037	6174	22124
	Age			
Most Vulnerable Group	Mean	42	35	33
	SD	17	0.94	0.2
	N	260	422	7602
Total Sample	Mean	33	41	34
	SD	23	0.28	0.11
	N	35107	6174	22124

The results in Table 5-7 suggest that Energy Adequacy using the cutoff point of 0.8, used often in the literature, may not be sensitive enough to detect food insecurity, with 85 and 73 percent of the CCHS and NHANES sample falling into the 'food insecure' category.

Table 5-8: Tabulation of Frequencies (Percent of Total Sample)

Variable	CCHS		NHANES		NNMB
Energy Adequacy	85%	1%	73%	7%	34%
Healthy Food Diversity	29%		33%		
Adult Food Security	6%		16%		
Child Food Security	0%		3%		

By examining the descriptive statistics presented in Table 5-7, Table 5-9, and Table 5-10, we observe that respondents in the most vulnerable group tend to have an average annual income significantly lower than respondents within the entire sample. For both the CCHS and NHANES results, average income of the vulnerable group is approximately 40 percent lower than that of the entire sample. Respondents for the CCHS vulnerable group tend to be older, while respondents for the NHANES vulnerable group tend to be younger, relative to the entire sample.

Examining frequencies for the CCHS (Table 5-9), it appears that only 30 percent of the most vulnerable groups are individuals that own their dwelling, suggesting that home ownership is less likely to result in cross-measure food insecurity – a result that may be somewhat compounded by income. A majority of the most vulnerable group would be categorized as mostly single, and with a slight majority, female.

For the NHANES frequencies, we observe that a majority of the vulnerable are married, female, and either high school graduates or attended some college, without post-secondary graduation. While having accessed emergency food or received the WIC benefit within the last 12 months does not appear to be linked to belonging to the most vulnerable category, an overwhelming majority (68 percent) of the most vulnerable group participated in the SNAP program (food stamps) within the last year.

Table 5-9: Vulnerable Group Frequencies; Canadian Communities Health Survey and National Health and Nutrition Examination Survey

	CCHS			NHAHNES	
Variable	Frequency	Percent (%)	Variable	Frequency	Percent (%)
Less than Secondary	68	0.26	Less than 9th Grade	850	12.65
Secondary Graduation	43	0.17	9th - 11th Grade	1165	17.34
Some Post-Secondary	34	0.13	High School Graduate/ GED	1640	24.41
Post-Secondary Graduation	107	0.41	Some College or AA Degree	1706	25.39
Home Owner	78	0.30	College Graduation	1192	17.74
Married	41	0.16	Married	3831	57.02
Single	114	0.44	Widowed	474	7.05
Divorced	50	0.19	Divorced	758	11.28
Separated/Widowed	54	0.21	Separated	758	11.28
Male	109	0.42	Never Married	799	11.89
			Living with Partner	389	5.79
			Emergency Food Accessed	535	8.01
			Food Stamp	1233	68.08
			WIC Benefit	654	13.28
			Male	3633	54.07

From the results presented in Table 5-10, it appears that the majority of respondents in the vulnerable group belong to a nuclear family and reside in a semi-pucca dwelling, The use of fire wood as the primary source of cooking fuel, the least favourable cooking fuel due to the high incidence of residual smoke, also appears to be predominant in the most vulnerable group. In addition, approximately 95 percent of the vulnerable group sample is married.

Table 5-10: Vulnerable Group Frequencies: National Nutrition Monitoring Bureau

	NNMB	
Variable	Frequency	Percent (%)
Scheduled Tribe	1194	15.69
Scheduled Caste	1876	24.65
Backward Caste	2646	34.77
Other	1895	24.9
Kutcha	1738	22.84
Semi-Pucca	5086	66.82
Pucca	787	10.34
Nuclear	4617	60.66
Extended	1489	19.56
Joint	1505	19.77
Open Well	1760	23.12
Tube Well	2746	36.08
Tap	2942	38.65
Pond/Tank/River/Stream	163	2.14
Fire Wood	7053	92.67
Kerosene	83	1.09
Bio-Gas	37	0.49
LPG	438	5.75
Married	7204	94.65
Un-Married	311	4.09
Widowed or Divorced	78	1.02

While the results from the preceding analysis highlight the effectiveness of a cross-measure analysis of households that fall into the food-insecure category across countries in identifying those households which are the most vulnerable, there do not appear to be any cross-country similarities aside from the importance of annual household income in affecting the food security status of households.

5.5 Policy Recommendations

> **(Objective 4):** Comparing the individual determinants of food security across countries to provide policy recommendations.

It is possible to assess the effect of food security enhancing policy schemes on our indicators of food security, Energy Adequacy and healthy food diversity, by comparing the income effects of these programs and the predicted effect of their cash equivalence. By examining the income effect of both the Targeted Public Distribution System (TPDS) in India, and the Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program, in the United States, it is possible to assess the effectiveness of these policy programs, relative to cash transfers. Within this section, I will provide a brief summary of both the PDS and SNAP. Using income equivalences retrieved from the literature, I will discuss the advantages and disadvantages associated with replacing either the PDS or SNAP with direct cash transfers.

There is significant literature on the different effects of direct cash transfers versus in-kind assistance schemes, such as the TPDS and SNAP. The PDS is a social policy program implemented by the Government of India, which allows for the distribution of subsidized rice, wheat, sugar, and kerosene fuel through Fair Price Shops (FPS) located throughout the country. The TPDS is the largest welfare program in India, with a budget that corresponds to 1 percent of the net national product (Svedberg, 2012). The two main aims of the TPDS are to alleviate poverty and malnutrition among poor households. Nearly 20 million poor households in India possess below poverty line (BPL) or Antyodaya Anna Yojana (AAY) ration cards, which allow access to the subsidized goods at the FPS. Based on the results of the 2002 national census, the most recent census cycle currently available in India, families were categorized as BPL based on 13 different kinds of 'deprivations' (Alkire & Seth, 2013). These BPL families were eligible for government support such as subsidized food and electricity, and other schemes that encourage the construction of housing and promote self-employment activities.

Up until 1991, the TPDS was a universal policy and all households, rural and urban, were entitled to access. In the most recent phase of the TPDS program, a universal PDS has been replaced with a more targeted approach, dividing households into either BPL or APL (Above Poverty Line), and charging a discriminating price based on these categories (Swaminathan, 2008). Ultimately, the PDS has been subject to much criticism. According to a performance review by India's planning commission, "the transition from universal PDS to TPDS has neither benefited the poor, nor helped reduce budgetary food subsidies" (Swaminathan, 2008, 5). Swaminathan (2008) highlights three key failures of the TPDS: first, targeting the program has led to the exclusion of genuinely needy persons from the PDS; second, targeting has affected the logistical economic

viability of the system and led to a collapse of the delivery network, resulting in mass wastage; and third, the TPDS has failed to achieve its objective of price stabilization, which was to be attained by transferring surplus cereals to regions of the country with deficits.

A Government of India review commission found that 27 percent of expenditures allocated towards the TPDS actually reach the intended households, and was described by India's Finance Minister as "an albatross around our neck and an opportunity for rent seekers to enrich themselves" (UNICEF India, 2012, p. 30). As a result, in terms of income equivalence, we can assume that $1 of expenditure on the TPDS is equivalent to $0.27 in cash transfer, due to the misallocation of funds.

In contrast to the PDS, the United States' SNAP program, is an income support policy program that provides electronic debit cards (EBTs) filled with cash to qualifying households which can be used for the purchase of food items, and excludes potential expenditures on alcohol, cigarettes and prepared food items. There is a complex system in place to judge the eligibility of respondents for the program. Pre-screening tools available online require information on earnings, rent or mortgage, utility bills, child support payments, day care expenses, medical bills (for those older than 60 or disabled), and Supplemental Security Income (for disabled individuals).

SNAP is the largest of USDA's food assistance programs, and in 2005, over 60 percent of the benefits provided by all domestic food assistance programs were distributed through SNAP (Reed & Levedahl, 2010). While some experimental evidence has found that $1 in food stamps is exactly equivalent to $1 in cash, the presence of a black market for food stamps, in which recipients re-sell their food stamps for a value less than $1 may suggest otherwise. In one study by economist Diane Whitmore, she suggests that $1 in food stamps is equivalent to $0.65 in cash (Whitmore, 2002).

Using the income equivalences retrieved from the literature, it is possible to assess the responsiveness of Energy Adequacy and healthy food diversity to changes in income. Ultimately, it is possible to compare the effects of the policy program and direct cash transfers using income-elasticities. Income-elasticities were calculated for all three data sets using the formula:

$$\delta_{income}(EA) = coef(income_{country}) * (mean\ income_{country})$$
$$\delta_{income}(HFD) = coef(income_{country}) * (mean\ income_{country})$$

Elasticities were calculated based on the log-level functional form, using the methodology originally discussed in Chapter 3: Table 3-15.

Table 5-11: Income Elasticities; Energy Adequacy and Healthy Food Diversity

Variable	NHANES	CCHS	NNMB
Mean Income	51029	49269	40091
Mean EA	0.768	0.758	0.814
Mean HFD	0.141	0.153	0.059
Coef(income); EA	4.7E-07	3.12E-06	1.93E-06
Coef(Income); HFD	1.58E-07	5.35E-07	3.63E-06
δ_{income} (EA)	0.02	0.15	0.07
δ_{income} (HFD)	0.008	0.02	0.14

Generated income-elasticities are presented in (Table 5-11). While there is no comprehensive national food policy program in Canada, it is observed that Canadian respondents' caloric intake is more responsive to changes in income than both Indian and U.S. respondents, with Indian respondents being more responsive to changes in their income than U.S. It is observed that HFD is less responsive to changes in income than Energy Adequacy for Canadian and U.S. respondents, relative to Indians. A 1 percent increase in income for Indians results in a 0.14 percent increase in HFD, for Canadian and U.S. respondents that result is less pronounced, with a 1 percent increase in income associated with a 0.008 and 0.02 percent increase in HFD, respectively. Using the elasticities calculated in Table 5-11 we can assess the effect of a direct cash transfers or in-kind assistance through either the TPDS or SNAP on Energy Adequacy and healthy food diversity, using the following formulas:

(1):

$$Income\ effect\ (\boldsymbol{Direct\ Cash}) = \partial_{income} * Cash\ Value$$

(2) :

$$Income\ effect\ (\boldsymbol{In-Kind\ Assistance}) = \partial_{income} * Cash\ Value\ Equivalance$$

Using the cash equivalences for SNAP and TPDS of $1000 direct cash transfer corresponds to $670 in-kind assistance, and $1000 direct cash transfer corresponds to $270 in-kind assistance, respectively, the income effects outlined in Table 5-12 were generated.

Table 5-12: Income Effect on Energy Adequacy and Healthy Food Diversity

		Income Effect	
Indicator	Country (Policy Program)	Direct Cash Transfer	Cash Equivalence
Energy Adequacy	United States (SNAP)	30	20.1
	India (TPDS)	100	27
Healthy Food Diversity	United States (SNAP)	170	113.9
	India (TPDS)	1310	353.7

Examining the results from Table 5-12, it is apparent that direct cash transfers would have a greater effect on both Energy Adequacy and healthy food diversity, with the effect for both direct cash transfers and our selected policy programs being greater for healthy food diversity. If we were to solely examine the income effect of the policy programs, it would be safe to conclude that direct cash transfers in both instances may provide greater monetary benefits to respondents than both SNAP and the TPDS. There are, however, associated effects with opting for in-kind assistance schemes that a direct cash transfer would not possess. A direct cash transfer would not have the restrictive aspects necessary to deter spending on extraneous items. In the United States, however, it is often observed that price response estimates to food stamps imply a "market-level marginal propensity to spend out of food stamps that is more than 100 times larger than the marginal propensity to spend out of income" (Reed & Levedahl, 2010, p. 1392). Some nutritionists argue that replacing food stamps with cash would lead to nutritional problems in recipients (Fraker, 1990). Perloff (2008) suggests four key issues which determine whether it would be beneficial to switch from food stamps to direct cash transfers (Perloff, 2008):

(1) Less food: a review of many statistical analyses suggests that an additional $1 of income causes an average low-income household to increase expenditures on food by $0.05 to $0.10 (Fraker, 1990).
(2) Fewer nutrients: cash recipients in Washington consumed between 6 percent and 11 percent less nutrients than food stamp recipients, although cash recipients consumed far in excess of the daily recommended allowance of most nutrients (Fasciano, Hall, & Beebout, 1993)
(3) Lower administrative costs: a 1982 experiment in Puerto Rico showed that administrative costs and losses due to fraud and theft could be reduced by switching to cash transfers (Moffitt, 1989).

(4) Higher utility: one Alabama study demonstrated that there is greater choice on what recipients can purchase with cash transfers, resulting in greater utility for recipients of cash transfers; in addition, many respondents reported feelings of embarrassment associated with the use of food stamps (Fracker, Martini, Ohls, Ponza, & Quinn, 1993).

In India, however, the inefficiencies associated with the PDS system suggest a cash transfer initiative may be successful. Recent research by Peter Svedberg (2012) suggests that the effects on the intended outcome variables of the TPDS, poverty and malnutrition, are practically nil, and inefficiencies are even larger than previously understood (Svedberg, 2012). In terms of the first objective of the TPDS, to alleviate poverty, Svedberg found that the subsidy to the average poor household amounted to Rs. 30/month, or Rs. 6/person; he posits that in a hypothetical situation in which all poor households were issued BPL cards and utilized their full allowance (35 kg/month), that value would be 5 times higher. The second objective of the TPDS, to improve food security and nutrition, Svedburg asserts that the outcome is even more disappointing. He found that poor cardholder households consumed 3.6% less rice and wheat than their peers, although the effect of the TPDS on consumption of other food-items was not discussed. Ultimately, Svedburg concludes that a cash transfer scheme could cover about two-thirds of households, and make larger transfers to the poorest than the TPDS.

Ultimately, policy programs aimed at enhancing food security should kept in place as long as they are effectively achieving their aims. In the case of SNAP, access to food stamps is resulting in greater food purchases and the consumption of more nutrients, although the administrative costs would be eased with a switch to cash transfer programs. In the case of India, numerous studies suggest that the TPDS is a failed subsidy program, and recent research suggests that it is not successfully achieving its aims of alleviating poverty and malnutrition, with the subsidy being ineffectively utilized, and not resulting in greater consumption of the subsidized food items. As a result, the inefficiencies and waste associated with the TPDS could be avoided with a switch to a direct cash transfer program.

5.6 Limitations and Conclusion

In order to effectively understand food security, it is imperative to examine different methods of measuring food security status, and how they each contribute to the overall understanding of a complex and multi-faceted concept, such as food security. There were five main objectives of this analysis:

(Objective 1): Examining the link between different indicators of food security including Energy Adequacy, healthy food diversity, and household food security status (based on a qualitative food security assessment), where available.

(Objective 2): Assessing the effect that different individual- and household- characteristics have on the indicators in (Objective 1), and to what degree the effects are similar or different across the three countries.

(Objective 3): Extrapolating the link between healthy food diversity and Energy Adequacy and qualitative food security status, and discussing what can be expected where qualitative food security data is not available.

(Objective 4): Assess which households are 'food insecure' according to all three food security indicators, and discuss the characteristics associated with falling into this 'vulnerable group'.

(Objective 5): Comparing the individual determinants of food security across countries to provide policy recommendations.

Analysis was undertaken through the utilization of three data sets: for India, the NNMB survey for rural populations (2004 – 05), for the United States, the NHANES survey (2007 – 08), and for Canada, the CCHS (2004).

A literature review (Chapter 2) contributed to both the definition of food security as a state "… in which most people are able, by themselves, to obtain the food they need for an active and healthy lifestyle, and where social safety nets ensure that those who lack resources still get enough to eat" (World Food Summit, 1996), and the selection of outcome indicators of food security status: Energy Adequacy, the Healthy Food Diversity Index, and Adult and Child Food Insecurity Score.

The conceptual model was presented in Chapter 3, along with model specifications. Regression techniques were discussed, along with the rationale behind the final methodology chosen. In Chapter 4, the results from both non-parametric and parametric regression techniques were presented. The original objectives were individually discussed in this chapter.

There are certain limitations to the results presented in this paper. For instance, while data sets were similar in terms of the types of questions asked and methodology for collection of nutrition intake data, certain demographic variables were assessed using different categorical designations. Ultimately, it would have been preferable to utilize the same econometric methodology across data sets, to make comparisons between countries using available indicators. Since data was collected by different statistical organizations, the statistical requirements of the data sets (and in some instances, analytical requirements designated by the statistical organization) dictated the methodology that was used.

Adult and child food security status were presented as a count indicator, but estimated using linear regression techniques for ease of estimation. In addition, Energy Adequacy was assessed for the NHANES and CCHS data sets using

precise formulas for the calculation of the Estimated Energy Requirement (EER). For the NNMB data set however, pre-determined organizational methodology dictated the use of Recommended Dietary Intakes (RDIs) as designated by the Indian National Institute of Nutrition.It is possible that recalculation of Energy Adequacy using the same criteria as the NHANES and CCHS will result in a lower relative adequacy of Indian respondents, to Canadian and U.S.

There has been criticism of the use of 'intake norms' as an assessment of undernourishment (Dreze & Sen, 1990). Drèze and Sen suggest four reasons why traditional assumptions about 'calorie requirements' may be misleading. First, there is considerable evidence about inter-individual variation in metabolic rates, and statistical analyses of these intakes may not take this variation into account, or recognize that some individual may choose low-intake diets, because they have low-intake needs. Second, the use of the 24-hour recall, as is done in this study, does not take into account intertemporal variations in diet, in which consumption in the survey period may be higher or lower than average, and ultimately balanced by higher or lower consumption later on. Third, there is evidence that biological differences between individuals bring about intake adjustments. For instance, a smaller built person may require less nutritional intake than a person that is of similar stature due to a nutritional deficiency. Fourth, some nutritionists have argued that bodies can "'adapt' to low intakes by cutting down the nutritional needs without any effect on body size and other physical features and without any impairment of bodily functionings" (Dreze & Sen, 1990, p. 8).

In addition, numerous indicators of food security status were listed in Table 1-1, while only three were selected for the preceding analysis. It is possible, with increased data availability, to utilize those other indicators to increase the explanatory power of the analysis.

Econometrically, associations between indicators were discussed using multiple linear regression techniques and descriptive statistics. Due to data access limitation, it was not possible to conduct a more complex analysis. Estimation for adult and child food security, as count indicators which could take on a value of 1 – 10 and 1 – 8, respectively, was done using OLS regression techniques. Given the count nature of the variables, regression models such as Poisson Regression, Negative Binomial Regression, Hurdle Models, or Zero-Inflated/Truncated Count Models may have been more accurate for estimation (UCLA Statistical Consulting Group, 2007). In addition, a TOBIT model may have been preferable for the estimation of HFD and EA, considering they are both non-negative dependent variables. These different techniques could be pursued in future analysis.

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7 Appendices

Appendix 1: Variable Descriptions

		NHANES (USA)	CCHS (Canada)	NNMB (India)
Name	Description	Value	Value	Value
CA	Energy Adequacy	continuous	continuous	continuous
HFD	Healthy Food Diversity Index	0 to 1 - 1/n	0 to 1 - 1/n	0 to 1-1/n
TCA	Log-transformed Energy Adequacy	continuous	continuous	continuous
THFD	Log-transformed Healthy Food Diversity Index	continuous	continuous	continuous
EER	Estimated Energy Requirement	continuous	continuous	
RDI	Recommended Dietary Intake			see table 15
BI	Berry Index	0 to 1 - 1/n	0 to 1 - 1/n	0 to 1 - 1/n
income	Annual Household Income	continuous	continuous	continuous
ADFS	Adult Food Security Score	0 to 10	0 to 10	
CDFS	Child Food Security Score	0 to 8	0 to 8	
pal	Physical Activity Level or Status	sedentary, low active, active, and very active	sedentary, moderate, active	sedentary, moderate, active
male	Gender	1=male, 0=female	1=male, 0=female	1=male, 0=female

wic	Women, Infants, and Child Beneficiary program recipient in the last 12 months	1= yes, 0= no		
food stamp	Food Stamp program recipient in the last 12 months	1= yes, 0= no		
emerg	Accessed emergency food from charity, or church in the last 12 months	1= yes, 0= no		
ed	Highest Education Level in Household	1=less than 9th grade, 2=9th - 11th grade, 3=high school graduate/GED equivalent, 4=some college or AA degree or 5=college graduate and above	1=less than secondary, 2=secondary graduation, 3=some post-secondary, 4=post-secondary graduation	continuous
marital status	Head of household marital status	married, widowed, divorced, separated, never married, and living with partnet	married, common-law, widowed, separated, divorced, single	married, un-married, widowed or divorced
age	Respondent age	12 to 80	12 to 150	12 to 99
hhsize	Number of persons in household	1 to 7	1 to 5	1 to 8

Land (Acres)	Total land owned by head of household			continuous
Community	Membership to government identified disadvantaged community			Scheduled tribe, scheduled caste, backward caste, other
Type of house	Physical house characteristics			Kutcha, Semi-Pucca, Pucca
Electrification	Household access to electric grid			1= yes, 2=no
Separate Kitchen	Kitchen separate from the rest of the residence			1= yes, 2= no
Type of Cooking Fuel	Type of cooking fuel used			Fire wood, Kerosene, Bio-gas, Liquified Petroleum Gas
Source of Drinking Water	Source of water used for drinking			Open well, Tube well, Tap, Pond, Steam
Sanitary Latrine	Presence of sanitary latrine on household premises			1= yes, 2= no

Appendix 2: Mean Energy Adequacy and Healthy Food Diversity

Variable	NHANES	CCHS	NNMB
CA			
MEAN	0.768	0.758	0.814
SD	0.37	1.407	2.614
HFD			
MEAN	0.141	0.153	0.059
SD	0.038	0.036	0.045

Appendix 3: National Health and Nutrition Examination Survey Summary Statistics

	HFD		CA	
Variables	Mean	SD	Mean	SD
Physical Activity Level				
Sedentary	0.143	0.037	--	--
Low Active	0.143	0.037	--	--
Active	0.144	0.037	--	--
Very Active	0.139	0.039	--	--
Gender				
Male	0.139	0	--	--
Female	0.144	0	--	--
WIC				
Yes	0.138	0.038	0.779	0.382
Food Stamp				
Yes	0.133	0.045	0.805	0.491
Emerg				
Yes	0.133	0.043	0.78	0.435
Education				
Less than 9th Grade	0.138	0.039	0.721	0.349
9 - 11th Grade	0.137	0.04	0.797	0.447
High School Graduate/GED	0.141	0.039	0.75	0.4
Some College or AA Degree	0.141	0.036	0.773	0.342
College Graduate or Above	0.146	0.037	0.788	0.323
Marital Status				
Married	0.143	0.036	0.758	0.336
Widowed	0.146	0.037	0.736	0.311
Divorced	0.139	0.039	0.764	0.421
Living with Partner	0.135	0.041	0.824	0.401
Single	0.135	0.042	0.782	0.423

Appendix 4: Canadian Communities Health Survey Summary Statistics

	HFD		CA	
Variables	Mean	SD	Mean	SD
Education				
0	0.152	0.036	0.675	0.340
8	0.148	0.035	0.749	1.923

12	0.152	0.036	0.743	1.444
14	0.152	0.036	0.724	0.347
16	0.155	0.036	0.77	1.331
Home Owner				
No	0.149	0.038	0.763	1.508
Yes	0.155	0.035	0.755	1.363
Physical Activity Level				
Active	0.159	0.034	0.646	0.329
Moderate	0.153	0.034	0.689	0.327
Sedentary	0.151	0.034	0.829	1.864
Gender				
Female	0.149	0.036	0.731	1.404
Male	0.158	0.035	0.787	1.410

Appendix 5: National Nutrition Monitoring Bureau ANOVA Results

State						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	14.22	8	1.78	1274.89	0
State						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	133.21	8	16.65	267	0
Physical Activity Level						
HFD	Source	SS	F	Prob > F		
	Between Groups	2.05	526.55	0		
Physical Activity Level						
CA	Source	SS	F	Prob > F		
	Between Groups	5.77	42.35	0		
Religion						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	1.45	4	0.36	183.34	0
Religion						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	6.52	4	1.63	23.94	0

Community						
HFD	Source	SS	F	Prob > F		
	Between Groups	2.93	513.24	0		
Community						
CA	Source	SS	F	Prob > F		
	Between Groups	5.34	26.15	0		
Occupation						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	2.93	8	0.37	192.54	0
Occupation						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	19.81	8	2.48	1274.89	0
Total Land Owned						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.13	5	0.03	12.43	0
Total Land Owned						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	13.17	5	2.63	1274.89	0
Sex						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.11	1	0.11	53.59	0
Sex						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	18.21	1	18.21	269.68	0
Type of House						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	1.61	2	0.8	409.86	0
Type of House						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	9.69	2	4.84	71.3	0
Sanitary Latrine						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	7.24	1	7.24	4234.8	0
Sanitary Latrine						
CA	Source	SS	df	MS	F	Prob > F

	Between Groups	1.61	1	1.61	23.64	0
Electrification						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	3.3	1	3.3	1752.34	0
Electrification						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.13	1	0.13	1.96	0.16
Separate Kitchen						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	1.85	1	1.85	948.29	0
Separate Kitchen						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.01	1	0.01	0.13	0.72
Source of Drinking Water						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	2	4	0.5	256.38	0
Source of Drinking Water						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	14.01	4	3.5	51.71	0

Appendix 6: National Health and Nutrition Examination Survey ANOVA Results

Physical Activity Level						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.005	3	0.002	1.27	0.282
Physical Activity Level						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	133.21	3	16.65	267	0
Marital Status						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.083	7	0.012	8.42	0
Marital Status						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	4	7	0.57	4.99	0

Education						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.032	6	0.005	3.78	0.001
Education						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	5.080	6	0.85	7.31	0
Gender						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	1.63E-05	1	0.000016271	0.01	0.915
Gender						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.97	1	0.97	8.37	0.003
Household Size						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.021	6	0.004	2.51	0.020
Household Size						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.55	6	0.09	0.79	0.576
WIC Recipient						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.005	3	0.002	1.13	0.337
WIC Recipient						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.23	3	0.08	0.6	0.616
Food Stamp Recipient						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.005	1	0.005	3.12	0.077
Food Stamp Recipient						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.45	1	0.45	3.25	0.071
Emergency Food						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.028	3	0.009	6.53	0.000
Emergency Food						
CA	Source	SS	df	MS	F	Prob > F

	Between Groups	0.364	3	0.12	1.05	0.37

Appendix 7: Canadian Communities Health Survey ANOVA Results

Education						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.185	4	0.046	36.41	0
Education						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	3.141	4	0.785	0.4	0.811
Home Owner						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.195	1	0.195	153.31	0
Home Owner						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	0.120	1	0.120	0.06	0.806
Physical Activity Level						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.128	4	0.032	25.17	0
Physical Activity Level						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	57.744	2	28.872	14.64	0
Income						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.310	9	0.034	26.86	0
Income						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	23.812	9	2.646	1.32	0.222
Gender						
HFD	Source	SS	df	MS	F	Prob > F
	Between Groups	0.632	1	0.632	502.96	0
Gender						
CA	Source	SS	df	MS	F	Prob > F
	Between Groups	6.840	1	6.840	3.46	0.06

Appendix 8: Canadian Communities Health Survey Dependent Variable Correlations

	HFD	CA	ADFS	CDFS
HFD	1.000			
CA	0.075	1.000		
	0.000			
ADFS	-0.075	0.006	1.000	
	0.000	0.619		
CDFS	-0.028	-0.006	0.582	1.000
	0.024	0.654	0.000	

*** significant at the 1% s.l. ** significant at the 5% s.l. *significant at the 10% s.l.

Appendix 9: National Health and Nutrition Examination Survey Dependent Variable Correlations

	ADFS	CDFS	CA	HFD
ADFS	1.000			
CDFS	0.507	1.000		
	0.000			
CA	-0.018	-0.005	1.000	
	0.099	0.670		
HFD	-0.053	-0.015	0.180	1.000
	0.000	0.007	0.000	

*** significant at the 1% s.l. ** significant at the 5% s.l. *significant at the 10% s.l.