

Investigating the Relationship Between Food & Nutrition Security Among Manitoba Youth

Using Survey and Linkable Administrative Data

By

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ABSTRACT

Background: Food and nutrition insecurity are shaped by social determinants of health and are risk factors for adolescents' long-term health and academic potential. Due to limitations in nutrition surveillance and gaps in food security assessment tools for youth, limited data exists in Manitoba examining the intersection of social and economic factors impacting food and nutrition security, and academic achievement in this population.

Objectives: 1) Establish current and comprehensive baseline data on the food and nutrition security status of Grade 9 youth in Manitoba. 2) Describe patterns of food insecurity among Manitoba youth. 3) Examine associations between food insecurity, nutrition-related behaviours (i.e., meal location, eating frequency, dietary choices) and key social determinants of health (i.e., income quintile, income assistance, social housing, and residential mobility) that are linked to increasing rates of food insecurity in Manitoba. 4) Assess the impact of food insecurity, nutrition-related behaviours, social determinants of health, and mental health on academic achievement. 5) Identify social and economic factors influencing nutrition security to inform school food and nutrition policy reform.

Methods: A cross-sectional study was conducted among Grade 9 students ($n = 1587$) across 14 schools divisions in Manitoba during 2018-2019. A web-based survey assessed students' food security status, diet, eating behaviours, and well-being. When consenting, parents or guardians could provide their child's personal health identification number (PHIN). The PHIN sub-sample ($n = 943$) were linked with social, education, and health data through a de-identified data repository, the Manitoba Population Research Data Repository, housed at the Manitoba Centre for Health Policy (MCHP). Bivariate analyses explored relationships between sociodemographic variables, diet quality (Healthy Eating Index Canada (HEI-C)), eating behaviours, mental health,

food security, and academics. Multivariable logistic regression models estimated adjusted odds ratios and 95% confidence limits (CL) for food security and academic achievement, and a general linear model (GLM) for diet quality ($p \leq 0.05$).

Results: Twenty percent of participants experienced food insecurity, 70% had sub-optimal diets (mean HEI-C = 56/100), and 9% did not achieve sufficient academic credits by the end of the academic year. Food security was positively associated with living rurally and in higher income neighbourhoods, and negatively associated with living in northern communities, infrequent lunch and family dinner meals, and poor self-rated health. Food security was not independently associated with diet quality. Better nutrition was associated with being female and eating lunch at school, while poorer diets were associated with living in northern communities, a mental health diagnosis, poorer self-rated health, and receiving income assistance. Food insecurity, income assistance, and non-urban residence were negatively associated with participants' academic achievement.

Conclusion: Food and nutrition insecurity remain public health concerns for Manitoba youth. While results highlight a socioeconomic and geographic vulnerability to food insecurity and youths' academic achievement, the diet quality of most adolescents was also low. Findings suggest that current programs and policies aimed at addressing the negative trajectory of food and nutrition insecurity are inadequate and harmonized approaches are imperative, as scaling up income-based supports alone will not be sufficient to improve the overall nutrition of Manitoba youth.

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The results and conclusions presented in this dissertation are those of my own and no official endorsement by the Manitoba Centre for Health Policy, Manitoba Health, or other data providers (Manitoba Families – Social Innovation Office, Manitoba Education, Manitoba Adolescent Treatment Centre) is intended or should be inferred.

DEDICATION

To my daughter Ione, you were the drive I needed to finish this work.

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LIST OF ABBREVIATIONS

ATC	Anatomical Therapeutic Chemical
BMI	Body Mass Index
CCHS	Canadian Community Health Survey
CFG	Canada's Food Guide
CFSSM	Child Food Security Survey Module
CIS	Canadian Income Survey
CL	Confidence Limits
CNCM	Child Nutrition Council of Manitoba
DGA	Dietary Guidelines for Americans
FANS	Food and Nutrition Security
FAO	Food and Agriculture Organization of the United Nations
GLM	General Linear Model
HEFI-2019	Healthy Eating Food Index
HEI	Healthy Eating Index
HEI-C	Healthy Eating Index Canada
HFSSM	Household Food Security Survey Module
ICC	Interclass Correlation Coefficient
ICD	International Classification of Diseases
MCHP	Manitoba Centre for Health Policy
OR	Odds Ratios
PHIN	Personal Health Identification Number
RECORD	Reporting of Studies Conducted using the Observational Routinely Collected Data
SDGs	Sustainable Development Goals
SEP	Socioeconomic Position
SES	Socioeconomic Status
UN	United Nations
UPFs	Ultra-processed Foods
USDA	United States Department of Agriculture
VIF	Variance Inflation Factor
WEB-Q	Web-based Eating Behaviour Questionnaire
WHO	World Health Organization

CHAPTER 1: INTRODUCTION

OVERVIEW & STUDY RATIONALE

Food and nutrition insecurity are established public health challenges that threaten youths' physical and mental health (Men, Elgar & Tarasuk, 2021; Moubarac et al., 2017; Public Health Agency of Canada, 2017; Sellers et al., 2024) as well as their academic potential (Faught et al., 2017; McIntyre et al., 2018); however, intersectional knowledge about these issues among this population group within the Manitoba context remains limited. Food insecurity refers to the inadequate access to food due to financial constraints (Li et al., 2023). Nutrition insecurity incorporates food insecurity and goes a step further to include diets that lack variety, diversity, nutrients, and safety to meet the needs and food preferences required for individual well-being and disease prevention (Ingram, 2020; Mozaffarian, Fleischhacker, & Andrés, 2021).

Adolescence is a pivotal time for personal growth, gaining independence, and establishing healthy behaviours that track into adulthood (Hanning et al., 2007; Peralta et al., 2016; Tugault-Lafleur & Black, 2020; Wadsworth et al., 2012). A high-quality diet that meets personal and cultural preferences is central to optimizing health and preventing nutrition-related chronic diseases (Mozaffarian et al., 2021; World Health Organization, 2018). Unfortunately, the dietary habits of Canadian youth are far from exemplary, as few meet the recommended dietary requirements for their age and sex (Garriguet, 2009; Hack et al., 2021; Jessri et al., 2016; Slater & Colatruglio, 2016; Wadsworth et al., 2012). In Canada, poor diets, resulting from dietary shifts toward convenience and ultra-processed foods (UPFs) (Moubarac et al., 2017) and unhealthy lifestyle behaviours (e.g., excessive screen time) (Statistics Canada, 2020), are placing youth at risk for obesity, heart disease, certain types of cancer, Type 2 diabetes, and mental health issues

(Afshin et al., 2019a; Davison, Gondara, & Kaplan, 2017; Men et al., 2021; Sellers et al., 2024; Wharton et al., 2020).

Nutrition security in Canada is threatened by food insecurity, which has reached unprecedented rates in Canada ((PROOF Food Insecurity Policy Research (PROOF), 2024)). In 2023, 8.7 million Canadians (22.9%) lived in food insecure households, including more than one quarter of children (PROOF, 2024). The burden is even greater in homes with children, where 26.8% of households experience food insecurity, affecting approximately one third of children (PROOF, 2024). These disparities are driven by unique structural and demographic inequities, which preclude many Manitobans from achieving food security. Food insecurity is closely linked to poverty (Li, Fafard St-Germain, & Tarasuk, 2023), and for over two decades, children in Manitoba have experienced deeper poverty than their peers in other provinces (Social Planning Council of Winnipeg, 2020). Although poverty rates have improved following initiatives such as Rent Assist in 2015 and the introduction of the Canada Child Benefit in 2016, Manitobans continue to face disproportionately high levels of poverty compared to the other provinces (Statistics Canada, 2026). Manitoba also has the largest proportion of Indigenous Peoples of any other province, with Winnipeg home to the largest urban Indigenous population (Statistics Canada, 2022). Ongoing impacts of colonialism (Boyer, 2014, p.22; Rudolph & McLachlan, 2013) have resulted in Indigenous populations being unjustly affected by both poverty and food insecurity (Li et al., 2023). In northern Manitoba, geographic isolation further intensifies these inequities, as high food costs, driven by transportation barriers and limited market competition for grocers, severely constrain access to affordable food (Wendimu, Desmarais, & Martens, 2018).

Despite the scale and severity of this issue, current tracking systems have been insufficient to fully understand the impacts of food insecurity. Household food security has been intermittently captured by provincial and territorial surveys since 2005 using the validated Canadian Community Health Survey (CCHS) (Government of Canada, 2012) and since 2018, using the Canadian Income Survey (CIS) following the implementation of Canada's Poverty Reduction Strategy (Tarasuk, St-Germain, & Li, 2022). However, only two comprehensive national nutrition surveys have been conducted (CCHS Nutrition 2004 and 2015) (Government of Canada, 2006; Statistics Canada, 2017). Provincial sample sizes for children and adolescents are too small to support meaningful regional analyses (Health Canada, 2017), limiting insight into the intersection of food and nutrition security among youth. Moreover, household-level measures fail to capture children's individual experiences, obscuring important links to outcomes such as education. Likewise, few Canadian studies have leveraged administrative data to examine connections between health and educational outcomes and food and nutrition security (Anderson et al., 2023; Kirk, Kuhle, Ohinmaa, & Veugelers, 2013; Men, Gundersen, Urquia, & Tarasuk, 2020a; Tait, L'Abbé, Smith, & Rosella, 2018). This gap represents a significant missed opportunity to generate actionable evidence and limits the ability of policymakers to design effective, targeted interventions.

Building on these limitations, the rising prevalence of food insecurity among children and youth (PROOF, 2024), alongside the early development of nutrition-related chronic disease such as Type 2 diabetes (Sellers et al., 2024), underscores the inadequacy of current provincial and federal responses. A key contributor to this gap is the persistent separation of food security and nutrition security within the literature, despite their inherently interconnected nature. Addressing these issues in isolation limits the development of effective policy solutions. An integrated

approach is therefore needed to examine the intersection of food and nutrition insecurity, particularly among children and youth, to better understand their combined influence on health and educational outcomes. Efficient and affordable data collection methods, such as administrative or routinely collected data, offers the opportunity to generate policy-relevant evidence to inform coordinated and equitable interventions.

Routinely collected data has emerged as a valuable tool in public health, offering an efficient means of assessing epidemiological trends, uncovering clinical relationships between risk factors and disease, and influencing health policy advocacy (Welk, 2020). Beyond its traditional applications, this type of data has proven advantageous in tackling health inequities and advancing social justice through its ability to facilitate intersectional analyses (Chadd, Cauter, Pettican, & Enderby, 2025; Mahendran, Lizotte, & Bauer, 2022; Wemrell, Karlsson, Perez Vicente, & Merlo, 2021). Manitoba is a national leader in leveraging administrative data to advance research (Katz et al., 2025; Urquia, St-germain, Godoy, Brownell, & Janus, 2025) and shape health policies (Chartier et al., 2020; Dahl et al., 2025; Lix et al., 2018), offering a unique opportunity to explore the intersection of food and nutrition insecurity with socioeconomic dimensions and move beyond the conventional, one-dimensional view of the socioeconomic gradient (Wemrell et al., 2021). This has been accomplished for reporting on the health of Manitobans by population health indicators and health service use for more than twenty years (Dahl et al., 2025), presenting insights into short- and long-term policy priorities based on regional needs. In the era of precision public health – delivering the right intervention to the right population at the right time - (Khoury, Iademarco, & Riley, 2016) and with both the federal and provincial governments (Government of Canada, 2024; Government of Manitoba, 2024a)

playing a role in the implementation of Canada's school meal program it is of great importance that policies be grounded in relevant, context-specific data to maximize their effectiveness.

STUDY AIM

As part of the FANS research initiative (*Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth*), this dissertation concentrates on understanding the food and nutrition security status of Manitoba youth. It thoroughly investigates nutrition-related eating behaviours alongside social determinants of health and educational outcomes using linked administrative data. By framing food and nutrition security as a social phenomenon, this research offers foundational insights to guide policy decisions aimed at enhancing the health and well-being of Manitoba youth.

RESEARCH OBJECTIVES

This study had five research objectives:

1. Establish current and comprehensive baseline data on the food and nutrition security status of Grade 9 youth in Manitoba.
2. Describe patterns of food insecurity among Manitoba youth.
3. Examine associations with nutrition-related behaviours (i.e., meal location, eating frequency, dietary choices) and key social determinants of health (i.e., income quintile, income assistance, social housing, and residential mobility) that are linked to increasing rates of food insecurity in Manitoba.
4. Assess the impact of food insecurity, nutrition-related behaviours, social determinants of health and mental health on academic achievement.
5. Examine social and economic factors that shape food and nutrition security to inform evidence-based school food and nutrition policy reform.

CHAPTER SUMMARY

This is a paper-based dissertation, in which chapters 4-6 have been prepared as manuscripts for publication.

Chapter 2 is a comprehensive review of the literature on food and nutrition security in youth, including current programs and policies aimed at addressing the issues.

Chapter 3 provides an in-depth overview of the methodology and methods used to analyze this dissertation and summarizes the study variables.

Chapter 4 presents the manuscript “Conceptualizing food insecurity among Manitoba youth: A cross-sectional Canadian study linking administrative data”.

Chapter 5 presents the manuscript “Food and nutrition insecurity may compromise youth academic achievement: Results from a Manitoba cohort utilizing linked administrative data”.

Chapter 6 presents the manuscript “Social and economic factors affecting youth nutrition security: A cross-sectional study linking administrative data in Manitoba.”

Chapter 7 presents a comprehensive discussion that summarizes the study findings in the context of the existing literature, including study strengths, limitations, and future considerations.

CHAPTER 2: LITERATURE REVIEW

Canada faces a public health crisis as rates of food insecurity and diet-related non-communicable diseases continue to rise (Afshin et al., 2019b; Li, Fafard St-Germain, & Tarasuk, 2023; Sellers et al., 2024). Following nearly 20 years of recording, Canadian rates of food insecurity in 2023 saw a record high of 8.7 million people (23%), including 2.1 million children affected (PROOF, 2024). The universal definition of food insecurity as established in the 1990s by the Food and Agriculture Organization of the United Nations (FAO) and The Committee on World Food Security states that “[f]ood security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996, p. 2). In Canada, however, the tool used to measure food insecurity on population surveys does not capture data on all the aspects of the above definition, but rather quantifies the economic access to food (Government of Canada, 2012). Therefore, the commonly utilized definition of food insecurity in Canadian practice and research is the “inadequate or insecure access to food due to financial constraints” (Li et al., 2023, p. 6). Food insecurity poses a significant risk to one’s nutritional status and is closely connected to socioeconomic vulnerability and may compromise physical and mental health, and academic achievement in youth (Faight et al., 2017; Kirkpatrick et al., 2010; Li et al., 2023; McIntyre et al., 2018; Men et al., 2021; Tarasuk et al., 2019).

Equally concerning are the increasing rates of childhood obesity and diet-related chronic diseases (Public Health Agency of Canada, 2017; Sellers et al., 2024; Statistics Canada, 2020), which are threatening population health and burdening the health care system (Loewen et al., 2019; Men et al., 2019; Nshimyumukiza et al., 2018). Nutrition is the leading modifiable risk factor for disease (Afshin et al., 2019a), yet children and youth in Canada have the most

nutritionally inadequate profiles compared to other population groups in the country (Garriguet, 2009; Hack et al., 2021; Jessri et al., 2016). Childhood is an opportune time to establish healthy eating behaviours that protect against long-term chronic disease outcomes (Tugault-Lafleur & Black, 2020) as learned behaviours and weight status at younger ages are known to track into adulthood (Acton et al., 2018). The establishment of nutrition security, or a diet that is of adequate variety/diversity, nutrient content, balance/moderation, and safety to meet the needs and food preferences for an active and healthy lifestyle (FAO et al., 2020; Mozaffarian et al., 2021; Slater & Yeudall, 2015) is contingent on food security.

The coexistence of food insecurity and nutrition insecurity presents a double burden for population wellbeing, especially amongst vulnerable population groups such as children and youth. Food and nutrition security are important social determinants of health that influence daily life and contribute to positive health outcomes (Mikkonen & Raphael, 2010; World Health Organization, 2025). Unfortunately, the effect of government policy on these two constructs is underrepresented in the present literature. This is mainly due to ambiguity in defining food and nutrition insecurity and a lack of consensus on their relationship (Hendriks, 2015). Consequently, food and nutrition security are too often examined separately, creating challenges for developing and implementing cohesive policies and programs to address them.

Over ten years into the implementation of the 2030 United Nations (UN) Agenda for Sustainable Development (United Nations, 2015), Canada remains off-target in meeting the ambitious goals of the agenda, one of which is to achieve zero hunger; a goal that includes food and nutrition security for *all*, and ending all forms of malnutrition (Government of Canada, 2019b; United Nations, 2015). The recent commitment by the federal and Manitoba provincial governments to provide universal school food programming (Government of Canada, 2024;

Government of Manitoba, 2024b) is a step in the right direction to ensure more equitable access to food and, in theory, make nutrition a top priority. However, a universal school food program alone will not be a solution to food and nutrition insecurity, and policy success will be highly dependent on its rollout, including staff education, ongoing infrastructure development, and program evaluation.

This literature review examines the food and nutrition security status of Canadian youth, with a particular emphasis on Manitoba, where relevant data are available. It explores the context, methods, risk factors, and outcomes of the relevant research, as well as current policies pertaining to each food and nutrition security construct separately, followed by a review of the intersection between both. Lastly, it acknowledges the research gaps of this complex topic area within the present literature.

2.1 FOOD (IN)SECURITY

In 2023, 25.6% of Manitobans, including nearly one-third of children, were living in food-insecure households, an upsurge from the previous four years, during which the average for the province was closer to 20% (PROOF, 2024). The prevalence of food insecurity has reached an all-time high since the advent of monitoring in 2005 (Li et al., 2023; PROOF, 2024).

Measuring Food Insecurity in Canada

Household food insecurity data has historically been collected using the CCHS (Statistics Canada, 2023a). The CCHS is a nationally representative cross-sectional survey administered by Statistics Canada biannually, which collects health information on a sample of approximately 65,000 Canadians per cycle (Statistics Canada, 2023a). Survey respondents include Canadians aged 12 and above from the ten provinces and three territories, excluding individuals living on First Nations reserves or in institutions, those who are homeless, full-time members of the

Canadian Forces, and those in some remote regions of Quebec (Statistics Canada, 2023a). The CCHS is a reliable measure of health data at the national, provincial and health region levels (Statistics Canada, 2024b); however, the 2023 cycle only focused on adults 18 years and older (Statistics Canada, 2024b).

Food security in Canada is measured as part of the core content (asked of all respondents) on the CCHS using a standardized and well-validated scale (Li et al., 2024) known as the Household Food Security Survey Module (HFSSM). The HFSSM was adapted from the food security measurement method developed by the United States and incorporated into the CCHS in 2005 (Government of Canada, 2012; PROOF, 2018).

The HFSSM gathers self-reports of uncertain, insufficient or inadequate food access (Government of Canada, 2012). A total of eighteen questions about experiences related to food insecurity over the previous twelve months are asked of adult respondents on behalf of the household (Government of Canada, 2012). Ten questions are specific to the experiences of adults in the household (Adult Scale), and eight are specific to the experiences of children under the age of 18 (Child Scale) (Government of Canada, 2012).

Although there is extensive literature on food insecurity in Canada, several limitations remain. First, provincial sample sizes of children and adolescents from national survey data are too small to allow for meaningful analysis at regional levels. Additionally, the food security data may not fully reflect authentic experiences for this group or individuals, as the HFSSM gathers food security information at the household-level, with adults serving as proxies for children. Parental perceptions might not accurately represent youths' experiences with food insecurity, as they may sacrifice their own food to support other family members (Baer, Scherer, Flegler, & Hassan, 2015). Secondly, it can be argued that the true prevalence of food insecurity among

Canadians is underestimated because it excludes some of the most vulnerable subpopulations, such as on-reserve First Nations, people living in remote areas, and the homeless (Loopstra & Tarasuk, 2015a; Tarasuk & Mitchell, 2020).

Determinants of Food Security in Canada & Manitoba

Food insecurity has been identified as an indicator of nutrition inequity and a strong social determinant of health (Tarasuk et al., 2018). Although it is closely tied to household income (Li et al., 2023; Ontario Dietitians in Public Health, 2020), several other factors also increase the risk and severity of food insecurity, including family structure, homeownership, and housing stability; and geographic location.

Income

Income is arguably the most important social determinant of food security. Vulnerability to food insecurity increases for those living below the poverty line, and poverty remains a pervasive issue in Canada and Manitoba (Food Matters Manitoba, 2020; Li et al., 2023; Social Planning Council of Winnipeg, 2020b). Unfortunately, Canada has been slow to respond to the issue of poverty in a comprehensive manner, as evidenced by the first-ever Poverty Reduction Strategy released only in 2018 (Government of Canada, 2018b). And Manitobans continue to struggle. Recent statistics show that a higher percentage of Manitobans live in poverty (8.8%) (Government of Manitoba, 2023) compared to the rest of the country (7.4%) (Statistics Canada, 2024a), affecting 9.5% of Manitoba children (Government of Manitoba, 2023). The post-pandemic economic environment has seen food and shelter costs rise faster than inflation (Hajer, Fernandez, & Apata, 2020), making it extremely challenging for families to put food on the table, especially those experiencing financial hardship or relying on social assistance, worker's

compensation, or employment insurance assistance (Food Matters Manitoba, 2020; Tarasuk, Fafard St-Germain, & Mitchell, 2019).

It is not surprising that, when budgets are tight, food quantity and quality are often compromised, putting children in those households at risk of food insecurity and poor nutrition (Hutchinson & Tarasuk, 2021; Kirkpatrick & Tarasuk, 2008; University of Alberta, 2020), increasing risk of poorer physical and mental health outcomes (Anderson et al., 2023; Davison et al., 2017; Mark et al., 2012; McIntyre et al., 2017; O’Neil et al., 2014; Oellingrath et al., 2013; Pickett et al., 2015; University of Alberta, 2020), and performance in school (Faught et al., 2017; McIntyre et al., 2018; Selvitopu & Kaya, 2023).

Family Structure, Homeownership & Housing Instability

Canadian households with children experience greater food insecurity than those without; this risk increases for lone-parent households, especially those headed by females (Matheson & McIntyre, 2014; Tarasuk et al., 2019). The relationship between food insecurity and housing circumstances is multifactorial and involves proper access, adequacy, affordability, and tenure (Dietitians of Canada, 2024). Researchers agree that costs associated with housing are a significant barrier to ensuring one’s ability to afford other basic needs such as food (Hulchanski et al., 2009; Miewald & Ostry, 2014). Recent statistics indicate that more than 1 in 4 households that rent are food insecure (Li et al., 2023), and among Canadian renters in government-subsidized housing, this number increases to 1 in 2 (St-Germain & Tarasuk, 2017). In Winnipeg, the median rent increased by more than 17% between 2016 and 2020, which is equivalent to more than 2.5 times the rate of inflation (Hajer et al., 2020), exacerbating food security challenges for low-income residents.

Income can also contribute to housing instability, often referred to as residential mobility, especially for families with children (Anastasio, Leventhal, & Amadon, 2022; Ma, Gee, & Kushel, 2008). There is no universal definition of housing instability; however, it is frequently characterized by the number of moves (residential mobility) and/or difficulties in affording housing or related costs (Gilman, Kawachi, Fitzmaurice, & Buka, 2003; Kushel, Gupta, Gee, & Haas, 2006). Residential mobility has been studied in population-based health research as an early-life stressor that impacts health and well-being across the lifespan (Anastasio et al., 2022; Chai, 2024; Simsek, Costa, & de Valk, 2021), contributes to behavioural and emotional issues during childhood and adolescence (Jelleyman & Spencer, 2008; Simoni & Bauldry, 2020), and increases contact with the healthcare system (Ma et al., 2008). Although food insecurity has previously been linked to children's health and well-being (Kirkpatrick et al., 2010; Li et al., 2023; Men et al., 2021a), the literature specifically examining how residential mobility influences food security outcomes is limited. To the author's knowledge, no studies have explored these issues in the context of Canadian children.

Since food insecurity often results from low income, and residential mobility is more common among low-income households; therefore, it is expected that residential mobility would be linked to food insecurity. A recent Canadian study exemplifies this connection, demonstrating that food insecurity mediates the negative relationship between residential mobility and physical and mental health outcomes for Indigenous young adults (Chai, 2024). Similarly, a longitudinal study in the United States examined factors that lead to movements into or out of very low food insecurity, as measured by the United States Department of Agriculture (USDA) Food Security Module, over the previous 12 months (Jacknowitz, Morrissey, & Brannegan, 2015). The researchers found that residential mobility, defined as moving at least once during the previous

survey cycle (annual) was associated with a higher risk of food insecurity among children from birth to age 5 (Jacknowitz et al., 2015). The relationship between residential mobility and food insecurity among Canadian children and youth remains unanswered in the current literature. Based on existing knowledge about food insecurity's negative association with low income, as well as residential mobility, a negative relationship between residential mobility and food insecurity is expected.

Geographic Location

Research relative to the retail food environment, which encompasses geographic food access and the availability of nutritious foods, is essential for understanding contemporary food security issues (Engler-Stringer et al., 2014; Minaker et al., 2016). Geographic location has implications for food access across the province of Manitoba as well as in urban centres such as Winnipeg. The northern part of the province, comprising smaller, more sparsely populated communities, is known to have significantly higher food costs and unpredictable food availability, particularly for non-perishable foods (Wendimu et al., 2018). Food costs can be upwards of 200% in some northern communities compared to the southern provincial capital of Winnipeg, even after accounting for grocery subsidies (Wendimu et al., 2018). Additional barriers to food access included distance to travel to a store and limited public transportation (Wendimu et al., 2018).

Travel and transportation costs limit food accessibility in larger urban centres such as Winnipeg, especially for low-income residents who are more likely to reside in *food deserts* (materially deprived residential spaces, with limited or no access to grocers with nutritious and affordable food) (Minaker et al., 2016; Slater, Epp-Koop, Jakilazek, & Green, 2017) and those living with disabilities. Travelling further to access a grocery store is more difficult without a

personal vehicle (Miewald & Ostry, 2014; Páez et al., 2010; Tsang et al., 2011) and reliance on public transit, or walking, limits the ability to bring groceries home (Miewald & Ostry, 2014) and can be especially challenging in the winter months. Low-income neighbourhoods are also more likely to have a higher density of fast food outlets and convenience stores, which encourage unhealthy eating behaviours (Minaker et al., 2016).

Furthermore, geographic limitations to food access and, importantly, access to nutritious food are contributing factors to health inequalities, such as higher prevalence of obesity and Type 2 diabetes observed among Manitoba youth (Food Matters Manitoba, 2020; Sellers et al., 2024; Yu et al., 2010).

Implications of Food Insecurity

Food insecurity is a fundamental social determinant of health and is associated with adverse outcomes in physical and mental health, nutritional status, social well-being, and life expectancy (Ontario Dietitians in Public Health, 2020; Tarasuk, Fafard St-Germain, & Mitchell, 2019). A growing body of research highlights the serious impact of food insecurity on children and youth. For example, youth who experience food insecurity are more likely to report poorer overall health and wellbeing (Kirkpatrick et al., 2010; Pickett et al., 2015), lower self-esteem and reduced self-efficacy in making healthy lifestyle choices (Godrich et al., 2019), and a less nutritious diet (Kirkpatrick & Tarasuk, 2008; Mark et al., 2012). They are also at increased risk of obesity (Mark et al., 2012; Pickett et al., 2015). Beyond physical health, food insecurity is linked to poorer educational outcomes and mental health. Food-insecure youth are more likely to drop out of high school (McIntyre et al., 2018), have lower academic achievement (Faught et al., 2017), and face a higher risk of mood and anxiety disorders, including emotional distress (McIntyre et al., 2017; Men et al., 2021). Consequently, food insecure youth in Canada access

more outpatient and acute care services for mental health or substance use (Anderson et al., 2023) compared to their food secure peers.

Food Insecurity, Physical Health, and Nutrition

Food insecurity has long been recognized as a threat to good nutrition among children and adults in high-income countries (Hanson & Connor, 2014; Hutchinson & Tarasuk, 2021; Kirk et al., 2015; Kirkpatrick et al., 2015; Kirkpatrick & Tarasuk, 2008). For instance, analyses of population nutrition data from the 2004 CCHS, Cycle 2.2, revealed that adolescents, and to a lesser extent children, experience poorer diet quality when food insecurity is present (Kirkpatrick & Tarasuk, 2008). This was especially true for key nutrients such as vitamin A, magnesium, phosphorus, zinc, folate (among girls aged 14-18), and protein (Kirkpatrick & Tarasuk, 2008). Additionally, of concern was the positive association between food insecurity and adolescent energy density (except for males aged 14-18 years) – an indicator that may have long-term implications for weight management (Kirkpatrick & Tarasuk, 2008). However, after adjusting for covariates such as socioeconomic position (measured by family income and highest level of education), immigration status, and household size, some of the effects of food insecurity were attenuated; yet, relationships with nutrient adequacy persisted (Kirkpatrick & Tarasuk, 2008).

Mark et al. (2012) further examined how low income and food insecurity affect dietary indicators, anthropometric measures, and activity levels among Canadian youth aged 9-18. Results showed mixed associations: low-income boys from food-insecure households had higher rates of overweight, but similar height percentiles; vitamin D levels were low overall; food-insecure girls drank less milk and more sweetened beverages; and, despite a non-significant trend, food-insecure boys ate fewer fruits and vegetables. These inconclusive findings suggest that food insecurity alone may not fully account for poor diet quality in low-income households.

Furthermore, unlike previous research by Kirkpatrick and Tarasuk (2008), this study only adjusted for age and height, limiting the understanding of food insecurity's full impact on family dietary choices.

A second population-based nutrition survey was conducted in 2015 (CCHS 2015 – Nutrition). Using that data, Hutchinson & Tarasuk (2011) found food insecurity to be strongly linked to diet quality scores (as measured by the Healthy Eating Food Index) after adjusting for household income, geographic region, and education level. Diet quality declined among children aged 9-18 years as food insecurity increased, with a notably higher proportion of calories coming from ultra-processed foods (Hutchinson & Tarasuk, 2021).

Food Insecurity and Academic Achievement

In addition to its effects on diet quality and health, food insecurity has implications for academic achievement. A significant body of research has demonstrated that food insecurity is linked to a range of academic, behavioural, and emotional challenges for children and youth from high-income countries (Shankar, Chung, & Frank, 2017). While the exact impacts vary across developmental stages, food-insecure children tend to struggle with cognitive development, exhibit behavioural problems (e.g., hyperactivity), have heightened psychosocial and mental health challenges (e.g., difficulties with peer relationships), and face greater academic difficulties compared to their food-secure peers (Shankar et al., 2017). In particular, studies of younger children (5-11 years old) have found food insecurity to be associated with lower academic performance in reading and math (Alaimo, Olson, & Frongillo, 2001; Faught et al., 2017; Jyoti, Frongillo, & Jones, 2005). For example, a Canadian study of Grade 6 students experiencing very low food security were significantly less likely to meet expectations for math, even after adjusting for covariates such as household income, parental education, diet, weight, physical

activity, screen time, sex, and region of residence (Faught et al., 2017). Similarly, research involving American children has shown that both the intensity of food insecurity and transitions into food insecurity can negatively impact students' performance in literacy and numeracy (Jyoti et al., 2005; Winicki & Jemison, 2003).

Food-insecure children are also more likely to require additional educational support (Kleinman et al., 1998), face grade repetition (Alaimo et al., 2001; Kleinman et al., 1998) and are at higher risk of high school dropout (McIntyre et al., 2018). Interestingly, longitudinal data from Canada suggest that even mild food insecurity can predict an increased likelihood of high school dropout, after adjusting for covariates; however, it does not seem to significantly affect the likelihood of pursuing post-secondary education (McIntyre et al., 2018).

Given that much of the existing literature demonstrating associations between academic achievement and food insecurity among children and youth originates from the United States (Alaimo et al., 2001; Baer et al., 2015; Jyoti et al., 2005; Shankar et al., 2017), coupled with subpar performances on recent international assessments in literacy and numeracy for Manitoba youth (Government of Canada, n.d.) and worsening statistics on food insecurity in Canada (Li et al., 2023), warrants a closer examination of this relationship. Additionally, some studies rely primarily on bivariate analyses to examine the relationship between food insecurity and academics, without adequately controlling for confounding factors. This methodological limitation diminishes the ability to fully understand the issue within its broader social and economic context. This may obscure potential confounding effects of food insecurity as it intersects with academic achievement, employment opportunities, and other vulnerabilities including housing type and location, availability of community supports, and physical and mental health. These interrelated factors may reinforce one another, contributing to a cyclical

pattern in which food insecurity both influences and is exacerbated by educational and socioeconomic disadvantage. The above-mentioned studies underscore the importance of understanding how early food insecurity and other social determinants influence a child's academic trajectory. However, a key limitation in the existing literature is the missed opportunity to account for critical factors such as the nutritional quality of food, meal frequency, and the location where meals are consumed in survey measures pertaining to academics. Including these additional factors, alongside sociodemographic covariates, will allow for a more nuanced understanding of the relationship between food insecurity and academic achievement. This, in turn, will provide clearer insights into when universal policies are most effective and when more targeted interventions are needed to ensure equitable outcomes for all children.

To better understand these relationships, there is growing recognition of the need to integrate routinely collected data across health and education datasets. This approach provides continuous tracking of outcomes, such as educational attainment, while enabling researchers to examine how early vulnerabilities, including food insecurity, influence academic trajectories over time. For example, researchers in Manitoba studied how early childhood vulnerabilities in Kindergarten (measured by the Early Development Instrument) impacted academic performance in Grade 3 (Brownell et al., 2012). The results showed that a child's academic trajectory is influenced very early in life, and children with more vulnerabilities in Kindergarten were more likely to experience academic difficulties in Grade 3, with material deprivation being the strongest predictor (Brownell et al., 2012). Similarly, Roos et al. (2013) used a nested multi-level model to assess predictors of adolescent academic achievement, as measured by the Grade 9 and Grade 12 Achievement Indices (Manitoba Centre for Health Policy, 2015a). The most significant predictors included factors such as socioeconomic status, receiving social assistance, maternal

age at childbirth, gender, residential mobility, a diagnosis of attention-deficit hyperactivity disorder, and having a child taken into care (Roos et al., 2013). While these Manitoba-specific studies do not include food insecurity as a covariate, they highlight the importance of early childhood vulnerabilities such as low income - one of the strongest predictors of food insecurity - as an influencing factor to child and adolescent academic success. It can therefore be hypothesized that food insecurity will play a role in academic trajectories of Manitoba students.

Food Insecurity and Mental Health

In addition to its impacts on nutrition and academic performance, food insecurity has been correlated with ramifications for mental health. For instance, hunger has been longitudinally linked with depression risk amongst Canadian youth, with the experience of hunger predicting depression in subsequent survey cycles (McIntyre et al., 2017). Recent data from the CCHS, further corroborate this relationship, showing a graded association between the severity of food insecurity and mental health outcomes, such as depression and suicidal ideation, among youth and young adults following adjustment for covariates - gender, age, race-ethnicity, household education, income, housing tenure, household type, province/territory of residence (Men et al., 2021). Even mild food insecurity was found to increase the risk of mental health disorders, while moderate to severe food insecurity had an even more pronounced effect, corresponding to greater odds of major depression and risk of suicidal ideation (Men et al., 2021).

The complexity of the relationship between food insecurity and mental health, exacerbated by numerous confounders, has hindered a deeper understanding of these variables (Alaimo, Olson, & Frongillo, 2002; Koyanagi et al., 2019; Teevale et al., 2016). However, addressing food insecurity, particularly in childhood, could mitigate long-term mental health

risks. Studies show that low self-esteem and self-efficacy, both of which are more common in food-insecure households, are strong predictors of mental health issues in adulthood (Godrich et al., 2019). Adults who experienced food insecurity in childhood often report similar deprivation in their own youth, suggesting that addressing food insecurity early could break the cycle of intergenerational poverty and poor mental health. Furthermore, Men et al (2021) postulate that food insecurity among youth acts as a significant source of anxiety and stress stemming from food hardship, especially as youth transition into adulthood. Limited financial resources, high cost of living, and marginalization contribute to mental health challenges, particularly for young adults transitioning to economic independence who are at greater risk for food insecurity and subsequent mental health issues as they leave the home (Men et al., 2021).

The Canadian and Manitoba-specific literature exploring the link between food insecurity and mental health remains limited, underscoring the need for innovative research methods to better grasp this complex issue. The use of administrative data has proven invaluable in this context. For example, a recent Ontario study leveraged the Institute for Clinical Evaluative Sciences Data Repository and multiple cycles of the CCHS to explore the association of food insecurity and access to mental health and substance use outpatient services (Anderson et al., 2023a). The findings showed that food-insecure individuals were disproportionately more likely to seek outpatient services for mental health and substance use issues (Anderson et al., 2023a). Given the independent negative impacts of both food insecurity and poor mental health on child and adolescent development and education, using a representative sample (Edwards et al., 2022; Shankar et al., 2017) highlights the seriousness of this issue. Replication has not been conducted in Manitoba, but it is feasible considering Manitoba's comprehensive data on youth mental health through MCHP.

Responses to Household Food Insecurity

Finding a resolution to food insecurity is a multifaceted process. While the development of Canada's first ever National Food Policy in 2019 (The Government of Canada, 2019b), which included the appointment of the Canadian Food Policy Advisory Council and recent commitment by the federal government of \$1 billion for a National School Food Program (Government of Canada, 2024) is promising, Canada continues to lack momentum to address the issue comprehensively.

The present food policy landscape still comprise a patchwork of government initiatives (policies, programs and strategies) at various levels (Food Secure Canada, 2017) that continue to deflect the issue of food insecurity to coalitions and emergency food resources as evidenced by the ongoing rise in food bank visits across Canada due in part to rising inflation and essential costs such as food, housing, and transportation (Charlebois et al., 2023; Food Banks Canada, 2023; Harvest Manitoba, 2022).

Food banks and other charitable food assistance can provide relief to desperate households, but are not reaching the majority of those who are food insecure, and their capacity to provide long-term relief to the severely food insecure is limited at best (Tarasuk et al., 2019). Additionally, when food bank statistics are used to describe the magnitude of food insecurity, the issue is understated and temporal shifts in food insecurity prevalence are camouflaged as food bank usage is insensitive to changes in food insecurity (Loopstra & Tarasuk, 2015b). Given the ongoing rise in food insecurity prevalence (PROOF, 2024) and the continued use of food banks in Canada (Food Banks Canada, 2023), the need for comprehensive food justice strategies is undeniable.

Literature on the effectiveness of income supports and supplements suggests that they are more promising in reducing food insecurity compared to emergency food responses. Successes include Newfoundland and Labrador's 2006 Poverty Reduction Strategy (Loopstra et al., 2015), the Ontario Child Benefit (Tarasuk et al., 2019), and the Canada Child Benefit (Government of Canada, 2018a), which all demonstrated meaningful supports for low-income families; however, food insecurity could not be completely eliminated for the most vulnerable. A policy update that removes the Canada Child Benefit for high-income households and reallocates those funds to better protect low-income earners could ensure funds are distributed more equitably.

Similarly, strategies like a Basic Income Guarantee may be more beneficial in addressing food insecurity compared to targeted benefits (i.e., Canada Child Benefit) as they ensure an income floor and can better support the most vulnerable (Tarasuk, 2017). The concept of a Basic Income Guarantee is based on the success in reducing food insecurity among those over 65 who receive Old Age Security and the Guaranteed Income Supplement through Canada's public pension system (McIntyre et al., 2016). Extending an income guarantee to all working-age Canadians through a Basic Income Guarantee may reduce poverty, food insecurity (McIntyre et al., 2016), and improve overall health, as observed in the *Mincome* social experiment in Dauphin, Manitoba (1974-1978) (Forget, 2011).

Lastly, school food programs have demonstrated positive outcomes related to food security, as well as improved student learning success, enhanced diet quality, enhanced physical and mental health, and reduced financial burden on the healthcare system (Coalition for Healthy School Food, n.d.). Until 2024, Canada remained one of the few industrialized countries without a school food program. Both the federal government and Manitoba's provincial government have made concrete monetary allocations to support this initiative, with initial funding released at the

end of the 2024 school year (Government of Canada, 2024; Government of Manitoba, 2024b).

While exciting and highly anticipated, the success of such a policy will require sufficient infrastructure, education, and training to align cost-effective menus with nutrition standards and cultural considerations.

Conclusion

Food insecurity in Canada, and particularly in Manitoba, remains a pressing and complex public health and social issue that disproportionately affects low-income households and geographically isolated populations. Despite years of national surveillance, food insecurity rates continue to rise, with over a quarter of Manitobans now living in food-insecure households. The impacts on children and youth are especially concerning, with research linking food insecurity to poor nutritional status, lower academic achievement, and increased risk of mental health disorders. However, measurement limitations and the absence of nuanced, child-centered data, obscure the true scope of the problem. Furthermore, the emphasis on financial constraints overlooks other critical factors such as housing instability, geographic access to food, and the broader lived experiences of those affected. The pervasive issue of food insecurity underscores the need for comprehensive public policy.

While emergency food responses, such as food banks, remain widespread, they are insufficient to address the systemic roots of food insecurity. Targeted provincial strategies that incorporate more than just income-based policy solutions are necessary to reduce food insecurity and associated health disparities. Promising developments such as the National School Food Program represent a step in the right direction, but their success will depend on equitable design and implementation. Ultimately, addressing food insecurity in Canada requires a comprehensive, multi-level policy approach grounded in social justice and health equity. First steps should

include integrating health and education data to better understand and effectively respond to the long-term impacts of food insecurity, especially among children and youth.

Simultaneously, while many Canadians are grappling with food insecurity, a large number experience nutrition insecurity either with or without food insecurity. The following section will explain the global phenomenon of nutrition security and rationalize why it is insufficient to provide only enough calories to feed the population.

2.2 NUTRITION (IN)SECURITY

Despite the recognition of nutrition security more than two decades ago (FAO et al., 2020), poor diets remain one of the greatest contemporary threats to public health (Afshin et al., 2019a). Nutrition security refers to diets that are not only adequate in variety and nutrient content but also balanced and safe, meeting the needs and preferences for an active, healthy lifestyle (FAO et al., 2020; Mozaffarian et al., 2021; Slater & Yeudall, 2015). Unlike food security, which focuses on the quantity and accessibility of food, nutrition security emphasizes food quality, the nutritional value of diets, the body's ability to utilize nutrients, and food's broader role in supporting health and well-being (Ingram, 2020; Mozaffarian et al., 2021).

Unhealthy food and lifestyle choices can contribute to metabolic risk factors – such as elevated blood pressure, hyperglycemia, hyperlipidemia, and overweight/obesity – which are linked to noncommunicable diseases like cardiovascular disease and Type 2 diabetes (Moubarac, 2017; World Health Organization, 2021b). While nutrition-related diseases have long been recognized in adults, the rising prevalence of overweight and obesity among Canadian children and youth means these diseases are presenting much earlier in life (Government of Canada, 2023b; Lobstein et al., 2015). It is therefore pertinent to better understand modifiable risk factors like dietary behaviours, as diet quality can influence proximal and distal health and educational

outcomes in youth (Afshin et al., 2019a; Florence, Asbridge, & Veugelers, 2008; Men, Elgar, et al., 2021b).

Childhood and adolescence are critical periods for physical growth and development, as well as the development of lifelong healthy eating habits (Hanning et al., 2007; Peralta et al., 2016; Wadsworth et al., 2012). Yet there is growing concern regarding the diet quality of Manitobans, with limited research guiding meaningful change, especially since the last population-based analysis was conducted in 2015 (Government of Canada, 2022a). Gaining a clearer understanding of the dietary patterns of Manitoba's youth is crucial for informing targeted policies and programs that promote population health and well-being.

To support this aim, a thorough review of dietary measurement tools commonly used in Canada was conducted and is presented below. This process helped inform the methodological approach for this research initiative.

Measuring Diet Quality in Canada

Diet quality is an important component of nutrition security, addressing dietary adequacy and balance (FAO et al., 2020). A diet considered to be healthy ranks high in *diet quality* and promotes nutrition security. It goes beyond an energy-sufficient diet (adequate calories, mostly from starchy foods) or even a nutrient-adequate diet (adequate calories, balanced macro- and micronutrient intake) (FAO et al., 2020). In addition to sufficient calories and nutrients, a healthy diet includes diversity from different food groups, prevents malnutrition and supports health and well-being as emphasized by Canada's Food Guide (CFG) (FAO et al., 2020; Government of Canada, 2020a).

In Canada, frequently used diet quality assessment tools include, Health Canada's Surveillance Tool Tier System (Health Canada, 2014), the NOVA food classification system

(Monteiro et al., 2018), and the Healthy Eating Index Canada (HEI-C) (Jessri et al., 2017). The HEI-C has been recently updated with the Healthy Eating Food Index (HEFI-2019) to align with changes in nutrition guidance from the 2019 CFG (Brassard et al., 2022). The use of dietary indices such as the HEI-C and HEFI-2019, gained momentum in the mid 1990s, as researchers began adopting a more holistic view of diet. Since then, a variety of such indices have been proposed, including those specifically designed for children and adolescents (Dalwood et al., 2020; Kim, Haines, Siega-Riz, & Popkin, 2003; Kourlaba & Panagiotakos, 2009).

Dietary indices combine multiple individual variables often referred to as “index items” or “components”, which are scored using weights and summed to provide an overall composite score (Kourlaba & Panagiotakos, 2009). In contrast, the Tier System and NOVA classification do not provide composite scores but rather serve as categorical systems for classifying foods.

[Table 2-1](#) summarizes the diet quality measures discussed in this section.

Table 2-1. Summary of diet quality measurement tools

Tool	Summary	Reference Databases	Measures and Outcomes	Key Messages and Critiques
Health Canada Surveillance Tool Tier System (Health Canada, 2014)	<ul style="list-style-type: none"> • Measures adherence of diets to Canada’s Food Guide (CFG) (version 2007) • Categorizes foods into four food groups based on key nutrient^a thresholds • Validated tool 	Canadian Nutrient Files	Diets assessed based on age and sex recommendations and expressed as a percent of total calories Tier 1 <ul style="list-style-type: none"> • Foods do not exceed lower threshold for key nutrients Tier 2 <ul style="list-style-type: none"> • Foods that exceed one or two lower thresholds for key nutrients 	<ul style="list-style-type: none"> • Majority of foods should come from Tier 1 and Tier 2 foods (those in line with CFG recommendations) • Tier 3 foods are partially in line with CFG and should be consumed in moderation • Tier 4 foods should be enjoyed sparingly • Difficult to use for comparison as no composite score is generated • Does not address overconsumption • Does not address food processing

			<p>without exceeding any upper thresholds</p> <p>Tier 3</p> <ul style="list-style-type: none"> • Foods that exceed all three lower thresholds for key nutrients <p>OR</p> <ul style="list-style-type: none"> • Foods that exceed one upper threshold for key nutrients <p>OR</p> <ul style="list-style-type: none"> • Foods that exceed the upper saturated fat threshold (milk alternatives and meat alternatives only) <p>Tier 4</p> <ul style="list-style-type: none"> • Foods that exceed at least two upper thresholds for key nutrients 	<ul style="list-style-type: none"> • Limited relevance to Canadian nutrition guidelines that are no longer serving size based
NOVA Classification System (Moubarac, 2017)	Classifies foods into four groups based on extent of food processing ^b	<ul style="list-style-type: none"> • Canadian Nutrient Files • Food and Ingredient Detail File • University of Toronto's Food Label Information Program Database 	<p>Unprocessed or minimally processed</p> <ul style="list-style-type: none"> • Foods have not undergone industrial processing <p>Processed culinary ingredients</p> <ul style="list-style-type: none"> • Refined ingredients by the food industry (e.g., oils) or those found in nature (e.g., salt) 	<ul style="list-style-type: none"> • Choose unprocessed or minimally processed foods most often • Proponents argue classifying foods based on processing is more in line with contemporary eating habits • Limited by inability to quantify adherence to

		(for free sugars)	<ul style="list-style-type: none"> Not consumed on their own <p>Processed foods</p> <ul style="list-style-type: none"> Addition of culinary ingredients to minimally processed foods (e.g., bread) <p>Ultra-processed foods</p> <p>Food and beverages that undergo numerous processes and are nutritionally poor (e.g., sugary drinks)</p>	<p>Canadian dietary guidelines</p> <ul style="list-style-type: none"> Does not provide composite score Does not address overconsumption Does not consider food fortification in processing classifications
Healthy Eating Index Canada (Jessri et al., 2017)	<ul style="list-style-type: none"> Measures adherence CFG recommendations based on components of adequacy and moderation Validated tool Regularly updated to reflect changes in nutrition directives 	<ul style="list-style-type: none"> Canadian Nutrient Files ESHA^c 	<p>Individual composite score out of 100 based on age and sex recommendations for CFG servings^d</p> <ul style="list-style-type: none"> Adequacy components – dietary elements that are encouraged (max 60/100) Moderation components – dietary elements with limits for consumption (maximum 40/100) <p>Diets can also be described categorically</p> <ul style="list-style-type: none"> <i>Poor Diet</i> (<50) <i>Needs Improvement</i> (50-80) <i>Good</i> (>80) 	<ul style="list-style-type: none"> A higher score reflects greater adherence to dietary guidelines Composite scores rather than examination of individual nutrients Easily interpreted for public health messaging Neglects food processing Incompletely addresses overconsumption, as a perfect score can be achieved with excess caloric intake for an individual

^atotal fat, saturated fat, sodium, sugar

^bphysical, biological, and chemical processes

^cElizabeth Stewart Hands and Associates

^dlatest adaptation, Healthy Eating Food Index reflects 2019 version of CFG that is no longer based on servings. Maximum scoring out of 80 based on 10 dietary components.

Tier System Surveillance Tool

In 2014, Health Canada introduced the country's first nutrient profiling system: the Surveillance Tool Tier System (Tier System) (Jessri et al., 2016). This validated tool assesses how well Canadian diets align with the 2007 CFG (Health Canada, 2014) by classifying foods into four tiers based on thresholds for key nutrients: total fat, saturated fat, sodium, and sugar (Health Canada, 2014). Foods in tiers 1 and 2 align with CFG recommendations and considered health-promoting (Health Canada, 2014). Tier 3 foods are higher in fat, sugar or salt and only partially align with CFG, while Tier 4 foods fall outside CFG guidance and should be limited (Health Canada, 2014).

Diet assessments using the Tier System involve counting servings from the four food groups based on age- and sex-specific recommendations. “Other” foods (Tier 4) are assessed by their percent contribution to total calories rather than servings (Health Canada, 2014). Nutrient data are derived from the Canadian Nutrient File (Government of Canada, 2023a).

In contrast to other nutrient profiling systems, the Tier System focuses solely on four “negative” nutrients and does not produce a composite diet score, limiting comparability (Jessri et al., 2016). It also overlooks energy balance and fails to address overconsumption, limiting its scope to addressing obesity and disease-related dietary risk factors (Jessri & L'Abbe, 2015; Jessri et al., 2016). Additionally, the tool's reliance on serving sizes makes it irrelevant under current food guide recommendations, and it does not account for food processing or evolving dietary patterns (Moubarac, 2017).

NOVA Classification System

Many dietary policies are based on tools and guidelines that emphasize conventional food groups and nutrients—a method suited to diets centered on minimally processed, home-cooked

meals. However, this approach no longer reflects modern eating patterns (Moubarac, 2017). The NOVA system, used internationally, addresses this gap by categorizing foods based on the type and extent of food processing (Monteiro et al., 2018; Moubarac, 2017).

NOVA divides foods into four groups:

1. **Unprocessed or minimally processed foods** (e.g., fresh, or whole foods derived from plants or animals)
2. **Processed culinary ingredients** (e.g., fats, oils, sugars, salt)
3. **Processed foods** (e.g., bread, cheese, pickled meats and fish, preserved fruit)
4. **Ultra-processed foods** - industrially formulated products that are nutritionally poor, contain additives and little intact food (e.g., sugary drinks, packaged snacks, reconstituted meats, frozen meals, and fast food) (Monteiro et al., 2018; Moubarac, 2017; Polsky et al., 2020).

First introduced in 2009 (Monteiro, 2009), the concept of UPFs is now widely used by health organizations and researchers (Monteiro et al., 2018). Advocates argue that food processing should be at the forefront of dietary guideline development; a gap in traditional Canadian dietary assessment tools (Moubarac, 2017). The revised CFG-2019 now includes recommendations to limit “highly processed foods and drinks” due to their link with chronic disease risk (The Government of Canada, 2019a). Despite its relevance, NOVA cannot directly measure adherence to dietary guidelines by age or sex, nor does it account for overconsumption or beneficial processing, such as food fortification.

The Healthy Eating Index

A diet quality index is a composite tool that evaluates the overall quality of a diet based on current dietary guidelines or health outcomes (Woodruff & Hanning, 2010). The Healthy

Eating Index (HEI) is a validated diet quality index developed by the USDA in 1995 and updated alongside the Dietary Guidelines for Americans (DGA), assessing diet quality through two components: *adequacy* (encouraged foods, max 60 points) and *moderation* (foods to limit, max 40 points), with a total possible score of 100 indicating a diet in complete alignment with the DGA (USDA Food and Nutrition Service, 2023). The version used in this dissertation has been validated for the Canadian population (Jessri et al., 2017).

Adaptations of the HEI for Canada (HEI-C) have been made to align with Canadian nutrition guidelines (Garriguet, 2009; Glanville & McIntyre, 2006; Jessri et al., 2017). For example, In 2009, Garriguet adapted the HEI-2005 ([Appendix A](#)) using CFG-based serving sizes instead of energy density approach used in the United States (Garriguet, 2009). Woodruff & Hanning (2010) developed the HEI-C-2009 ([Appendix B](#)) for children and adolescents, and the HEI-C-2010 underwent adjustments to the point allocation for adequacy components with sub-category classifications of seafood and refined grains added ([Appendix C](#)) (Guenther et al., 2013; Jessri et al., 2017). While component weights and total scores have remained consistent (60 for adequacy, 40 for moderation), each version reflects evolving nutrition science and Canadian dietary guidance (Garriguet, 2009; Jessri et al., 2017; Woodruff & Hanning, 2010).

The latest Canadian adaptation, the Healthy Eating Food Index (HEFI-2019), launched in 2022, aligns with the 2019 CFG, which is no longer serving sized based (Brassard et al., 2022). The HEFI-2019 includes 10 components (five food-based, one beverage, and four nutrient-based), scored out of 80. Components are based on alignment with healthy food choice recommendations in CFG-2019 (Brassard et al., 2022; The Government of Canada, 2019a). Seven components assess adequacy, while three focus on moderation of nutrients of concern like saturated fats, free sugars, and sodium (Brassard et al., 2022). Positive correlations between the

HEFI-2019 earlier versions have been reported (Brassard et al., 2022; Panahimoghdam et al., 2025).

The HEI-C is considered one of the best indicators for assessing the diet quality of Canadians, as it correlates with the proportion of dietary recommendations met by an individual based on current dietary guidelines (Dubois et al., 2000; Woodruff & Hanning, 2010). Early nutrition epidemiology relied on the dominant approach of investigating single nutrients and chronic disease outcomes, which, from a population health perspective is difficult to discern as individual diets are complex; thus, the shift to dietary pattern analysis can be more beneficial in determining relationships between diet and health outcomes (Kourlaba & Panagiotakos, 2009). Further, dietary indices were developed to overcome issues in analysis with highly correlated data (Kourlaba & Panagiotakos, 2009). Entering individual components into a model can pose challenges in evaluating effect modification and confounding, which can lead to multicollinearity and result in less robust estimates of the coefficients (Kourlaba & Panagiotakos, 2009). The HEI can easily be interpreted as either a continuous (0-100 score) or categorical variable (<50 poor diet, 50-80 diet in need of improvement, >80 good diet), allowing for a variety of statistical applications (Dubois et al., 2000; Woodruff & Hanning, 2010).

Like any tool, the HEI-C is not without its limitations. A perfect diet quality score can be achieved despite overconsumption. The majority of the sub-components are arbitrarily assigned and weighted similarly, implying all have the same effect on healthy eating and health outcomes (Kourlaba & Panagiotakos, 2009; Woodruff & Hanning, 2010). Lastly, the tool does not consider food processing, an increasingly important factor in diet quality (Moubarac, 2017).

It should also be noted that all tools mentioned are reliant on self-reported data which are subject to errors in recall, challenges in quantifying portions, as well as reliance on nutrient-

composition databases that may contain errors (Subar et al., 2015). Despite these limitations, self-reported dietary data remains highly relevant in population nutrition research because it provides contextual insight into nutrient intake and dietary patterns, which are important for assessing individual and population level intake relative to dietary guidelines.

Diet Quality of Canadian Children and Youth

The diet quality of Canadian youth is far from exemplary, and recent analyses of dietary intake indicate they have the most nutritionally inadequate profiles compared to all other age groups (Hack et al., 2021; Jessri et al., 2016). Using the 2004 CCHS-Nutrition data, the mean HEI-C for youth aged 14-18 was 54.3 for boys and 55.6 for girls out of 100, with a statistically significant difference between sexes ($p < 0.05$) (Garriguet, 2009) and scores reflecting diets in need of improvement. Both mean values were also statistically different from the previous age group (9-13 years), which had a mean HEI-C of 60, at the 5% significance level. Similarly, a 2025 study comparing diet quality index scores of Western Canadian school-aged children ($n = 1887$, data from 2016, 2018, and 2020/21) found lower scores among boys compared to girls, based on multivariable regression analysis ($\beta = -1.44$, 95% CI: -2.38, -0.50) (Panahimoghadam et al., 2025).

The 2004 CCHS-Nutrition data assessed using the Tier System, revealed that 14- to 18-year-olds did not meet the recommendations for any food group (Jessri et al., 2016). Additionally, 31% of their total energy came from Tier 4 or “other” foods not recommended by CFG which include high-fat, high-sugar foods, and energy-dense beverages (Jessri et al., 2016). Examples of these foods included processed meats, fried potatoes, refined grains, and fruit juices (Jessri et al., 2016).

A similar analysis conducted using the 2015 CCHS–Nutrition data found minimal changes in diet quality over the eleven-year gap (Hack et al., 2021). Youth aged 14-18 years still did not meet food guide recommendations for any food group, except for grain products, but only when Tier 4 foods were included (Hack et al., 2021). Energy intake from Tier 4 foods decreased to 23%; however, most calories in line with CFG came from foods and beverages recommended to “choose few of” (Tier 3), such as fried potatoes, flavoured milks, high fat/processed cheese, and deli meats (Hack et al., 2021). The authors caution against over-interpreting this decline in the percentage of calories from Tier 4 foods, noting that the 2015 CCHS had more under-reporters compared to the 2004 cycle (Hack et al., 2021). Additionally, standard food sizes have changed, which may have contributed to the higher rate of under-reporting in the 2015 survey (Hack et al., 2021).

Using the NOVA classification system, Polsky et al. (2020) compared energy intake from UPFs in both cycles of the CCHS – Nutrition. In both years, over 50% of daily calories for children and adolescents came from UPFs (Polsky et al., 2020), indicating that these population groups consume a limited number of freshly prepared meals and whole foods (Moubarac, 2017). This is concerning, as UPFs are nearly twice as energy-dense, higher in nutrients of concern (sodium, sugar, saturated fats), and lower in dietary fibre and micronutrients compared to minimally processed foods (Moubarac, 2017).

A 2016 pilot study in Manitoba examined the dietary and food behaviours of youth and found that over half of participants did not meet food guide servings from any of the four food groups recognized in the 2007 CFG, and less than 10% met fruit and vegetable intake recommendations for their age group (Slater & Colatruglio, 2016). Sodium intake was significantly above the tolerable upper level, while saturated fat and sugar intake were also high,

and fibre, calcium, and vitamin D levels were below recommended amounts (Slater & Colatruglio, 2016). Likewise, more recently published Manitoba dietary data from the FANS research initiative collected in 2018-2019 continue to show nutritional concerns (Slater et al., 2022). The majority of males and females were not meeting recommendations for fibre, calcium or vitamin D, and saturated fat intake was too high (Slater et al., 2022). Males also exceeded sodium recommendations and more than fifty percent of female participants were not meeting recommendations for folate or zinc (Slater et al., 2022).

These findings underscore the need to better understand the various factors contributing to poor diet quality among youth.

What Shapes the Diet Quality of Youth?

Diet quality is shaped by a complex interplay of individual, environmental, and social factors (Garriguet, 2009; Gasser et al., 2017). While the previous section highlighted the concerning dietary patterns among Canadian children and youth, the following will explore relevant aspects that influence these patterns, offering a deeper understanding of what shapes youth's diet quality within the context of the research for this dissertation.

Socioeconomic Position, Determinants of Health & Food Environments

Socioeconomic position (SEP), or a person's 'place' in society, is influenced by the broader socioeconomic and political context in which they live (i.e., structural determinants) (Solar & Irwin, 2010). SEP is stratified by factors such as income, education, occupation, and race/ethnicity. These factors operate through intermediary determinants, also known as the social determinants of health – such as housing, living conditions, food security, and nutrition (Solar & Irwin, 2010). Both structural and intermediary determinants impact population health equity and overall well-being (Solar & Irwin, 2010).

Several studies demonstrate a differential in diet quality by SEP (Faught et al., 2019; Garriguet, 2009; Gasser et al., 2017; Panahimoghadam et al., 2025), with inequities in diet quality widening throughout the life course (Faught et al., 2019). Using baseline data from the Canada Food Study, Faught et al (2019) confirmed a negative gradient in diet quality across declining SEP groups. Their results also found that adult SEP mediated the association between childhood SEP and adult diet quality, suggesting that exposure to low SEP in childhood increases the likelihood of low SEP later in life (Faught et al., 2019). In a secondary data analysis from the Longitudinal Study of Australian Children, low parental education and belonging to the lowest SEP group (which included parental occupational status, parental educational attainment, and annual family income) greatly increased the odds of children following unhealthy dietary trajectories from early childhood to at least fifteen years of age (Gasser et al., 2017). However, in contrast to other studies, Attorp et al. (2014) did not find an association between family socioeconomic status (SES), including parental income and educational level and vegetable and fruit consumption among Grade 5 and 6 participants in British Columbia. This deviation from earlier findings may be related to the researcher focusing on a specific component of diet quality (i.e., fruit and vegetable consumption), rather than using the total diet quality index score in relation to socio-economic status. Interestingly, despite a more affluent study population indicated by income quintiles compared to all British Columbia households in the same period (Statistics Canada, 2025a), 85% of participants (n = 665) were not meeting the recommended intake for fruits and vegetables (Attorp et al., 2014). Such findings underscore nutrition security as a population-based concern. Inconsistencies in study findings may be due to differences in sample characteristics, diet quality measures, sampling bias, or covariates adjusted for.

Beyond individual choices, food environments—shaped by both physical and social factors—play a significant role in what people eat (Engler-Stringer et al., 2014). Geographic access to healthy food is recognized as an important intervention, especially among economically disadvantaged neighbourhoods (Government of Canada, 2013; Mah et al., 2016). Food swamps (i.e., low-income neighbourhoods with a high proportion of unhealthy food outlets) (Minaker et al., 2016) are highly visible in Winnipeg, notably in the downtown-core (Manitoba Collaborative Data Portal, 2020). These environments promote greater intake of nutritionally poor foods and beverages, resulting in unequal nutrition outcomes for individuals living in underserved neighbourhoods within urban areas (Vilar-Compte et al., 2021).

Moreover, the retail density of nutritionally poor food options has increased around Canadian schools (Hanning et al., 2019). For example, in Quebec, most public schools are within walking distance of a fast-food outlet (<1 km), which is associated with increased junk food consumption at lunch even after controlling for demographic characteristics and parental education (Cutumisu et al., 2017). Similar results were found by He et al. (2012), who examined the relationship between the neighbourhood food environments and purchasing behaviours of adolescents in Ontario. The close proximity and high density of fast-food outlets near homes or schools increase the likelihood of adolescents purchasing food from these outlets (He et al., 2012). The increase in retail food density, coupled with adolescents' increased freedom during school hours, raises concerns about diet quality, contributing to higher consumption of calories and nutrients of concern, such as sodium, saturated fat, and sugar (Hanning et al., 2019).

Societal Trends & Eating Behaviours

In addition to socioeconomic and environmental influences, broader societal shifts have impacted how people eat and relate to food. Changing social norms around food and cooking,

along with increased work hours, and more women in the workforce, have altered how people eat (Slater, 2013). The decline in in-home food mentoring has also changed people's relationship with food (Slater, 2013). These shifts, along with a decline in food literacy, the devaluation of home economics education in Manitoba, excessive screen time use and an increased desire for autonomy in adolescence, have led to greater dependence on convenience and UPFs (Moubarac et al., 2017; Nardocci et al., 2018; Priftis & Panagiotakos, 2023; Rodriguez-Barniol, Pujol-Busquets, & Bach-Faig, 2024; Slater, 2013).

Food processing has rapidly increased with the industrialization of the food system (Moubarac, 2017). This profitable industry has capitalized on the societal shifts mentioned above. Diets high in UPFs tend to be nutritionally unbalanced and intrinsically harmful to health (Monteiro, 2009; Moubarac et al., 2017). For example, regular consumption of UPFs has been linked to a 32% increased risk of developing obesity (Nardocci et al., 2018), as well as higher intakes of sodium, sugar, and saturated fats, and lower intake of fibre and micronutrients (Monteiro, 2009; Moubarac et al., 2017). Recent literature point to a rise in screen time (television, tablets, phones, computers, video games) as a contributing factor in the uptick of UPFs consumed by children and adolescents (Priftis & Panagiotakos, 2023; Rodriguez-Barniol et al., 2024; Shang et al., 2015). In a Canadian study of children 8-10 years of age, screen time (≥ 2 hours/day) correlated with overall higher energy intake, lower fruit and vegetables consumption, and lower fibre after variables like SES, sex, physical activity and age were controlled for (Shang et al., 2015). A qualitative study of Spanish adolescents (12-16 years of age) explored perceptions, attitudes and motivators of UPF consumption (Rodriguez-Barniol et al., 2024). Participants cited that UPF consumption increased when they were using screens because of mindless eating. They also noted being persuaded to buy or request certain products from their

parents based on endorsement by online influencers and advertisements to, and that UPFs consumption increased when they were alone versus when participating in family meals (Rodriguez-Barniol et al., 2024).

Shifting eating behaviours also play a key role in shaping diet quality among adolescents. A growing body of literature indicates that meal skipping, fewer family meals, and eating outside of the home to be associated with poor diet quality (Doggui et al., 2021; Storey et al., 2009; Woodruff et al., 2010; Woodruff & Hanning, 2009b). Watts et al., (2016) found these patterns often begin in adolescence and are associated with SEP, persisting into young adulthood. Longitudinal research suggests that eating trajectories tend to worsen during adolescence, particularly around ages 13-14, with declines in breakfast consumption, increased fast-food consumption, and reduced fruit and vegetable consumption (Doggui et al., 2021). FANS data corroborate these patterns, demonstrating poorer diet quality scores among participants who ate breakfast less frequently and who purchased meals and snacks from vending machines (Slater et al., 2023). Notably, the FANS study also identified a correlation between lower diet quality scores and elevated body mass index (BMI) (Slater et al., 2023). These findings are especially important given that adolescence is a critical time for developing long-term eating habits and food skills that are health-promoting (Hanning et al., 2007; Laska et al., 2012).

In contrast, family meals have been consistently associated with healthier diets among children and adolescents (do Amaral e Melo et al., 2020; Hammons & Fiese, 2011; Woodruff & Hanning, 2009). They promote the intake of fruits and vegetables, whole grains, calcium-rich foods and protein, while reducing the consumption of fried food and sugar-sweetened beverages (Fulkerson et al., 2009; Harbec & Pagani, 2018; Welsh et al., 2011; Woodruff & Hanning, 2009a). Additionally, family meals help prevent overweight and disordered eating (Hammons &

Fiese, 2011; Woodruff & Hanning, 2008) and increase self-efficacy for healthy eating (Woodruff & Hanning, 2009). Hammons and Fiese's (2011) meta-analysis found that children and adolescents who ate family meals together at least three times per week were 24% more likely to eat healthy foods and maintain healthy eating habits, while reducing their likelihood of being overweight by 12%. Moreover, adolescents who engaged in family meals at least five times per week decreased their likelihood of disordered eating by 35% compared to those who did not (Hammons & Fiese, 2011). The positive eating behaviours established through family meals are crucial for developing lasting habits, particularly as the frequency of family meals tends to decline with age (Woodruff & Hanning, 2008). Unfortunately, recently published data from a Manitoba cohort of youth (ages 13-16) found that the majority of participants were not meeting nutritional guidelines for age and sex and that foods not compliant with recommendations were displacing total caloric requirements (Slater et al., 2022) despite over three-quarters of participants reporting they eat family dinners at least five times per week (Slater et al., 2023). This relationship may point to societal shifts away from homecooked meals may be weakening the positive impact of family meals on diet quality. Scratch meals are increasingly being prepared with boxed or pre-prepared ingredients, which are often highly processed (Moubarac, 2017). Wiggers et al. (2018) found that although 80% of Canadians 16-30 years old reported preparing meals at home, more than a quarter of these meals were made with ready-to-eat/box food.

Canadian trends also indicate that fast-food intake is highest among adolescents and young adults (Black & Billette, 2015). Eating meals outside of the home – especially “on the go” or at restaurants – is associated with lower diet quality, higher energy intake, and increased saturated fat, sugar, sodium, and sugar-sweetened beverages (Lillico, Hammond, Manske, &

Murnaghan, 2014; Powell & Nguyen, 2013; Taher, Evans, & Evans, 2019; Woodruff & Hanning, 2009b). Adolescents who regularly consume fast-food or take-out meals are also more likely to be overweight or obese (Black & Billette, 2015). Notably, older adolescents are also more likely than their younger counterparts to eat restaurant and fast-food meals (Lillico et al., 2014; Tugault-Lafleur & Black, 2020), and particularly on school days (Woodruff and Hanning, 2009b).

Evidence from the 2015 CCHS – Nutrition cycle suggests that lunch is an important contributor to total daily calories, contributing over one-quarter of adolescents’ daily energy (Tugault-Lafleur & Black, 2020). Among adolescents 14- to 17-year-olds, those who ate lunch at school reported higher intake of vegetables and fruit, whole grains, and fibre, and lower intake of high-calorie beverages compared to those who ate elsewhere (Tugault-Lafleur & Black, 2020). These findings highlight the potential of school-based interventions to support healthier eating patterns in adolescence.

Taken together, results from the current literature highlight how societal changes are reshaping youth food and nutrition behaviours. Nutrition-focused interventions, which have historically placed significant emphasis on individual behaviour, must adapt to address the broader social and structural factors. In doing so, public health polices can more effectively address the negative consequences of poor nutrition among youth, including physical and mental health challenges, as well as difficulties with academic performance.

Implications of Nutrition Insecurity in Youth

Physical Health Outcomes

The growing public health crisis of overweight and obesity among youth, driven largely by poor diets, is putting them at risk for heart disease, certain cancers, Type 2 diabetes, and

mental health issues (Wharton et al., 2020). These trends impose a substantial burden on the healthcare system and threaten Canadian economic prosperity. In 2017, North America had the highest age-standardized total diet-related deaths from Type 2 diabetes globally (41%) (Afshin et al., 2019a). Diabetes is a well-known risk factor for other noncommunicable diseases, including cardiovascular and renal disease (Diabetes Canada, 2024).

Over the last four decades, the prevalence of obesity among Canadian children and youth has risen significantly, with nearly one-third of 5- to 17-year-olds being classified as overweight or obese (Rao et al., 2016; Statistics Canada, 2020d). This trend is closely linked to increased consumption of UPFs and more sedentary lifestyles (Craigie et al., 2011; Nardocci et al., 2018). The growing rates of childhood obesity are paralleled by the alarming rise in Type 2 diabetes diagnoses among this age group. Notably, 95% percent of adolescents with Type 2 diabetes are also obese (Amed et al., 2010). Canadian regional differences are also stark. Manitoba, for example, has seen an 88% increase in the incidence of Type 2 diabetes among children, rising from 16.0 to 31.1 per 100,000 in less than a decade (Sellers et al., 2024). Furthermore, the average of diagnosis continues to decline (Panagiotopoulos et al., 2018).

Overweight and obesity in children and youth have also been associated with high sodium intake and elevated blood pressure, two key risk factors for cardiovascular disease (Woodruff et al., 2014). Evidence from a 20-year longitudinal study shows that elevated blood pressure in childhood tends to persist into adulthood (Kelly et al., 2015), further increasing long-term health risks.

Mental Health Outcomes

Mental illness affects approximately one in four Canadian youth aged 9 to 19 (Men et al., 2021), with mood and anxiety disorders being the most prevalent subgroups (Statistics Canada,

2023c). Mood disorders involve disruptions in emotional state (e.g., major depressive disorder, bipolar disorder), while anxiety disorders are characterized by persistent worry, apprehension, and fear (e.g., generalized anxiety disorder) (Public Health Agency of Canada, 2016). Compared to other age groups, youth – particularly females – report the highest rates of mood disorders in Canada (Statistics Canada, 2019a, 2023c).

Nutrition insecurity has been associated with worse mental health outcomes across all age groups, including children and adolescents (Davison et al., 2017; King, Davison, & Pickett, 2021; Men, Elgar, et al., 2021b; O’Neil et al., 2014; Oellingrath et al., 2013). However, the relationship between nutrition and adolescent mental health has yet to receive broad recognition. This is possibly due to inconsistencies in how diet quality and mental health are measured, and variations in study designs (Wu et al., 2021).

A systematic review by O’Neil et al. (2014) found that most studies examining diet as the exposure variable reported a consistent and significant relationship between unhealthy diets and poorer mental health (anxiety, depression, low mood) in children and adolescents. Similarly, a cross-sectional study of Fijian adolescents found a dose-response relationship, with higher diet quality scores associated with fewer depressive symptoms (Sinclair et al., 2016). Norwegian researchers also observed that adolescents who consumed more nutrient-dense foods (e.g., fish, whole grains, vegetables and fruit) were more likely to report positive mental health outcomes, while frequent consumption of junk food was associated with increased risk of hyperactivity disorders (Oellingrath et al., 2013).

While these findings are congruent, it is important to note that cross-sectional designs cannot establish causality. What remains unclear is whether poor nutrition leads to poor mental

health or if poor mental health contributes to inadequate diets, a bidirectional relationship that remains challenging to discern.

Prospective studies aim to address the reverse causality, though studies of this design are limited. In O’Neil et al.’s (2014) review, three prospective studies were included; of these studies, two found that worse mental health in childhood and adolescence was associated with poorer subsequent dietary habits. In Canada, a population-based cohort by Wu et al. (2021) found that children with lower nutrition security and more sedentary lifestyles were more likely to be diagnosed with internalizing disorders and attention deficit hyperactivity disorder even after adjusting for sociodemographic factors. These diagnoses were also more prevalent among boys (Wu et al., 2021). Supporting these findings, an Australian cohort study found that adolescents who consumed a Western dietary pattern – characterized by frequent takeaway meals, red meat, and confectionery – had reported greater emotional and behavioural challenges, including withdrawal, anxiety, depression, aggression at age 14 (Oddy et al., 2009).

The consequences of poor nutrition extend beyond physical and mental health, also affecting cognitive development and academic performance.

Educational Outcomes

Several studies have demonstrated that students who are properly nourished are more likely to learn better and show improvements in academic outcomes. In a study of over 5,000 Grade 5 students from Nova Scotia, diet quality was found to be independently associated with academic performance on a provincial standardized literacy assessment (Florence et al., 2008). The authors note that “dietary adequacy and variety were identified as specific aspects of diet quality important to academic performance” (Florence et al., 2008, p.5).

Similarly, in a prospective cohort of Australian children, consumption of lower-quality foods such as fast food, red meat, soda, and fried or refined foods at age 14 was associated with a decline in cognitive performance by age 17 (Nyaradi et al., 2014). Conversely, increased consumption of green leafy vegetables and fruits were positively associated with cognitive performance (Nyaradi et al., 2014). Northstone et al. (2012) also found that participants who followed a “processed” dietary pattern – characterized by high-fat, high-sugar foods from processed and convenience sources – at age three had lower general intelligence scores five years later. As expected, a healthy dietary pattern resulted in higher intelligence scores at follow-up (Northstone et al., 2012).

A review by Adolphus et al. (2013) aimed to investigate the impact of breakfast on behaviour and academic performance among children and adolescents. Breakfast consumption was consistently associated with improved on-task behaviour across both observational and experimental studies, regardless of nourishment status or socioeconomic background. The authors also found that regularly consuming a healthy breakfast was positively associated with improved concentration and alertness, suggesting that simple dietary interventions can support learning outcomes (Adolphus et al., 2013).

Given the clear associations between nutrition insecurity and youth health, mental well-being, and academic performance, it is critical to examine how current policies and programs are responding to these challenges.

Current Responses to Youth Nutrition Insecurity

Effective responses to youth nutrition insecurity must support positive food environments that encourage healthy behaviours. At the national level, initiatives have emerged over the last decade, including Health Canada’s *Healthy Eating Strategy* (2016) (Government of Canada,

2021b) and Canada's first-ever *Food Policy* (Government of Canada, 2020d), which prioritizes access to nutritious food for all Canadians. A major milestone was the 2024 announcement of a universal school meal program, the first of its kind in Canada (Government of Canada, 2024).

Schools are important institutions for promoting health and shaping dietary outcomes, as approximately one-quarter of children's dietary energy is consumed at lunch on school days (Tugault-Lafleur & Black, 2020). While each province and territory is responsible for developing School Nutrition Policies, implementation is left to the school board (Critch, 2020). In Manitoba, school nutrition policies were last updated in 2015. Although these policies have been associated with better dietary habits and healthier weight trajectories (Critch, 2020; Ickovics et al., 2019; Veugelers & Fitzgerald, 2005), evidence suggests there is still work to be done, particularly at the high school level (Acton et al., 2018).

In an effort to respond to growing concerns of children's diets, many schools have adopted meal or snack programs, which show promise in increasing nutrition knowledge, food skills, and affinity for nutrient-dense foods (Colley et al., 2019). These programs have been positively associated with improved intake of micronutrients and fibre (Colley et al., 2019). However, the extent to which school food programs have been able to reach their full potential is often constrained by short program duration, limited intensity, and insufficient resources (Colley et al., 2019).

Until 2024, Canada had been criticized for being the only G7 country without a universal school meal program, relying on a patchwork of local initiatives that reach only a small proportion of students (Food Secure Canada, 2021). In Manitoba, the Child Nutrition Council of Manitoba (CNCM) has been a key stakeholder in supporting school nutrition policies, administering funding for meal and snack programs, and providing training and education for

school staff (Child Nutrition Council of Manitoba, n.d.). Despite this, provincial funding had remained frozen since 2014, and by the 2020-21 school year, the CNCM was unable to support new applicants (Child Nutrition Council of Manitoba, 2021).

In January 2024, the Manitoba government committed \$9 million over the 2023-24 and 2024-25 school years to expand school nutrition programming through the CNCM (Government of Manitoba, 2024b). Federally, Budget 2024 included a \$1 billion dollar investment over five years for the National School Food Program (Government of Canada, 2024). While these investments are promising, questions remain about the adequacy of funding and the infrastructure needed to implement such a program equitably across diverse school contexts (Webb, 2024). Success will depend on strong policies, sustained funding, adequate staffing (including community dietitians), cultural considerations, menu development support, and facilities capable of supporting food preparation and service.

Conclusion

Few Canadian children are meeting recommendations for health-promoting foods as recommended by CFG and there is a growing reliance on energy-dense and nutrient-poor processed foods (Hack et al., 2021; Polsky et al., 2020). The physical and social environments are significant contemporary influences on youth's dietary habits (Engler-Stringer et al., 2014; Vanderlee et al., 2023a). These shifts in eating behaviours are reflective in trajectories of increased BMI among children and youth, placing them at increased risk for other health issues such as Type 2 diabetes and cardiovascular disease (Wharton et al., 2020).

School-based food programs are promising avenues for addressing nutrition insecurity and reducing the number of children and youth on poor health trajectories. However, despite recent investments by both the provincial and federal governments in school food initiatives, a

critical gap remains in routine, population-level nutrition surveillance to guide these efforts. The last comprehensive dietary assessment was conducted in 2015, resulting in outdated data to inform decisions about nutrition policy. Without consistent and representative monitoring of food intake, dietary habits, and the food environments, it will be difficult to evaluate program effectiveness or target interventions when necessary.

2.3 INTERSECTION OF FOOD AND NUTRITION (IN)SECURITY

Food security and nutrition security are often conflated in public health literature and policy, despite being distinct yet interrelated concepts (Slater & Yeudall, 2015). While food security refers to consistent physical and economic access to safe and culturally appropriate food, it does not account for nutritional implications, nor does it emphasize *how* food is consumed (UN Standing Committee on Nutrition, 2013). As such, it is possible for individuals to be food secure, yet still experience nutrition insecurity, characterized by inadequate nutrient intake or an overall poor diet quality. Focusing solely on food insufficiency risks overlooking the broader implications of diet quality and related health and socioeconomic effects of long-term poor nutrition.

To address the limitations of a siloed approach, in 2013, the UN Standing Committee on Nutrition sought to integrate the concepts of both food and nutrition security to streamline actions aimed at eradicating hunger and malnutrition. According to this definition, “food and nutrition security exists when *all* people at *all times* have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life” (UN Standing Committee on Nutrition, 2013). This integrated approach emphasizes that nutrition security cannot be achieved in the absence of food

security, but that food security alone is insufficient to ensure a nutritious diet. Once again, this distinction is increasingly important in the Canadian context, where current evidence indicates both food-insecure and food-secure youth are at risk of poor diet and inadequate nutrient intake (Hack et al., 2021; Polsky & Garriguet, 2020). These challenges are particularly concerning in childhood and adolescence, as they are critical developmental periods when nutrition is essential to learning and growth, and food autonomy increases.

From a systems perspective, food and nutrition security share many overlapping determinants, including SEP, government policy, education, region of residence, and the built food environment. In Canada, food insecurity has been strongly correlated with worsening health outcomes (Tarasuk, 2017), reinforcing its role as a marker of nutritional inequity experienced across the socioeconomic spectrum. Investing in public health strategies that address both dimensions is not only imperative, but it also ensures approaches are rooted in equity and social justice.

Canada's commitment to the UN's Sustainable Development Goals (SDGs) (The Government of Canada, 2019b; United Nations, 2015) reflects international momentum toward a more comprehensive understanding of food systems. Although progress has been made, such as the introduction of Canada's first-ever Food Policy, the appointed Food Policy Advisory Council, and the 2024 announcement of a National School Food Program, there is still work to do to move food and nutrition security policy forward (Government of Canada, 2019b; United Nations, 2015).

Worldwide examples of school-based meal programs exemplify this opportunity (Hoyer, Gupta, Tasala, Weber, & Trask, 2025). They have demonstrated a reduction in household economic constraints by reducing food costs in addition to delivering nutritious meals,

promoting food literacy and academic success, and supporting learning environments for *all* students (Food Secure Canada, 2021; Hoyer et al., 2025; Ruetz, Zhang, & Edwards, 2024).

A recent report supported by the Coalition for Healthy School Food highlights the importance of grounding national nutrition programs in best practices from successful international models (Hoyer et al., 2025). A key recommendation is that programs must be designed with clear goals and measurable objectives, supported by robust provincial and territorial-specific data to assess impacts, gaps, and opportunities. They advocate for online data collection systems to enable consistency of tracking in a timely manner. In Canada, where nutrition surveillance is lacking, school meal program evaluation could serve as an opportunity to address this gap for children and youth.

2.4 RESEARCH GAPS

Good nutrition is paramount in the prevention of non-communicable diseases such as obesity and type 2 diabetes (Afshin et al., 2019a) with food insecurity and nutrition insecurity closely tied with nutritional quality (Kirkpatrick et al., 2015; Nardocci et al., 2018). Despite a lack of comprehensive population nutrition surveillance of Canadians, the consensus from the literature remains that adolescents' diets are a cause for concern (Hack et al., 2021; Jessri et al., 2016) and may explain in part why rates of pediatric Type 2 diabetes have risen exponentially in Manitoba since 2010 (Sellers et al., 2024). Simultaneously, one quarter of Canadian youth struggle with mental health challenges such as mood and anxiety disorders, often linked to poor diets, food insecurity, socioeconomic disadvantage, and body dissatisfaction (Bodega et al., 2023; Men et al., 2021; O'Neil et al., 2014).

Unfortunately, little to no progress has been made in addressing either nutrition insecurity or food insecurity in Canada. According to 2023 statistics, the percentage of food insecure

households has reached record highs across all ten provinces (PROOF, 2024). Manitoba observed one of the largest increases (7.2%) in household food insecurity over a one year period (second only to Saskatchewan), equating to 27% of the population, including 32.6% of children under the age of 18 (PROOF, 2024). A persistent gap in food security assessment is the inability for population surveys to capture the lived experiences of adolescent food insecurity as surveys often rely on parent or guardian proxies to assess household food insecurity (Baer et al., 2015). This methodological limitation of assessing food insecurity may not only underestimate the true prevalence and severity of food insecurity experienced by youth (Baer et al., 2015), but further limits the ability to interpret findings with other individual-level outcomes such as academic achievement, a concern relevant to Manitoba (Government of Canada, n.d.).

Likewise, comprehensive nutrition data across Canada are outdated. The most recent nutrition-focused survey, conducted over a decade ago, included only a limited sample from Manitoba (n = 1,408 individuals aged 1 year and older) (Health Canada, 2017), making meaningful inferences of sub-provincial and age-specific analyses difficult. These limitations in food security and dietary assessment underscore the need for individual- and child-reported data collected using child-specific tools that more accurately capture children’s food and nutrition experiences, as well as barriers to achieving food and nutrition security. Addressing this gap by demonstrating the feasibility of routine nutrition assessment in school settings will be an asset in supporting evaluation of existing and emerging nutrition policies, including school meal programming.

Despite the known links between food insecurity, poverty, and child outcomes, limited research in Canada – and specifically in Manitoba – has examined the intersection between food and nutrition security, social determinants of health, and downstream impacts on youth health

and educational outcomes. Manitoba researchers have been able to correlate childhood vulnerabilities such as material deprivation with worse academic outcomes using administrative data (Brownell et al., 2012; Roos et al., 2013); however, the vulnerability of food insecurity has not previously been included. Research from other jurisdictions does however articulate negative relationships between food insecurity and developmental and academic outcomes in children and youth, which becomes highly relevant in the current Manitoba landscape where performance in numeracy and literature falls below the national average (Government of Canada, n.d.). It would therefore be hypothesized that food insecurity and poorer academic outcomes would be expected.

Furthermore, the relationship between residential mobility and eating behaviours remains largely unexplored. Frequent residential moves are considered an early-life stressor and have been associated with a range of adverse outcomes, including emotional, behavioural, mental health and academic challenges (Chai, 2024; Jelleyman & Spencer, 2008; Roos et al., 2013; Simoni & Bauldry, 2020). These outcomes are also commonly observed among food-insecure children (Shankar et al., 2017), yet the interrelationships between residential mobility, food insecurity, and eating behaviours remain poorly understood.

To bridge these knowledge gaps, this study combines quantitative survey data with routinely collected health, social, education, and registry data from the Manitoba Population Research Data Repository, the most comprehensive administrative database in Canada. Given the persistent worsening of food insecurity in Manitoba (Li et al., 2023; PROOF, 2024; Tarasuk, Li, & St-germain, 2021), outdated population nutrition data, and subpar scoring in academics (Government of Canada, n.d.), the use of a novel web-based diet and food security assessment tool, linked with administrative records will allow for a deeper, systems-level understanding of

how food access and good nutrition intersect with social determinants and educational outcomes in youth.

Finally, this research will begin to address the call for ongoing monitoring and evaluation of school-based meal programming (Hoyer et al., 2025), including Canada's newly implemented universal school food program. This study will not only generate foundational baseline data but demonstrate methodological opportunities for routine data collection through the school system, supporting long-term tracking of progress of multi-outcome initiatives in a diverse region such as Manitoba. Regional insights will be imperative for assessing community assets and gaps and tailoring programs to jurisdictional needs.

CHAPTER 3 METHODOLOGY

3.1 THEORETICAL AND ANALYTICAL FRAMEWORK

Four theoretical perspectives and frameworks were used to develop the theoretical framework ([Figure 3.1](#)) for this research, which combines some of the FANS survey variables linked with administrative data to answer separate research objectives. Initially, a *systems thinking* lens (Research Alliance for Health Policy and Systems Research (RAHPSR) & World Health Organization (WHO), 2009) and *social ecological* perspective (Stokols, 1996) laid the foundation for conceptualizing the complexities of food and nutrition security across multiple levels (i.e., individual, social, population). They further supported assessing the gaps in current programs and policies aimed at addressing food and nutrition insecurity. Second, the *WHO Commission on the Social Determinants of Health* (Solar & Irwin, 2010) and *The Sustainable Livelihoods for Food and Nutrition Security Framework* (Slater & Yeudall, 2015) contributed to the development of my framework.

A *systems thinking* approach to problem-solving considers the dynamic components and fundamental characteristics of the entire system or space in which the issue exists, enabling the identification of strategic leverage points (i.e., where an intervention can result in system-wide change) for integrated solutions to gaps or *problems* within the system (RAHPSR & WHO, 2009). Overall, this approach demonstrates a clear understanding of relationships within a system and anticipates how an intervention might flow through it.

Within the context of this research, the *problems* of food and nutrition insecurity, as well as subsequent downstream negative health and educational outcomes, are part of a dynamic system that demands a deeper understanding of the connections among its elements (i.e., structural policies, systemic inequities, and personal assets) that make up the system. This high-

level overview facilitates conceptual thinking about the research process and consideration of how current programs and policies operate within the larger system to either strengthen or impede food and nutrition security for youth.

Similarly, *social ecology* theory, derived from systems thinking, posits that public health challenges are complex and require comprehensive approaches to understand, explore, and address determinants of health at multiple levels (Stokols, 1996). Research and interventions using this perspective demand integrated knowledge translation and close coordination with various disciplines and stakeholders to achieve success (Stokols, 1996). In this way, the theory highlights the dynamic interplay between situational and personal factors that contribute to well-being.

The WHO Commission on the Social Determinants of Health (Solar & Irwin, 2010) illustrates how social, economic, and political mechanisms create socio-economic positions. Through the stratification of a population, socio-economic position then shapes the social determinants of health that ultimately influence health outcomes and health equity (Solar and Irwin, 2010).

The Sustainable Livelihoods for Food and Nutrition Security Framework (Slater and Yeudall, 2015) is a pragmatic analysis of key aspects of food and nutrition security, including assets and threats to gaining food and nutrition security within a vulnerability context. The vulnerability context is shaped and influenced by structural determinants (e.g., government, social and public policies, food environments, culture, laws), which influence how the effects of social determinants of health are presented. This model clearly shows that food and nutrition security must coexist to achieve positive health outcomes. It also helps place study variables from the individual level into the wider societal context. Finally, a feedback loop demonstrates a

continuous cycle between health and equity outcomes, which are dependent in part, through the establishment of food and nutrition security. Future research will be needed to examine the effects of the feedback loop, but it is hypothesized that outcomes and health equity assets will strengthen one's socio-economic position, increase resilience in the face of vulnerabilities and facilitate ongoing achievement of food and nutrition security. For example, if food and nutrition security increase the possibility of meeting academic requirements for high-school graduation, leading to employment and stable wages; it would be expected that an individual in this situation would be more likely to maintain positive food and nutrition security status despite changes in the political environment that results in rising grocery prices. Outcomes can change depending on the priority issues set by stakeholders or system partners.

The theories and frameworks discussed above guide this research and prevent isolating any single issue as the root cause of food and nutrition insecurity. Instead, they help view all interconnected elements and outcomes as part of a holistic approach to achieving food and nutrition security. The theoretical framework developed for this research, independently created by the author, aims to foster critical thinking about current programs, policies, and social norms that perpetuate power imbalances at the structural level. Such imbalances threaten to weaken the system by creating unequal opportunities to attain food and nutrition security, which ultimately leads to poorer health and educational outcomes.

In this research, the following variables are considered part of both the vulnerability context and the structural and social determinants of health: sex, income quintile, geographic region, residential mobility, having lived in social housing, and accessing income assistance. How these economic and personal determinants are experienced influences additional social determinants, such as food and nutrition security, which are closely linked to one's assets. Assets

include health and educational outcomes, such as mental health, self-reported health, body mass index (BMI), and academic achievement. The system encompasses all aspects of an individual's life that impact the acquisition of food and nutrition security. Interested parties, such as community partners and academic institutions, can support policy reform by identifying gaps in the system and advocating for government action. For example, school divisions were interested in understanding the relationship between food and nutrition insecurity and academic outcomes and the Child Nutrition Council was keen to learn about regional food insecurity prevalence and socio-demographic correlates to support advocacy efforts for increased program funding.

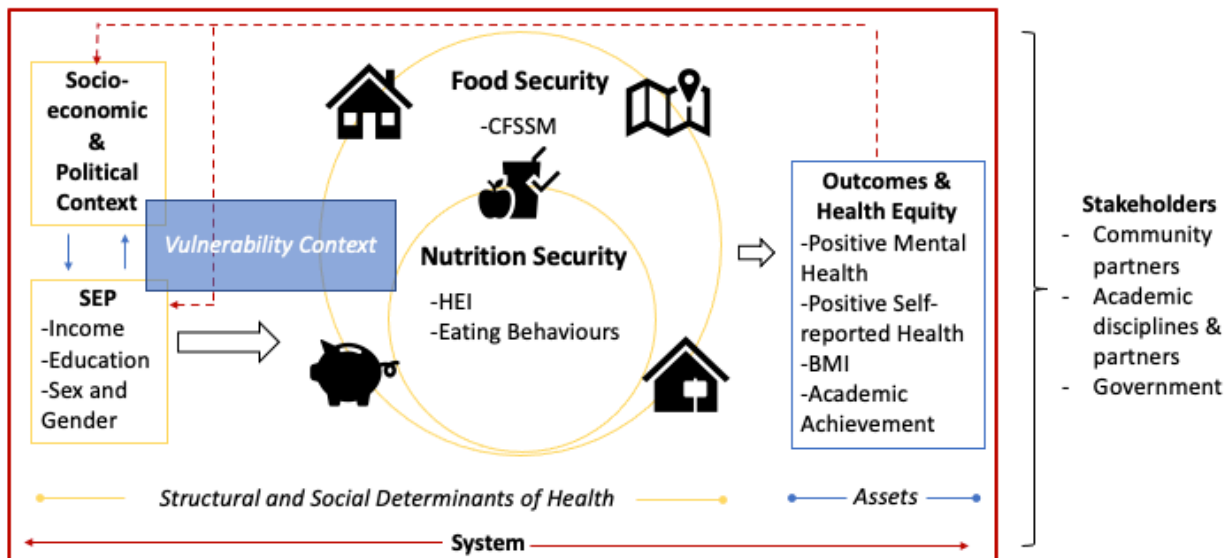


Figure 3.1: Theoretical Framework. Abbreviations: socio-economic position (SEP), Child Food Security Survey Module (CFSSM), Healthy Eating Index (HEI), body mass index (BMI)

Preface to Section 3.2

This dissertation uses secondary data from the FANS study conducted in Manitoba. Because of the author's participation in data collection and cleaning for the FANS study, details on the methods for the broader FANS study as well as those used for this dissertation are presented in Section 3.2. Alongside the FANS study coordinator and research assistant, the author participated in data collection throughout Winnipeg and the rural school division of Mountain View. These activities included travel to and from participating schools, administration of the FANS survey as well as collection and proper storage of consent forms. Additionally, the author reviewed line-level FANS survey data with the study's Principal Investigator and study coordinator and supported preparation of the FANS dataset for distribution to MCHP. More details on these processes are found in Section 3.2.

3.2 METHODS

Setting

The FANS study was conducted in Manitoba, Canada, which had a population of nearly 1.3 million at the time of data collection (October 2018 – May 2019) (Statistics Canada, 2023b), with an estimated 60% of the province's residents residing in Winnipeg, the capital city (Manitoba Health Seniors and Active Living, 2019).

Study Design & Sampling

Using a cross-sectional study design, this dissertation's research examines eating behaviours, food and nutrition security, and their relationship with health-related variables, as well as the social determinants of health among Grade 9 students living in urban, rural, and northern Manitoba. A web-based survey was linked with provincial health, education, and social data stored in the Manitoba Population Research Data Repository (Repository) housed at the

Manitoba Centre for Health Policy (MCHP). The Repository comprises administrative, registry, survey, and other data related to residents of the province, supporting interdisciplinary research across multiple institutions (Manitoba Centre for Health Policy, n.d.). All FANS data were de-identified before transfer to MCHP. MCHP is a research centre within the Rady Faculty of Health Sciences, at the University of Manitoba and the steward of the information in the Repository.

During the sampling period, there were a total of thirty-seven school divisions in the province (Manitoba Education and Training, 2019). Of those, nine divisions initially expressed support for the research study through letters, and after receiving grant approval, other divisions were contacted. Recruitment was initiated through the divisional research officer (superintendent or another designated individual). Recruitment packages were distributed to all schools within each division that had classes of ten students or more, and the school administration decided whether to participate. To minimize volunteer bias, the FANS study coordinator directly contacted schools that did not respond after receiving the recruitment packages and re-invited them before the data collection period to include as many school divisions and schools as possible.

Nineteen school divisions were excluded due to small Grade 9 cohorts and prohibitive travel costs for the research team. Independent or faith-based were excluded due to logistical challenges with engagement. Additionally, francophone schools were excluded as the survey was only available in English. Overall, fourteen divisions agreed to participate: six urban, five rural, and three northern.

Participants & Study Cohorts

Study participants included all consenting Grade 9 students (aged 13-16 years) from recruited schools. Once a school agreed to participate, the study coordinator mailed parental consent forms with a pre-filled, unique identifier (i.e., FANS ID) for privacy and student login on data collection day. Classroom teachers distributed the consent forms to students. The parental informed consent form ([Appendix D](#)) had two parts: (1) consent for the child to complete the online survey; (2) provision of the child's family and personal health identification number (PHIN) for data linking with the Repository. Survey administration took place during class time, and students used either classroom laptops or computers in the school computer lab to complete the survey. Student cohorts included all students present at school on the data collection day, including both participants and non-participants. To ensure parental consent, the FANS research team collected written consent forms upon arrival at the classroom or computer lab and verified parental signatures before allowing students to log in to the survey. Students without a signed consent form were not permitted to participate, and unsigned forms were collected by the research team for appropriate disposal. All students from whom parental consent was received were given the opportunity to provide assent at the start of the online survey. After students logged in, consent forms were collected again and returned to the University of Manitoba campus. Participant names, associated FANS IDs, and where applicable, PHINs were manually entered into an Excel file to allow for participant verification if necessary and to create a linkable file that would later be shared with MCHP. This process ensured that identifying information was not captured by the third-party company collecting the online survey data. Paper consent forms were securely stored at the University of Manitoba according to ethics protocols.

The final sample consisted of 1587 student participants (FANS Total cohort) and 987 accompanying PHINs, of which 960 were validated for data linkage. The final linkable sample consisted of 943 students following data cleaning (PHIN subsample cohort). Sampling strategy details and derived cohorts are illustrated in [Figure 3.2](#), adapted from Slater et al (2022). Analysis throughout this dissertation utilizes the entire FANS cohort when analysis is limited to survey data, and the PHIN subsample when the Repository variables are included.

Data Cleaning

Data were captured using a web-based tool hosted by PeaceWorks Technology Solutions in Waterloo, Ontario. PeaceWorks provided the raw data from the FANS survey in an Excel workbook, and the FANS research team manually reviewed the line-level data for implausible and missing values. Errors with food classification (e.g., bread not categorized in the food group ‘grains and starches’) were resolved before importing the data into SPSS version 27. Students with implausible energy intakes, such as consuming <200 kcal/day or >6000 kcal/day (n = 35), were excluded from analysis, consistent with standard practice within the literature for energy cut points (Hanning et al., 2007; Woodruff, Campbell, Campbell, & Cole, 2014). Records where meal-specific food items were selected in excess (e.g., more than four times) and were inconsistent with other food choices for these records, which coincided with internet connectivity issues during data collection at some sites, resulting in 28 instances, were adjusted to the median number of servings chosen by the sample (2 servings) instead of deleting the observations.

The analytical team at MCHP prepared the initial dataset, including the creation of repository variables using the cleaned FANS dataset. The author independently handled subsequent variable manipulation (such as collapsing categories and changing variable types for analysis) and all SAS programming, with guidance from MCHP analysts when necessary.

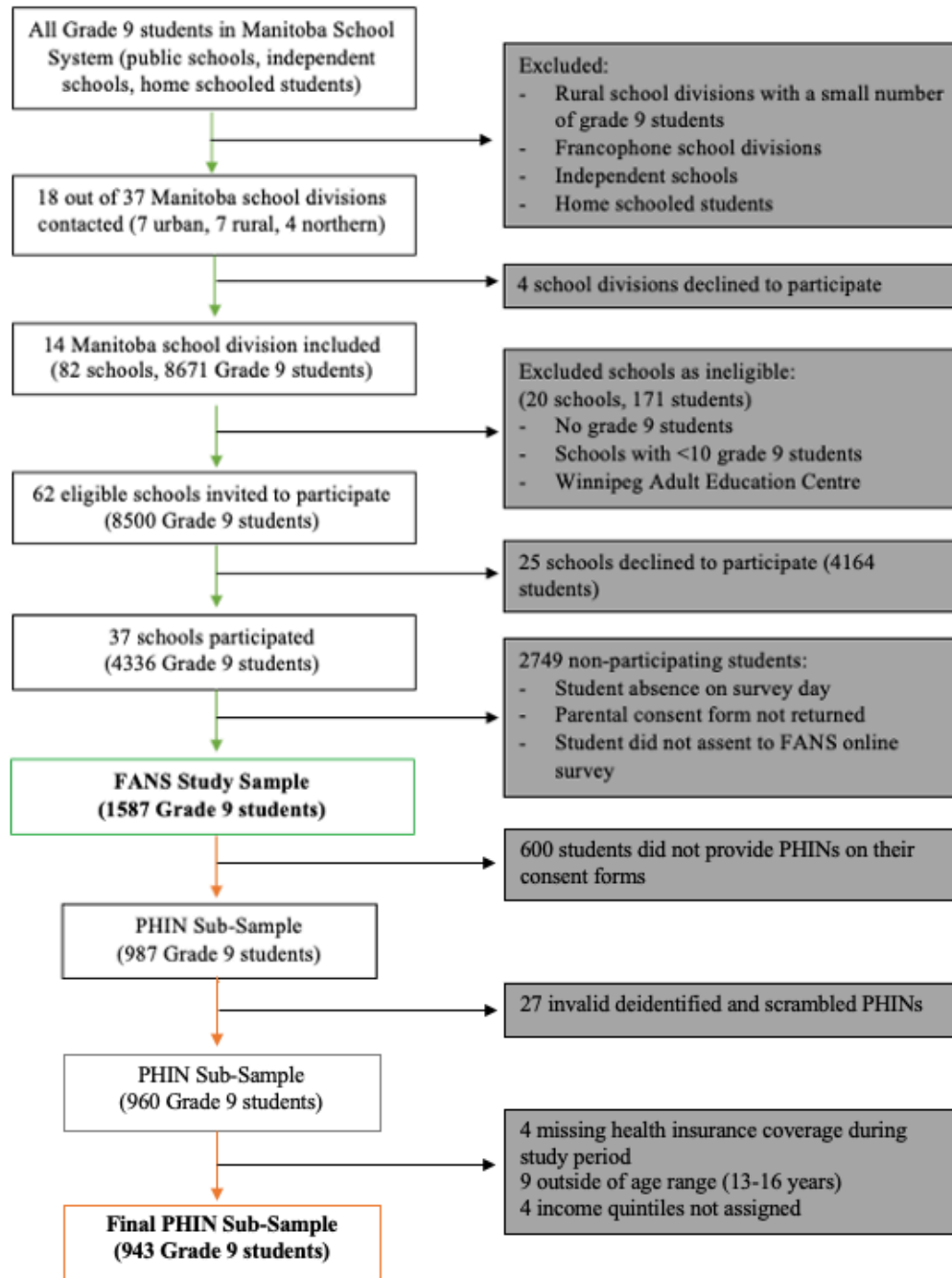


Figure 3.2: Sampling Strategy and Study Cohorts.

Tools and Survey Measures

FANS Survey

An online survey was administered to all participating students. Students had to enter their unique FANS ID, which was found on their consent form, to begin the survey. The FANS survey ([Appendix E](#)) consisted of three modules and took approximately 30-45 minutes to complete. Students completed the survey independently during class time, under the supervision of a trained FANS research assistant and a classroom teacher. Support was given when needed for question clarification. School staff provided one-on-one support for students whose first language was not English. Students did not have to complete the previous question before moving on. The data collected were stored on servers at PeaceWorks, where nutrient analysis software processed the food intake data based on portion sizes defined in the 2001b version of the Canadian Nutrient File database and CFG (2007). The survey consisted of three main components, as described below. Variable definitions for the FANS survey are provided in [Appendix F](#).

- 1. Participant characteristics.** Demographic questions included age, self-reported sex/gender (male/female/other), arrival to Canada (Newcomer status), and Indigenous ancestry (Métis, First Nations, Inuit, Don't Know). Indigeneity questions were developed in collaboration with Indigenous academic partners, and Newcomer status was developed in partnership with academic and community partners. Data derived from these cohorts have been examined elsewhere (Alexiuk, Pilli, Hinds, Urquia, & Slater, 2023; Perchotte et al., 2025). Students' geographic location of residence was defined according to the health region boundaries of the province. School divisions and their respective schools in the Winnipeg Health Region are considered urban (Seven Oaks, River East Transcona,

Winnipeg, St. James-Assiniboia, Pembina Trails, and Louis-Riel); divisions in the Northern Health Region are classified as northern (Kelsey, Flin Flon, and Mystery Lake), and all other divisions are considered rural (Garden Valley, Mountain View, Portage la Prairie, Swan Valley, and Western) (Fransoo et al., 2019). Because dietary recommendations are based on age- and sex-specific recommendations, and due to the small number of participants who answered “other” for gender (n = 34), only sex was considered for analysis. For those who selected “other” on the FANS survey, this category was treated as missing but retained for bivariate analysis using the entire FANS sample. When analyzed using the PHIN subsample, sex data for missing participants were imputed from the registry.

- 2. Dietary intake/food behaviours/health indicators/food security status.** As a component of the FANS survey, the Waterloo Eating Behaviour Questionnaire (WEB-Q), a valid and reliable assessment tool for children and adolescents of diverse backgrounds (Hanning et al., 2009), was used to gather information on dietary intake, food behaviours, and health indicators of study participants. The WEB-Q combines a 24-hour diet recall and a food frequency questionnaire, allowing participants to select from a list of approximately 800 foods and beverages. Divided into meals and snacks, students chose their foods, beverages, and portions based on pictures and text using a drag-and-drop method onto a virtual plate. If a meal was not available, students were instructed to substitute a similar item or select individual items to “build” their own meal. Research personnel were available to assist as needed. Students were prompted with reminders for condiments and beverages, mimicking a dietitian-administered multiple-pass method. At the end, students confirmed their meals and snacks and/or had to opportunity to make

revisions. In addition to a 24-hour recall, participants were asked about the frequency of meals and snacks, the location of meals/snacks, and the meals they consumed with family members. The final screen provided students with a summary of their intake compared to food guide servings in accordance with the 2007 version of Eating Well with Canada's Food Guide. In comparison with dietitian-administered 24-hour diet recalls, the WEB-Q demonstrated good agreement for total caloric intake [interclass correlation coefficient (ICC) = 0.56], macronutrients (ICC 0.48 to 0.58) and key micronutrients (ICC 0.35 to 0.92) within the same 24-hour period in grades six to eight students (n = 201) from Ontario (p<0.001 for all nutrients) (Hanning et al., 2009). WEB-Q results were translated into an HEI-C score (0-100) using a modified version of the 2010 HEI-C (Jessri et al., 2017) ([Appendix G](#)). Apart from data exploration, the HEI-C was examined as a continuous variable only.

Health indicator variables included self-reported height and weight, which were used to derive BMI and calculated using WHO z-scores (Rodd et al., 2014). Further health indicators included efforts to gain or lose weight (yes or no), adequate sleep for age (Government of Canada, 2019a) and self-reported health (measured on a Likert scale).

Food security was evaluated at the individual level using the nine-item Child Food Security Survey Module (CFSSM), a validated and reliable tool for measuring food security in children aged 12 years and above within the North American context (Connell, Nord, Lofton, & Yadrick, 2004). The module is a revised version of the United States Food Security Survey Module, developed following cognitive testing and a pilot survey (n = 345) among students in Grades 5-8 (Connell et al., 2004). This tool is

considered a more accurate method for evaluating how food security affects the nutritional status as well as physical and mental health in youth 12 years and above (Connell et al., 2004). It is also necessary to use a tool that captures individual experiences rather than a household's when evaluating the outcome of academic achievement for Objective 3. Questions centered on access to food, concerns about food availability, modified eating behaviours, and hunger levels over the past year. Standard scoring was used; each positive response (“a lot” or “sometimes”) received a score of 1, and the total positive responses summed to produce a score from 0 to 9. Individuals with a total score of 0-1 were considered food secure, while those scoring 2-9 were classified as food insecure. Sub-classification of food insecurity (marginal, moderate, or severe), sometimes described in the literature, was not possible due to the study's sample size; thus, the variable food security is measured as a binary outcome (food secure/food insecure). Participants with more than two missing responses were excluded from the analysis. Participants with one (n = 77) or two (n = 4) missing responses were included in the analysis.

Administrative Data Linkage and Repository Variables

In total, ten datasets were linked for this study ([Figure 3.3](#)). Details about the datasets, including variable definitions, years accessed, and their use in this study, are described in [Appendix H](#). To facilitate the linkage between the FANS survey responses and the Repository variables, a Participant Crosswalk file containing participants' unique FANS ID and PHIN from the consent form was sent to Manitoba Health to assign a scrambled PHIN for each participant. A stripped file with de-identified information was then returned to MCHP, uploaded to their secure network, and linked with the FANS survey results using the unique scrambled PHIN to

create the FANS database. Line-level data combined the FANS survey responses and repository variables. Aside from income quintile, all repository variables are provided at the individual level. The Reporting of Studies Conducted using the Observational Routinely Collected Data (RECORD) checklist for observational studies using administrative health data was used for each manuscript (Chapters 4-6) within this dissertation (Appendices [M Supplement 1](#); [N Supplement 2](#); [O Supplement 1](#)).

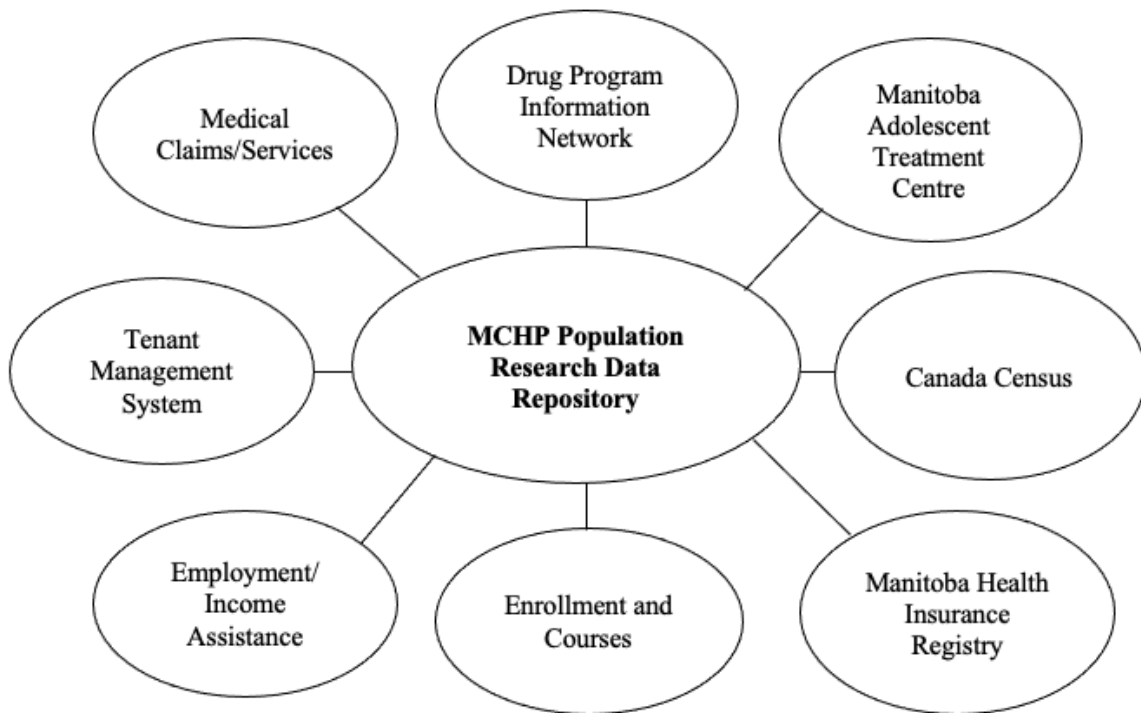


Figure 3.3: Linked Administrative Datasets.

3.3 ETHICAL CONSIDERATIONS & APPROVALS

Ethics and project approvals have been received from the University of Manitoba Research Ethics Board [Protocol J2018:040 (HS21666)] (Appendices [I](#), [J](#)), the Health Information Privacy Committee at Manitoba Health (No. 2018/2019-32), and MCHP (#2019-023) (Appendices [K](#), [L](#)).

3.4 DATA ANALYSIS

A combination of theoretical knowledge following a close examination of the literature and preliminary data exploration (frequencies, percentages, means, medians, Chi-square tests for association and independent samples t-test) informed variable selection for subsequent multivariable logistic regression models for the outcome variables *food security* (objective 3) and academic *achievement* (objective 4), and a general linear model for *diet quality* (objective 5).

Following sample stratification, a decision was made to use an unweighted sample as sub-groups became too small, resulting in unstable analyses once weighted. A subsequent sensitivity analysis was completed by a FANS analyst, which did not reveal meaningful differences when data were weighted by region and sex. To ensure that the subsample cohorts used for objectives 3 (n = 909), 4 (n = 847), and 5 (n = 872) were comparable to the total FANS cohort, statistical differences were examined based on the demographic characteristics of sex, region, and age and analyzed with a chi-square and independent samples t-test where appropriate. Total sample sizes for each outcome of interest varied due to data availability from participants' responses. Analyses comparing the FANS total cohort to respective PHIN subsamples are provided within the methods section of Chapters 4-6.

Variable manipulation involved collapsing categories of the FANS survey variables to satisfy the conditions of the Chi-Square test (i.e., ensuring all expected cell counts were at least 5). Refer to [Appendix F](#) for an explanation of variable categories. The entire FANS cohort was used for bivariate analyses whenever possible to include as many observations as possible.

A semi-stepwise process informed initial variable selection for the multivariable logistic regression models (objectives 2 and 3) and the general linear model (objective 4). Manual model building began with the inclusion of all variables significantly associated with the outcome

variables, following data exploration using frequencies, percentages, means, standard deviations, χ^2 tests for associations, and independent samples t-tests. Additionally, variables without a statistically significant relationship but considered relevant from the literature were included. Once the explanatory variables were determined for each model, a series of multicollinearity tests were performed before the final models were run. Correlation coefficient matrices (Tables [3-1](#), [3-2](#), [3-3](#)) using the Spearman Rho coefficient were used as a preliminary method of assessing for multicollinearity, with concerns denoted for coefficients outside the parameters of ≤ -0.8 and ≥ 0.8 (Senaviratna & Cooray, 2019). All variables showed weak to no correlation for each matrix; however, tolerance and its reciprocal, the variance inflation factor (VIF), were also assessed for each group of explanatory variables (Tables [3-4](#), [3-5](#), [3-6](#)), as multicollinearity can still be present despite low to no correlation between variable pairs (Senaviratna & Cooray, 2019). If multicollinearity were present, the significance of explanatory variables may be diminished by inflating variances of regression coefficients and masking true relationships with the outcome variables (Kleinbaum, Kupper, Nizam, & Rosenberg, 2014). Tolerance refers to the variance of an explanatory variable that cannot be explained, and the VIF illustrates how much the variance of the coefficient estimate is inflated by multicollinearity (Senaviratna & Cooray, 2019). The literature indicates that a tolerance of ≤ 0.1 is concerning, and a VIF above 10 (or above 2.5 in the case of logistic regression) is suggestive of multicollinearity (Senaviratna & Cooray, 2019). No group of explanatory variables reached these thresholds; thus, multicollinearity was not assessed as an issue.

Table 3-1. Correlation Coefficient Matrix of Explanatory Variables for the Outcome Food Security

Variables	Region	Sex	Social Housing	Residential Mobility	Income Quintile	Income Assistance	Location PM Snack¹	Frequency of Family Dinner	Frequency of Breakfast	Frequency of Lunch	Self-reported Health
<u>Region</u>	1	-0.068	-0.021	0.064	-0.084	-0.076	-0.040	0.059	-0.050	0.020	-0.015
<u>Sex</u>	-0.068	1	0.012	-0.043	-0.046	-0.012	0.016	0.086	0.211	0.045	0.168
<u>Social Housing</u>	-0.021	0.012	1	0.106	-0.116	0.440	-0.027	0.046	0.007	-0.009	0.055
<u>Residential Mobility</u>	0.064	-0.043	0.106	1	-0.091	0.168	0.016	0.049	0.042	0.017	0.097
<u>Income Quintile</u>	-0.084	-0.046	-0.116	-0.091	1	-0.188	-0.008	0.025	-0.028	-0.002	-0.054
<u>Income Assistance</u>	-0.076	-0.012	0.440	0.168	-0.188	1	0.016	-0.008	0.060	-0.072	0.059
<u>Location PM Snack¹</u>	-0.04	0.016	-0.027	0.016	-0.008	0.016	1	0.018	0.020	-0.013	-0.058
<u>Frequency of Family Dinner</u>	0.059	0.086	0.046	0.049	0.025	-0.008	0.018	1	0.248	0.255	0.159
<u>Frequency of Breakfast</u>	-0.050	0.211	0.007	0.042	-0.028	0.060	0.020	0.248	1	0.234	0.179
<u>Frequency of Lunch</u>	0.020	0.045	-0.009	0.017	-0.002	-0.072	-0.013	0.255	0.234	1	0.141
<u>Self-reported Health</u>	-0.015	0.168	0.055	0.097	-0.054	0.059	-0.058	0.159	0.179	0.141	1

Cell value: Spearman rho correlation coefficients.

¹Afternoon snack

Table 3-2. Correlation Coefficient Matrix of Explanatory Variables for the Outcome Academic Achievement

Variables	Region	Sex	Social Housing	Income Quintile	Income Assistance	Frequency of Family Dinner	Food Security	HEI ¹	Frequency of Breakfast	Frequency of Lunch	Mood/Anxiety Disorder
Region	1	-0.068	-0.021	-0.084	-0.076	0.059	0.043	0.093	-0.050	0.021	-0.039
Sex	-0.068	1	0.012	-0.046	-0.012	0.086	-0.001	0.068	0.211	0.045	0.074
Social Housing	-0.021	0.012	1	-0.116	0.440	0.046	-0.126	0.018	0.007	-0.009	0.031
Income Quintile	-0.084	-0.046	-0.116	1	-0.188	0.025	0.118	0.064	-0.028	-0.002	0.002
Income Assistance	-0.076	-0.012	0.440	-0.188	1	-0.008	-0.128	-0.113	0.060	-0.072	0.040
Frequency of Family Dinner	0.059	0.086	0.046	0.025	-0.008	1	0.064	-0.070	0.248	0.255	0.084
Food Security	0.043	-0.001	-0.126	0.118	-0.128	0.064	1	0.039	0.097	0.095	-0.041
HEI ¹	0.093	0.068	0.018	0.064	-0.113	-0.070	0.039	1	-0.158	-0.091	-0.106
Frequency of Breakfast	-0.050	0.211	0.007	-0.028	0.060	0.248	0.097	-0.158	1	0.234	0.072
Frequency of Lunch	0.021	0.045	-0.009	-0.002	-0.072	0.255	0.095	-0.091	0.234	1	0.093
Mood/Anxiety Disorder	-0.039	0.074	0.031	0.002	0.040	0.084	-0.041	-0.106	0.072	0.093	1

Cell value: Spearman rho correlation coefficients.

¹Healthy Eating Index

Table 3-3. Correlation Coefficient Matrix of Explanatory Variables for the Outcome Diet Quality

Variables	Region	Sex	Income Assistance	Adequate Sleep	Food Security	Breakfast Location	Lunch Location	BMI ¹	Self-reported Health	Frequency of Breakfast	Frequency of Lunch	Frequency of Family Dinner	Eating Less to Lose Weight	Mood/Anxiety Disorder
<u>Region</u>	1	-0.068	-0.076	0.033	0.043	0.045	0.028	-0.109	-0.017	-0.050	0.020	0.059	-0.001	-0.039
<u>Sex</u>	-0.068	1	-0.012	0.154	-0.001	0.042	0.025	-0.088	0.153	0.211	0.045	0.086	0.117	0.074
<u>Income Assistance</u>	-0.076	-0.012	1	-0.033	-0.128	0.025	0.022	0.048	0.034	0.060	-0.072	-0.008	0.009	0.040
<u>Adequate Sleep</u>	0.033	0.154	-0.033	1	-0.072	0.034	-0.014	0.027	0.187	0.210	0.109	0.133	0.090	0.025
<u>Food Security</u>	0.043	-0.001	-0.128	-0.072	1	-0.060	0.016	-0.013	0.042	0.097	0.095	0.064	-0.037	-0.041
<u>Breakfast Location</u>	0.045	0.042	0.025	0.034	-0.060	1	0.117	0.027	-0.050	0.144	0.022	-0.013	0.028	-0.036
<u>Lunch Location</u>	0.028	0.025	0.022	-0.014	0.016	0.117	1	-0.014	-0.019	-0.014	0.028	-0.04	0.055	0.023
<u>BMI¹</u>	-0.109	-0.088	0.048	0.027	-0.013	0.027	-0.014	1	-0.008	0.010	0.074	0.033	-0.140	0.064
<u>Self-reported Health</u>	-0.017	0.153	0.034	0.187	0.042	-0.050	-0.019	-0.008	1	0.286	0.253	0.268	0.151	0.091
<u>Frequency of Breakfast</u>	-0.050	0.211	0.060	0.210	0.097	0.144	-0.014	0.010	0.286	1	0.234	0.248	0.076	0.072
<u>Frequency of Lunch</u>	0.020	0.045	-0.072	0.109	0.095	0.022	0.028	0.074	0.253	0.234	1	0.255	0.056	0.093
<u>Frequency of Family Dinner</u>	0.056	0.086	-0.008	0.133	0.064	-0.013	-0.040	0.033	0.268	0.248	0.255	1	0.003	0.084
<u>Eating Less to Lose Weight</u>	-0.001	0.117	0.009	0.090	-0.037	0.028	0.055	-0.140	0.151	0.076	0.056	0.003	1	0.028
<u>Mood/Anxiety Disorder</u>	-0.039	0.074	0.040	0.025	-0.041	-0.036	0.023	0.064	0.091	0.072	0.093	0.084	0.028	1

Cell value: Spearman rho correlation coefficients.

¹Body Mass Index

Table 3-4. Collinearity Statistics for the Outcome Variable Food Security

Variables	Collinearity Statistics	
	Tolerance	VIF ¹
Region	0.949	1.054
Sex	0.927	1.080
Social Housing	0.775	1.291
Residential Mobility	0.952	1.050
Income Quintile	0.927	1.079
Income Assistance	0.730	1.370
Location PM Snack ²	0.988	1.012
Frequency of Family Dinner	0.947	1.055
Frequency of Breakfast	0.920	1.087
Frequency of Lunch	0.960	1.042
Self-reported Health	0.920	1.087

¹Variance Inflation Factor²Afternoon snack**Table 3-5. Collinearity Statistics for the Outcome Variable Academic Achievement**

Variables	Collinearity Statistics	
	Tolerance	VIF ¹
Region	0.935	1.070
Sex	0.943	1.061
Social Housing	0.822	1.217
Income Quintile	0.925	1.081
Income Assistance	0.793	1.261
Frequency of Family Dinner	0.886	1.128
Food Security	0.903	1.108
HEI ²	0.918	1.089
Frequency of Breakfast	0.827	1.209
Frequency of Lunch	0.886	1.129
Mood/Anxiety Disorder	0.966	1.035

¹Variance Inflation Factor²Healthy Eating Index

Table 3-6. Collinearity Statistics for the Outcome Variable Diet Quality

Variables	Collinearity Statistics	
	Tolerance	VIF ¹
Region	0.950	1.052
Sex	0.909	1.100
Income Assistance	0.940	1.064
Adequate Sleep	0.907	1.103
Food Security	0.945	1.058
Breakfast Location	0.951	1.051
Lunch Location	0.977	1.023
BMI ²	0.952	1.050
Self-reported Health	0.877	1.140
Frequency of Breakfast	0.873	1.146
Frequency of Lunch	0.941	1.062
Frequency of Family Dinner	0.922	1.084
Eating Less to Lose Weight	0.952	1.051
Mood/Anxiety Disorder	0.962	1.040

¹Variance Inflation Factor

²Body Mass Index

A logistic regression model was used to assess associations between the selected explanatory variables and the binary outcomes—food security and academic achievement—for objectives 2 and 3, respectively. In contrast, objective 4 investigates associations with the continuous outcome variable, diet quality, measured using the HEI-C. Results from the logistic regression models are presented as odds ratios (OR) and 95% confidence limits (CL), while the those from general linear model (GLM) are shown as parameter estimates and 95% CL. All statistical analyses were conducted using SAS version 9.4 (SAS Institute), with a threshold for significance set at p -value ≤ 0.05 .

Chapters 4 through 6 contain results in manuscript format that address the objectives of this dissertation.

CHAPTER 4: CONCEPTUALIZING FOOD INSECURITY AMONG MANITOBA YOUTH: A CROSS-SECTIONAL STUDY LINKING ADMINISTRATIVE DATA

Preface

The current literature identifies household food insecurity as a pervasive issue disproportionately affecting households with children (Li et al., 2023); however, current food security assessment tools may not be accurately capturing the individual experiences of youth. Likewise, provincial sample sizes also hinder detailed local analysis. This chapter will expand on previous work by using a validated child-specific food security assessment tool and link results with known factors associated with food insecurity. It further aims to contextualize food insecurity risk among youth in Manitoba using administrative data and establish preliminary associations with nutrition security and eating behaviours. This foundational understanding of food insecurity will be expanded on in subsequent chapters with the overarching goal of generating robust data to support food and nutrition policy updates.

Abstract

Background: Food insecurity is a key determinant of health affecting over a quarter of Manitobans. Economic constraints are associated with worsening food security which may affect children's eating behaviours and mental health status. Exposure in childhood is associated with poorer future socioeconomic status and health outcomes later in life. Gaps in current assessment tools limit a comprehensive understanding of risk factors that may increase food insecurity risk for Manitoba youth. **Methods:** A cross-sectional study of Grade 9 students (n = 1587) took place across 14 Manitoba school divisions in 2018-2019. Students completed a web-based survey on food security, eating behaviours, and health behaviours. When consenting, parents or guardians could opt to provide their child's personal health identification number (PHIN). Survey data for

the PHIN subsample (n = 943) were linked with social and health variables through a de-identified data repository at the Manitoba Centre for Health Policy (MCHP). Descriptive statistics (counts and percentages) illustrate distributions of participant characteristics by sample cohorts. Baseline characteristics were compared between food secure and food insecure participants using a T-test for continuous variables and a Chi-square test for binary or categorical variables for both cohorts. A multivariable logistic regression model estimated odds ratios (OR) and 95% confidence limits (CL) for food security status after adjusting for covariates.

Significance was set at $p \leq 0.05$ for all analyses. **Results:** Twenty percent of participants were food insecure. Food security was positively associated with living in a rural area compared to urban [OR 2.10 (1.11-4.33)] and in higher income neighbourhoods [Q5 OR 2.57 (1.41-4.73); Q4 OR 2.32 (1.24-4.40)]. Conversely, living in a northern community [OR 0.21 (0.12-0.39)], reporting fair or poor self-rated health [OR 0.64 (0.44-0.94)], and less frequent eating of family dinner [OR 0.47 (0.31-0.71)] and lunch [OR 0.56 (0.36-0.90)] were associated with a decreased likelihood of being food secure. Diet quality did not differ by food security status, as categorized by the HEI-C ($p = 0.44$). **Conclusions:** Findings indicate a large proportion of Manitoba adolescents are food insecure, especially those experiencing socioeconomic and geographic vulnerabilities. An overhaul of current policies and programs to address these issues in Manitoba must be examined beyond income supports alone to effectively address this issue.

Keywords: food security, youth, social determinants of health, Manitoba, Canada, administrative data

Introduction

Food insecurity – limited access to food due to financial constraints – is a powerful indicator of nutrition inequity and key determinant of health (Li et al., 2023; Tarasuk et al., 2018). Canada is facing a growing public health crisis as food insecurity and diet-related chronic diseases continue to rise (Afshin et al., 2019b; Li et al., 2023; Sellers et al., 2024). Food insecurity in Canada is unprecedented despite regular monitoring since 2005. In 2023, 23% of Canadians (8.7 million) were food insecure, including 2.1 million children [PROOF Food Insecurity Policy Research (PROOF), 2024)]. In Manitoba, the rate was even higher at 27% (PROOF, 2024). These figures indicate a pressing need for policy reform at all levels of government.

While food insecurity is closely linked to economic factors such as income, income source, and social housing, other coexisting factors including family structure, geography, residential mobility, race, gender, and food environments, contribute to its complexity (Alexiuk et al., 2023; Li et al., 2023; Morley, Monster, Bonnell, Goodridge, & Falkeisen, 2019; Roos et al., 2013; Slater et al., 2017). A growing body of literature highlights the magnitude of food insecurity on children’s physical and mental health (increased risk of mood and anxiety disorders) (McIntyre et al., 2017; Men et al., 2021), and poorer academic performance (Faught et al., 2017; Shankar et al., 2017). Yet, current assessment tools such as the Household Food Security Survey Module (HFSSM) assess household – not individual – conditions, and often rely on adult proxies to understand the child experience (Government of Canada, 2012; Tarasuk et al., 2021). Therefore, limitations may occur when measuring outcomes such as academic performance, nutrition, and physical and mental health conditions at the individual level. Small provincial sample sizes also restrict meaningful sub-provincial analysis in Manitoba.

As a result, addressing food insecurity has been a slow process. However, routinely collected administrative data can support a more nuanced understanding of this complex issue through intersectional analyses (Chadd et al., 2025; Mahendran et al., 2022; Wemrell et al., 2021). Manitoba is a leader in leveraging administrative data, offering a unique opportunity to explore the links between food insecurity, eating behaviours and socioeconomic dimensions beyond traditional measures (Wemrell et al., 2021).

This paper, as part of the *Food and Nutrition Security (FANS) in Manitoba Youth* research initiative, aims to describe patterns of food insecurity among Manitoba youth and examine associations with dietary behaviours (i.e., meal location, eating frequency, dietary choices) and key social determinants of health (i.e., income quintile, income assistance, social housing, and residential mobility) through survey and administrative data.

Methods

Setting

The FANS study took place in the province of Manitoba, Canada, which had a population of nearly 1.3 million at the time of data collection (October 2018 – May 2019) (Statistics Canada, 2023b) and nearly 60% of the provincial population resided in the capital city of Winnipeg (Manitoba Health Seniors and Active Living, 2019).

Ethics & Approvals

Ethics and project approvals were received from the University of Manitoba Research Ethics Board [Protocol J2018:040 (HS21666)], the Health Information Privacy Committee at Manitoba Health (No. 2018/2019-32), and MCHP (#2019-023).

Data Sources

Using a cross-sectional design, the study explored the relationship between food security status, eating behaviours, dietary intake, and social determinants of health among Grade 9 students residing in urban, rural, and northern regions of Manitoba.

FANS Survey

Participants completed a web-based survey consisting of three modules (demographic characteristics, dietary intake/food behaviours/health indicators, and food security), which was administered to all participating students and took approximately 30-45 minutes to complete. Data were captured using a web-based tool hosted by PeaceWorks Technology Solutions located in Waterloo, Ontario. Students independently completed the survey during class time under the supervision of a trained FANS research assistant and school staff member. All survey questions were optional, and missing data were retained for analysis. Nutrient analysis software was used to process the food intake data, using portion sizes defined in the 2001b version of the Canadian Nutrient File database and the 2007 version of Canada's Food Guide (Health Canada, 2019).

Administrative Data Linkage

FANS survey results were linked with health and social data using the Manitoba Population Research Data Repository (Repository), housed at the Manitoba Centre for Health Policy (MCHP), for consenting participants whose parents or guardians provided their personal health identification numbers (PHINs). MCHP is a research centre within the Rady Faculty of Health Sciences at the University of Manitoba with the purpose of carrying out population-based research related to health services, population and public health, and the social determinants of health (University of Manitoba, 2020a). The Reporting of Studies Conducted using the

Observational Routinely Collected Data (RECORD) checklist for observational studies using administrative health data is presented in [Appendix M, Supplement 1](#).

Sampling & Study Cohorts

During the sampling period, there were a total of thirty-seven school divisions in the province (Manitoba Education and Training, 2019). Of those, nine offered initial letters of support for the research study and following grant approval, additional divisions were approached. Recruitment was initiated through the divisional research officer (superintendent or another appointed individual). Recruitment packages were distributed to all schools within the division, and participation was determined by individual school administration. Nineteen school divisions were excluded due to small Grade 9 cohorts and prohibitive travel costs for the research team. Independent/faith-based and francophone schools were excluded due to logistical difficulties with engagement and the survey's availability in English only. Best efforts were made to reduce volunteer bias by actively recruiting as many schools as possible within the confines of the FANS research team's ability and re-inviting those who did not respond to the initial recruitment packages.

In total, eighteen of the thirty-seven public school divisions were contacted by email and follow-up phone calls, and fourteen divisions were recruited to participate. Urban divisions were located within the Winnipeg Health Region (Seven Oaks, River East Transcona, Winnipeg, St. James-Assiniboia, Pembina Trails, and Louis-Riel), northern divisions from the Northern Health Region (Kelsey, Flin Flon, and Mystery Lake), and the remaining school divisions were considered rural (Garden Valley, Mountain View, Portage la Prairie, Swan Valley, and Western). Details on sampling for the FANS study have been published elsewhere (Slater et al., 2022).

To facilitate the linkages between the FANS survey responses and the Repository variables, a Participant Crosswalk file was created, which included participants' unique FANS IDs and PHINs from the consent form. This file was then sent to Manitoba Health to assign a scrambled PHIN to each participant. A stripped file with de-identified information was then sent back to MCHP, uploaded to their secure network, and linked with FANS survey results to create the FANS database.

The sampling strategy is adapted from Slater et al (2022) ([Appendix M, Supplement 2](#)). Study participants included all consenting Grade 9 students from recruited schools. Once a school agreed to participate, the study coordinator mailed parental consent forms that included a pre-populated unique identifier (i.e., FANS ID) for privacy and student login on data collection day. Paper consent forms were distributed to students by classroom teachers and included two parts: (1) consent for the child to complete the online survey; (2) provision of the child's family and PHIN for purposes of data linking. Paper consent forms were reviewed by the research team for parental signatures before being distributed to student participants for login. Any students without a consent form were unable to participate. All students could provide assent at the beginning of the online survey. The final sample consisted of 1,587 students (FANS cohort) and 987 accompanying PHINs, of which 960 were validated for data linkage. The final usable sample consisted of 943 students following data cleaning (PHIN subsample cohort). Due to incomplete food security data for 34 participants, the regression analysis utilized the PHIN subsample with a sample size of 909. Sample cohorts were compared for statistical differences.

Outcomes

The primary outcome was participants' food security status within the 12 months preceding data collection. Food security was measured using the nine-item Child Food Security

Survey Module (CFSSM), a valid and reliable tool for assessing food security in children aged 12 years and older in the North American context (Connell et al., 2004). Questions focused on access to food, concerns about food availability, modified eating behaviours, and hunger levels. Standard scoring was used; each affirmative response (“a lot” or “sometimes”) was given a score of 1, and the sum of affirmative responses gave a total score out of 9. Individuals with a total score between 0 and 1 were considered food secure, while those with scores between 2 and 9 were food insecure ([Appendix M, Supplement 3a](#)). The option to use this tool enables the examination of individual- rather than household-level food security status. Participants with >2 missing responses were excluded from analysis. Participants with 1 (n = 77) or 2 (n = 4) missing responses were included for analysis.

The secondary outcome, *diet quality* as a function of food security status, was assessed using a modified version of the 2010 Healthy Eating Index-Canada (HEI-C) (Jessri et al., 2017). The HEI-C is a validated diet quality index for Canadians based on components of adequacy (dietary elements that are encouraged) and moderation (dietary elements with recommended limits). Diet quality is scored out of 100, with a perfect score of 100 based on age- and sex-specific recommendations. Diet quality index scores can also be categorized as *poor* (<50), *needs improvement* (50-80), or *good* (>80) ([Appendix M, Supplement 3b](#)).

Covariates

Participant Characteristics

Demographic questions asked for participants’ age, self-reported sex/gender (male/female/other), age of arrival to Canada (Newcomer status), and Indigenous ancestry (Metis, First Nations, Inuit, Don’t Know). Results focusing on Newcomer and Indigenous data have been published elsewhere (Alexiuk et al., 2023; Perchotte et al., 2025). Participating school

divisions and schools were classified by geographic regions (urban, rural, and northern) in accordance with geographical boundaries used by MCHP (Fransoo et al., 2019). Because only a small number of participants (n = 34) responded with “other” when asked about their gender, only sex was included in the analysis. When examining data from the PHIN subsample, sex was imputed from administrative records for participants with missing gender data. This approach improved participant retention and enabled the analysis of sex-specific dietary data from the FANS survey. FANS variable definitions are available in [Appendix M, Supplement 4a](#).

Dietary Intake and Food Behaviours

The Waterloo Eating Behaviour Questionnaire (WEB-Q), a valid and reliable assessment tool for children and adolescents from diverse backgrounds (Hanning et al., 2009), was used to gather information on dietary intake, food behaviours, and health indicators such as sleep and self-reported health. The WEB-Q combines a 24-hour diet recall and food frequency questionnaire, allowing participants to choose from a list of approximately 800 foods and beverages. Divided into meals and snacks, students select their foods, beverages, and portions using pictures and text, employing a drag-and-drop method onto a virtual plate. If a meal option is unavailable, students were instructed to substitute a similar item or to pick individual items to “build” their own meal. Students received prompts for condiments and beverages, mimicking a multiple-pass interview method, mitigating recall bias, a common limitation of 24-hour diet recalls. At the end, students confirmed or revised their meal and snack selections. They were also asked about the location of their meals and snacks, as well as how often they have supper with family members. The final screen provided a summary of their intake as food guide servings, including feedback based on age- and sex-specific recommendations. This information was then converted into an HEI-C score ranging from 0 to 100. In comparison with dietitian-administered

24-hour diet recalls, the WEB-Q demonstrated good agreement for total caloric intake [interclass correlation coefficient (ICC) = 0.56], macronutrients (ICC 0.48 to 0.58) and key micronutrients (ICC 0.35 to 0.92) within the same 24-hour period in Grade six to eight students (n = 201) from Ontario (p<0.001 for all nutrients) (Hanning et al., 2009).

Health Indicators

Health indicator questions included self-reported height and weight, intentional efforts to gain or lose weight (categories collapsed to yes or no), adequate sleep for age based on Canadian guidelines (Government of Canada, 2019a) and self-reported health (measured on a Likert scale). Body mass index (BMI) was classified using World Health Organization z-scores (Rodd et al., 2014).

Linked Variables

Seven data sources provided additional information on factors known to be associated with food insecurity. Variable definitions, including years accessed, are found in [Appendix M, Supplement 4b](#). Variables selected included income quintile (Q1 = lowest – Q5 = highest), receiving social assistance (Yes/No), receiving employment/income assistance (Yes/No), living in social housing (Yes/No), residential mobility (moving ≥ 3 times in the ten years prior to the study period) (Yes/No), and diagnosis of a mood or anxiety disorder (Yes/No) based on ICD (International Classification of Diseases) and ATC (Anatomical Therapeutic Chemical). Outside of income quintile, all repository variables are measured at the individual level.

Data Analysis

An unweighted sample was used as sampling stratification led to unstable analyses once weighted. Furthermore, a sensitivity analysis using the entire FANS cohort did not reveal meaningful differences when weighted by region and sex. To ensure that there were no statistical

differences in sample characteristics between the total FANS cohort and the PHIN subsample, differences were assessed based on demographic characteristics before running any analysis. No differences were observed by sex ($\chi^2 = 0.156$, $df = 1$, $p = 0.693$), region ($\chi^2 = 1.139$, $df = 2$, $p = 0.566$), or age ($t = 0.32$ (2488), $p = 0.751$); thus, for any bivariate analysis, the total FANS cohort was utilized whenever possible.

When necessary, categorical variables were manipulated to satisfy conditions of the χ^2 test (i.e., ensuring all expected cell counts were at least 5). A semi-stepwise process guided initial variable selection for the multivariable logistic regression model. Manual model building started with the inclusion of all variables significantly associated with the outcome food security, following data exploration using frequencies, percentages, means, standard deviations, and χ^2 tests for associations. Additionally, variables that showed no relationship but were considered relevant from the literature (e.g., sex) were included. Once all explanatory variables were identified, a series of multicollinearity tests were conducted before running the fully adjusted model. This ensures that the independent variables are not highly correlated with each other, which can indicate confounding, distort the true relationships between the independent variables and the outcome, and result in a loss of significance for individual parameters by inflating variance estimates of the coefficients (Kleinbaum et al., 2014). All variables showed weak to no correlation in the Spearman Rho correlation matrix, using the parameters ≤ -0.8 and ≥ 0.8 (Senaviratna & Cooray, 2019). As well, thresholds for collinearity statistics for logistic regression (tolerance ≤ 0.1 and the variance inflation factor > 2.5) were not met (Senaviratna & Cooray, 2019); therefore, multicollinearity was not considered a concern, reducing uncertainties about confounding, and increasing confidence in model coefficient estimates. Collinearity analysis is presented in [Appendix M, Supplement 5](#). Covariates in the fully adjusted model

included: sex, region, self-reported health, social housing, residential mobility, income quintile, income assistance, frequency of breakfast, lunch, and family dinner, as well as the location of the participants afternoon snack.

Output from the logistic regression model is expressed as odds ratios (OR) and 95% confidence limits (CL), for both adjusted and unadjusted models, using the PHIN subsample. All statistical analyses were conducted using SAS version 9.4 (SAS Institute), with a significance level set at p -value ≤ 0.05 .

Results

Participant Characteristics

Demographic data are depicted according to the PHIN subsample and the total FANS sample when examining FANS survey data. Administrative data is presented using the PHIN subsample only. For both cohorts, just over half of participants identified as female, while 4.8% of the FANS sample self-identified their sex as “other” or chose not to identify ([Table 4-1](#)). This small proportion of participants was excluded from the analysis due to sample size; however, sex was imputed for *other* or gender non-conforming in the PHIN subsample analysis. Over three-quarters of participants resided in an urban setting, with the remainder from rural and northern regions of the province. Nearly half of the participants from the PHIN subsample resided in an affluent neighbourhood as described by income quintiles 4 and 5 ([Table 4-1](#)). Most PHIN subsample participants were from families who had not received income assistance within the past five years, had not resided in social housing, and close to three-quarters had not moved residences frequently within a ten-year period of the study start.

Table 4-1. Participant characteristics: PHIN subsample and FANS total sample

Variable	PHIN Subsample^{a,1} n (%)	FANS Total Sample^{b,1} n (%)
Sex^c		
Male	450 (47.5)	709 (44.7)
Female	493 (52.3)	802 (50.5)
Other	-	10 (0.6)
Missing	-	66 (4.2)
Region		
Urban	744 (78.9)	1230 (77.5)
Rural	120 (12.7)	223 (14.1)
Northern	79 (8.4)	134 (8.4)
Age		
13 years	34 (3.6)	54 (3.4)
14 years	770 (81.7)	1296 (81.7)
15 years	131 (13.9)	225 (14.2)
16 years	5 (0.5)	8 (0.5)
Missing	3 (0.3)	4 (0.3)
Income Quintile		
Q1 (low)	161 (17.1)	n/a
Q2	184 (19.5)	
Q3	167 (17.7)	
Q4	182 (19.3)	
Q5 (high)	249 (26.4)	
Received Income Assistance		
Never	867 (91.9)	n/a
Currently/ In the past 5 years	76 (8.1)	
Ever Lived in Social Housing^d		
Yes	27 (2.7)	n/a
No	916 (97.1)	
Residential Mobility (moved ≥ 3 times in 10 years prior to survey)		
Yes	258 (27.4)	n/a
No	685 (72.6)	

^an=943 unless data missing^bn=1587 unless data missing^cdata imputed where possible with registry data^ddata only available up to May 2018¹sample cohorts can be treated equally as no differences in bivariate analyses were observed by sex ($\chi^2 = 0.156$, $df = 1$, $p = 0.693$), region ($\chi^2 = 1.139$, $df = 2$, $p = 0.566$), or age ($t = 0.32$ (2488), $p = 0.751$)

Table 4-2. Food security status by sex and region

Variable	Food Secure n (%)	Food Insecure ^b n (%)	p-value
Total FANS Sample^a	1222 (77.0)	312 (19.7)	-
PHIN Subsample^c	724 (76.8)	185 (19.6)	-
Sex (Total FANS Sample)^{d,e}			0.3301
Male	558 (46.5)	150 (49.7)	
Female	641 (53.5)	152 (50.3)	
Sex (PHIN Subsample)^e			0.7010
Male	348 (48.1)	86 (46.5)	
Female	376 (51.9)	99 (53.5)	
Region (Total FANS Sample)			<0.001*
Urban	948 (77.6)	237 (76.0)	
Rural	189 (15.5)	28 (9.0)	
Northern	85 (7.0)	47 (15.1)	
Region (PHIN Subsample)			<0.001*
Urban	576 (79.6)	141 (76.2)	
Rural	102 (14.1)	12 (6.4)	
Northern	46 (6.4)	32 (17.3)	

^aResults generated using entire FANS sample, 53 (3.3%) missing

^bFood insecure combines categories moderately and severely food insecure

^cResults generated using PHIN Subsample, 34 (3.6%) missing

^dCategory other/not specified too small for statistical analysis

^eImputed variable using sex from registry data where possible

*p-value <0.05: χ^2 test for association with food security status

Food Security by Sex and Region

Twenty percent of the total participants were considered food insecure ([Table 4-2](#)), with no difference by sex for either study cohort. However, a significant geographical difference was observed, with more participants from the northern regions identifying as food insecure compared to those identifying as food secure, for both study cohorts.

Differences in Eating Behaviours and Health Indicators by Food Security Status

Regardless of food security status, over half of participants reported eating breakfast more than four times per week, and at least three-quarters ate lunch just as frequently ([Table 4-3](#)). However, significant differences in food security status were evident for those who ate breakfast and lunch more frequently – 5 to 7 days per week, compared to 0 to 4. These participants were more likely to be food secure. The same was true for those who ate dinner with family more often.

Sixty-four percent of food-secure students self-reported their health as excellent or very good, compared to 45.6% of food-insecure students ($p < 0.001$). Other health indicators that differed by food security status included intentional weight gain, with 23.9% of food-insecure participants reporting a desire to gain weight, compared to 15.6% of their food-secure counterparts. Food security status did not differ according to BMI.

Table 4-3. Differences in eating and health behaviours by food security status (total FANS sample)

Food, Nutrition, or Health Behaviour	Total^a n (%)	Food Secure n (%)	Food Insecure n (%)	p-value
Meal Frequency				
Breakfast				0.0082*
0-4d/wk	584 (38.5)	446 (36.9)	138 (45.1)	
5-7d/wk	932 (61.5)	764 (63.1)	168 (54.9)	
Lunch				0.0015*
0-4d/wk	261 (18.5)	192 (16.9)	69 (25.2)	
5-7d/wk	1149 (81.5)	944 (83.1)	205 (74.8)	
Family Dinner Frequency				
0-4d/wk	349 (23.6)	251 (21.3)	98 (33.2)	<0.0001*
5-7d/wk	1127 (76.4)	930 (78.8)	197 (66.8)	
Previous Day Meal/Snack Location				
Breakfast				0.0603
Home	1298 (91.0)	1046 (91.7)	252 (88.1)	
School/Other	129 (9.0)	95 (8.3)	34 (11.9)	
Morning Snack				0.0563
Home	430 (35.5)	325 (34.1)	105 (40.5)	
School/Other	781 (64.5)	627 (65.9)	154 (59.5)	
Lunch				0.8223
Home	340 (22.9)	273 (23.0)	67 (22.4)	
School/Other	1145 (77.1)	913 (77.0)	232 (77.6)	
Afternoon Snack				0.0390*
Home	688 (54.5)	558 (56.0)	130 (48.9)	
School/Other	575 (45.5)	439 (44.0)	136 (51.1)	
Dinner				0.7908
Home	1389 (91.9)	1107 (92.0)	282 (91.6)	
School/Other	122 (8.1)	96 (8.0)	26 (8.4)	
Evening Snack				0.6666
Home	1209 (92.9)	956 (93.1)	253 (92.3)	
School/Other	92 (7.1)	71 (6.9)	21 (7.7)	
Self-reported Health				
Excellent/Very Good	906 (60.6)	770 (64.3)	136 (45.6)	<0.001*
Fair/Poor	590 (39.4)	428 (35.7)	162 (54.4)	
Intentional Weight Loss				
No	1097 (73.4)	888 (74.6)	209 (69.0)	0.0495*
Yes	397 (26.6)	303 (25.4)	94 (31.0)	
Intentional Weight Gain				
No	1225 (82.7)	996 (84.4)	229 (76.1)	0.0006*
Yes	256 (17.3)	184 (15.6)	72 (23.9)	
Body Mass Index				
Underweight	33 (2.7)	25 (2.6)	8 (3.3)	0.0613
Normal weight	870 (72.2)	710 (73.4)	160 (66.1)	
Overweight/Obese	302 (25.1)	228 (23.7)	74 (30.6)	
Adequate Sleep for Age				
Yes	805 (53.7)	670 (56.2)	135 (44.1)	0.0002*
No	694 (46.3)	523 (43.8)	171 (55.9)	

^aResults generated using entire FANS sample (n=1587), unless data missing

*p-value <0.05: χ^2 test for association with food security status

Food Security and Diet Quality

Food-secure participants had a significantly higher mean diet quality score of 57 compared to food-insecure participants, whose mean score was 55 (Table 4-4). However, the observed difference by food security status was no longer observed when diet quality scores were categorized as shown in Table 4-5. Most participants had diets falling into the *needs improvement* category (70%), and only 2% consuming high quality diets as categorized by an HEI-C score over 80.

Table 4-4. Mean difference in diet quality scores between food-secure and food-insecure participants

Food Security Status	N	Mean	Std Dev	Std Error	Min	Max	t (DF) ^a	p-value
Food Insecure	286	55.0245	11.2539	0.6655	19.1	88.01	-2.33 (1425)	0.0198*
Food Secure	1141	56.7502	11.1712	0.3307	18.42	89.24		

^aFolded F test for equal variances p=0.8600, pooled method for equal variances

*p-value <0.05

Table 4-5. Differences in diet quality scores by food security status

Diet Quality Rank	Total ^a n (%)	Food Secure n (%)	Food Insecure n (%)	p-value
Healthy Eating Index				0.4438
Poor (HEI <50)	401 (28.1)	312 (27.3)	89 (31.1)	
Needs Improvement (HEI 50-80)	996 (69.8)	805 (70.6)	191 (66.8)	
Good (HEI >80)	30 (2.1)	24 (2.1)	6 (2.1)	

^aTotal FANS sample, n=1587 unless data missing

*p-value <0.05: χ^2 test for association with food security status

Differences Between Food Security Status, Social Determinants of Health, and Mental Health

Over sixty percent of food-secure participants were from middle- to high-income neighbourhoods (Q3-Q5), compared to about 50% of food-insecure participants (Table 4-6). Food security status differed by income quintile, with a higher percentage of food-insecure participants residing in the lowest two income quintiles. Food-insecure participants were also more likely to have received income assistance in the five years preceding or during the study

period and were also more likely to reside in social housing. Food security status did not differ for participants with or without a diagnosed mood or anxiety disorder.

Table 4-6. Differences between food security status and linked variables

Health Determinant	Total ^a n (%)	Food Secure n (%)	Food Insecure n (%)	p-value
Income Quintile				0.0034*
Q1 (low)	154 (16.9)	113 (15.6)	41 (22.2)	
Q2	175 (19.3)	127 (17.5)	48 (26.0)	
Q3	162 (17.8)	130 (18.0)	32 (17.3)	
Q4	178 (19.6)	151 (20.7)	27 (14.6)	
Q5 (high)	240 (26.4)	203 (28.0)	37 (20.0)	
Received Income Assistance				<0.001*
Never	836 (92.0)	680 (93.9)	156 (84.3)	
Currently/over last 5 years	73 (8.0)	44 (6.1)	29 (15.7)	
Ever Lived in Social Housing^b				<0.001*
Yes	26 (2.9)	12 (1.7)	14 (7.6)	
No	883 (97.1)	712 (98.3)	171 (92.4)	
Residential Mobility (moved ≥ 3 times in 10 years prior to survey)				<0.001*
Yes	250 (27.5)	176 (24.3)	74 (40.0)	
No	659 (72.5)	548 (75.7)	111 (60.0)	
Mood or Anxiety Disorder				0.1208
Yes	36 (4.0)	25 (3.5)	11 (6.0)	
No	873 (96.0)	699 (96.6)	174 (94.1)	

^aPHIN subsample, n=943 unless data missing

^bdata currently only available up to May 2018

*p-value <0.05: χ^2 test for association with food security status

Associations with Food Security Status

After covariate adjustment, participants from northern communities had a 79% decrease in the likelihood of being food secure compared to urban residents [OR 0.21 (0.12-0.39)]. As well, lower meal frequency of both lunch and family dinners was associated with a 44% [OR 0.56 (0.36-0.90)] and 53% [OR 0.47 (0.31-0.71)] respective decrease in likelihood of being food secure compared to those who ate those meals five to seven days per week. Negative associations between the missing data for lunch [OR 0.50 (0.27-0.97)] and family dinner frequency [OR 0.30 (0.13-0.71)] were also noted. (Figure 4.1). Conversely, living in a rural community [OR 2.10 (1.11-4.33)] compared to urban, as well as living in a neighbourhood with a higher median income [Q5 OR 2.57 (1.41-4.73); Q4 OR 2.31 (1.24-4.40)] were conditions positively associated

with being food secure. The frequency of breakfast consumption was not associated with food security status in the adjusted or unadjusted model. After model adjustment, living in social housing, receiving income assistance, or moving residences more often were no longer associated with participants' food security status. A comparison with the unadjusted model is found in [Appendix M, Supplement 6](#).

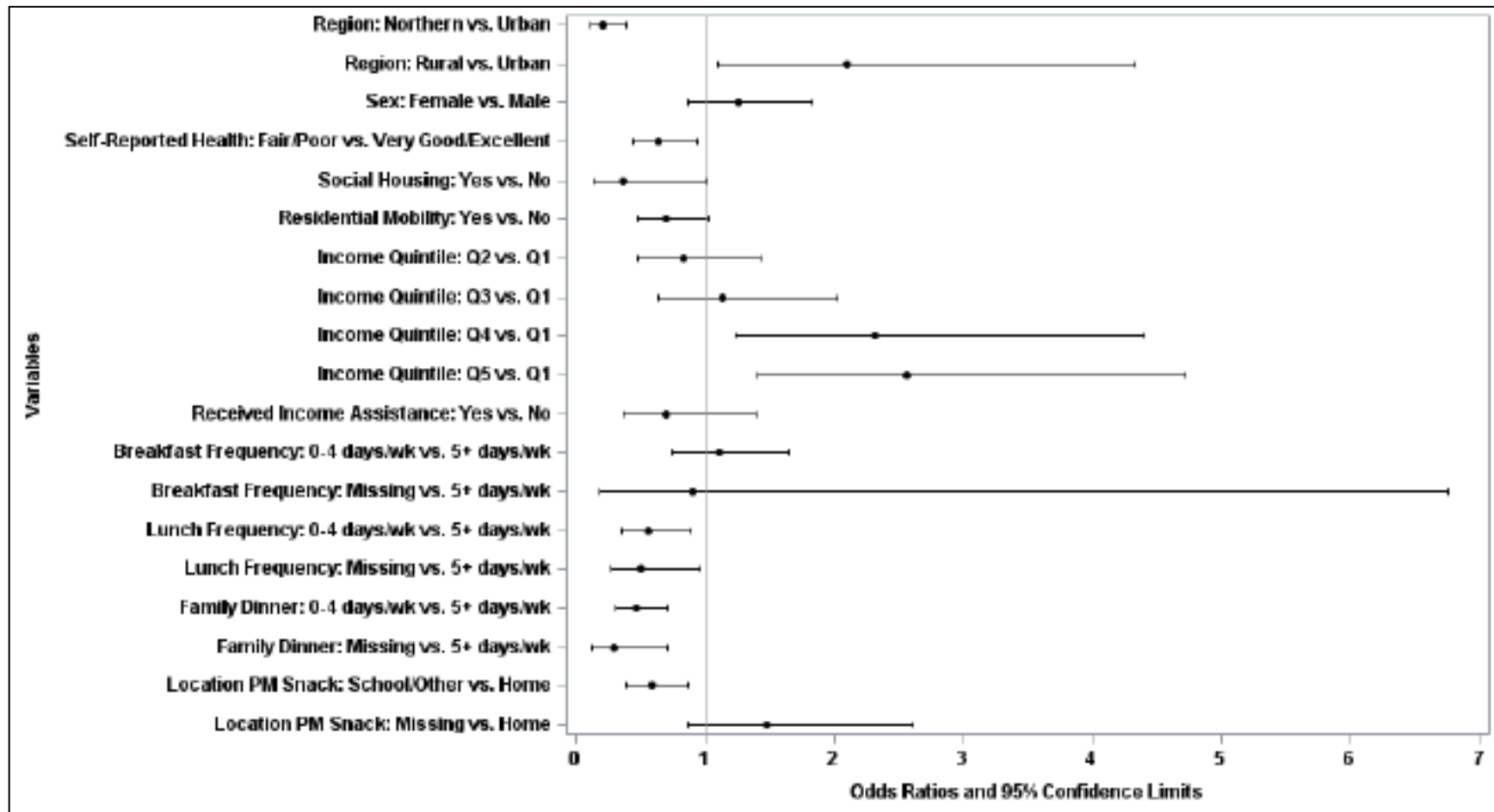


Figure 4.1: Adjusted Multivariable Logistic Regression Model for Food Security. Adjusted multivariable logistic regression model depicting odds ratios and 95% confidence limits for the outcome food security (n=909). Variables positively associated with higher odds of being food secure include living rurally compared to urban and living in neighbourhoods with higher income quintiles (Q4 and Q5) compared to Q1. Living in a northern community compared to urban, reporting fair or poor health compared to very good or excellent, lower weekly frequencies of both lunch and family dinners, including those with missing data for the respective variables, and afternoon snacks reported at school compared to at home were associated with being food insecure.

Discussion

This Manitoba-based qualitative study linked youth food insecurity data with administrative health and social datasets. To the author's knowledge, this study, together with one other publication that analyzed a subsample of the FANS food security data (Alexiuk et al., 2023), represents the first Canadian research to capture children's individual-level experiences of food insecurity experiences. In this sample, food insecurity affected 1 in 5 participants, aligning with provincial household-level estimates from the same period (Tarasuk & Mitchell, 2020).

Geographic region emerged as a key determinant. Living in rural communities appeared protective against food insecurity. Steady employment growth in rural Manitoba, along with more affordable living, has led to a higher-than-average population density outside urban centres (Ashton, LaBelle, Mealy, & Wuttunee, 2015; Kelly, Lam, Letkemann, Arksey, & Bullock, 2021), which could boost demand for larger grocery stores offering more competitive prices in the area. Other potential features of rural living that may protect against food insecurity include stronger social networks and food sharing (Bowen, Elliott, & Hardison-Moody, 2022), as well as increased access to emergency food resources (Gundersen, Dewey, Hake, Engelhard, & Crumbaugh, 2017). Rural residents are more likely to own their homes and pay less for housing compared to urban dwellers (Statistics Canada, 2025b), which are known contributors to food security (Li et al., 2023), and may contribute to this trend. Further research, including mixed-methods or qualitative study designs would give breadth and nuance to understanding this phenomenon and whether it is specific to Manitoba or observed in other jurisdictions.

Unfortunately, youth from northern Manitoba did not experience the same protective effects of their rural counterparts. Participants from the north were more likely to experience food insecurity, reflecting known vulnerabilities to food insecurity, such as limited access to and

high costs of food (Li et al., 2023; Wendimu et al., 2018). These findings highlight equity imbalances to achieving food security between these distinctly different regions.

Income remains a strong predictor of food insecurity (Li et al., 2023; Mikkonen & Raphael, 2010). Participants from the lowest neighbourhood income quintile were more likely to be food insecure. Despite provincial poverty reduction strategies such as Rent Assist (2015) and the Canada Child Benefit (2016), Manitoba continues to have higher poverty (8.8%) (Government of Manitoba, 2023) than the national average (7.4%) (Statistics Canada, 2024a). Child poverty continues to be a pervasive issue in Manitoba, with rates exceeding the national average by over 10% (Government of Manitoba, 2021; Social Planning Council of Winnipeg, 2020).

Living in social housing or receiving income assistance were socioeconomic variables negatively associated with food insecurity in the unadjusted model only. This may be due to the small sample size for these groups. Study replication may help determine potential temporal- or policy-specific reasons for this finding, as food hardship is well-documented among low-income families or those receiving income assistance (Food Matters Manitoba, 2020; Li et al., 2023; Tarasuk, Fafard St-Germain, & Mitchell, 2019). Likewise, the anticipated association between residential mobility and food insecurity (Anastasio et al., 2022; Ma et al., 2008) may have been attenuated by the higher-than-average proportion of affluent households in the sample (Statistics Canada, 2025c). Likewise, it was not possible to determine a family's reason for moving (e.g., change in employment) or their destination (e.g., shared accommodations, living independently as a family unit, or to a community with increased supports), which limited the interpretation of findings related to positive transitions such as a higher number of adults in a household or job promotion – both established protective factors of food security (Jackowitz et al., 2015).

Interestingly, food-insecure participants were more likely to desire gaining weight, though BMI was not associated with food security status. This aligns with research linking food insecurity to disordered eating, specifically binge-eating disorder among adolescents (Nagata et al., 2023); however, it is discordant with research connecting it to a higher risk of obesity (Mark, Lambert, O’Loughlin, et al., 2012; Pickett et al., 2015).

No association was found between food insecurity and clinically diagnosed mood or anxiety disorders, though this may reflect measurement limitations as only diagnosed conditions were assessed, excluding subclinical symptoms. Previous studies highlight the mental health toll of food insecurity, including increased risk of depression, poorer self-reported mental health, and suicidal ideation (McIntyre et al., 2017; Men et al., 2021). While a mental health diagnosis was not associated with food insecurity; for participants of this study, better food security was associated with higher self-rated health, a finding consistent with earlier research (Kirkpatrick et al., 2010; Pickett et al., 2015).

Food insecurity has been associated with lower self-esteem and self-efficacy in making healthy lifestyle choices (Godrich, Loewen, Blanchet, Willows, & Veugelers, 2019), as well as a less nutritious diet (Kirkpatrick & Tarasuk, 2008; Mark, Lambert, Loughlin, & Gray-donald, 2012). A preliminary examination of the linear relationship between food insecurity and diet quality yielded a statistically significant difference in mean HEI-C scores, with food insecure participants having lower scores. However, a one-point difference is arguably trivial in the broader interpretation of HEI-C values; for example, scores of 55 versus 56 both indicate dietary inadequacy for most participants when examined categorically. Nevertheless, these findings raise concerns for future population health, including increased healthcare costs (Afshin et al., 2019a; Loewen et al., 2019). Despite the modest difference observed in this study, the significant linear

trend should not be overlooked in future studies. This finding suggests potential population-level implications of food insecurity that may be more pronounced in studies with greater representation of groups experiencing more severe food insecurity, such as underserved populations or those living in more remote communities (Chan et al., 2019; Kenny, Fillion, MacLean, Wesche, & Chan, 2018; Li et al., 2023; Statistics Canada, 2024c).

Previously published FANS research points to the importance of regional considerations as an important factor in nutritional outcomes for Manitobans (Slater et al., 2024). Lower diet quality scores and higher BMI among northern dwelling participants (Slater et al., 2024, 2023) may be precipitating factors of food access, food availability, and high food costs in northern communities (Kenny et al., 2018; Wendimu et al., 2018), which are driving up consumption of less-expensive, ultra-processed foods (Polsky et al., 2020). Regional-specific considerations affecting food and nutrition insecurity must be considered when addressing policy gaps.

As expected, meal frequency was positively associated with food security; yet eating location was not. As data were captured before the rollout of universal meal programming in Manitoba public schools, it was expected that a difference would have been observed for meals and snacks consumed on school days, which may have been attributed to schools where meal and snack provisions were provided, but this was not directly assessed.

Strengths & Limitations

A major strength of this study was the ability to capture individual-level food security status of a larger sample of youth than what would be possible using secondary data from national surveys. This was done by asking participants directly about their food security status using an age-validated tool (Connell et al., 2004). National- and provincial-level food security data is acquired using parents or guardians as proxies for children and youth (Government of

Canada, 2020b). Using proxies may underestimate food insecurity of dependents as parental perception of food insecurity may not be reflective of youth's experiences as adolescents may be sacrificing food for other family members (Baer et al., 2015).

This study was not without limitations. The cross-sectional nature of the study design, the study's exclusion criteria, and exclusive use of Grade 9 students introduces selection bias and diminishes external validity, limiting the ability to generalize findings to the wider youth population in Manitoba. However, this is the first study in the province to generate a sample of this size to examine youth food security status and relationship to nutrition and eating behaviours, health indicators, and social variables. Volunteer bias may also reduce generalizability of study findings as parental consent was required and not all schools participated. The use of a 24-hour diet recall introduces recall bias decreasing validity of results and may not represent usual intake; however, by using the Web-Q, which prompted meals, snacks, beverages, and condiments using photos, common limitations of the assessment tool were mitigated, enabling an increase in accuracy of nutrient analysis. Self-reported measures of height and weight introduce additional bias. Among adolescents, height tends to be over-estimated for males and females, and weight underestimated for both females and individuals who are overweight (Sherry, Jefferds, & Grummer-Strawn, 2007). This may have skewed BMI results presented here, reflecting an underestimation of overweight and obesity.

Unfortunately, school involvement or intensity of participation in meal or snack programs was not assessed. This limited our ability to make any connections with food security status and provincial meal/snack programming, as well as the relationship with breakfast and lunch frequency and food and nutrition security status.

Nutrition and food insecurity research lacks data on implications for the gender diverse community, especially among youth. Present literature highlights an increased vulnerability to food insecurity and mental health stressors (Ferrero et al., 2023; Russomanno et al., 2019). While this study did include a question on self-reported gender, options were limited and future research should include a two-step method (Linsenmeyer & Waters, 2021) to ensure sex and gender are distinct variables as they may have separate implications on use of nutrition services, outcomes such as food insecurity and mental/physical health, and identify gaps in nutrition education for healthcare professionals.

Lastly, administrative data is not collected to answer specific research questions, thus there are limitations of how results may be interpreted. Mental health data in this study is under-represented as it only accounts for treatment prevalence, not true prevalence; it is also susceptible to physician coding error and is only evaluating mood and anxiety disorders. This study did not examine subclinical thresholds of depression or anxiety associated with food insecurity that is documented in the literature, nor does this variable capture eating disorders, an emerging field in the study of food insecurity research. This is another opportunity for future research to address the understudied areas of mental health and gender diversity in connection with food insecurity.

Conclusion

Study findings underscore the complexity of food insecurity and contribute important insights into youth food insecurity in Manitoba, highlighting regional, socioeconomic, and eating behaviour associations. Regardless of food security status, the diets of Manitoba youth are falling short of nutrition standards, indicating that initiatives to address food security and good nutrition should not be siloed.

Unprecedented rates of food insecurity should sound the alarm that current public policies and programs are simply ineffective and must be re-framed to address more than income supports if there is any hope of addressing this issue in a meaningful way. Policies must review specific barriers to achieving food security by region and address root causes, not symptoms of food insecurity. To ensure this, participation from a variety of stakeholders, including government officials, school administrators, academics, not-for-profit organizations, advocacy groups, and community members, cannot be up for debate.

**CHAPTER 5: FOOD AND NUTRITION INSECURITY MAY COMPROMISE YOUTH
ACADEMIC ACHIEVEMENT: RESULTS FROM A MANITOBA COHORT USING
LINKED ADMINISTRATIVE DATA**

Preface

Chapter 4 established food insecurity as a concern for approximately one-fifth of the study population, with increased vulnerability observed for those living in northern communities and in poor neighbourhoods. Interestingly, rural residence appeared to have a protective effect. This chapter examines whether the same regional and economic vulnerabilities linked to food security also impact academic performance among study participants and build on previous work in Manitoba linking early childhood vulnerabilities with poorer educational outcomes, where food insecurity was not assessed (Brownell et al., 2012; Roos et al., 2013).

The previous chapter further demonstrated that most students were consuming nutritionally inadequate diets irrespective of their food security status. Proper nutrition and food security are both associated with better academic and behavioural outcomes in children and youth (Alaimo et al., 2001; Faught et al., 2017; Florence et al., 2008; Jyoti et al., 2005; Northstone et al., 2012; Nyaradi et al., 2014). At the same time, standardized testing shows that Manitoba students are underperforming in reading and math compared to national averages (Government of Canada, n.d.). While provincial-level data provide a broad picture, regional data could offer more targeted insights to inform policy actions aimed at addressing food and nutrition insecurity. The following chapter demonstrates the utility of using routinely collected data to examine associations between food and nutrition insecurity and academic performance at sub-provincial levels and advocates for ongoing surveillance as a component of school nutrition programming.

Abstract

Background: Food insecurity, a major public health concern in Canada closely tied to socioeconomic status, has been shown to compromise the dietary habits, physical and emotional health, and academic success of youth from high-income countries. Youth in Manitoba are falling short on national academic metrics, and there is limited provincial data examining these outcomes in relation to food and nutrition status.

Methods: A cross-sectional study of Grade 9 students ($n = 1587$) took place across 14 Manitoba school divisions during the 2018-19 academic year. Students completed a web-based survey on food security, eating behaviours, and health behaviours. Parents and guardians could opt to provide their child's personal health identification number (PHIN) during the consent process to link survey data with administrative social, educational, and health information (PHIN subsample ($n = 943$)) through the data repository at the Manitoba Centre for Health Policy (MCHP). Academic achievement was assessed based on students' ability to meet ≥ 8 Grade 9 course credits by the end of the school year. Bivariate associations explored relationships between food security, diet quality, eating behaviours, socioeconomic indicators, mental health, and academic achievement. A multivariable logistic regression model estimated adjusted odds ratios (OR) and 95% confidence limits (CL) for academic achievement after adjustment for covariates ($p \leq 0.05$).

Results: Food insecurity decreased the likelihood of meeting academic credit requirements by 55% [0.45 (0.25-0.83)], as did living outside of an urban centre by 66% [0.338 (0.15-0.78)] for northern and by 63% [0.37 (0.19-0.76)] for rural participants in the adjusted model. Participants from families reliant on income assistance [0.33 (0.15-0.72)] as well as those who ate lunch less often [0.49 (0.25-0.97)] were also less likely to achieve sufficient Grade 9 credits.

Conclusions: Findings demonstrate a strong connection between food insecurity, geographic location, income assistance, lunch frequency, and the ability to meet academic requirements among a Manitoba cohort of Grade 9 youth. Without prompt review of current programs and policies aimed at addressing food insecurity, the success of younger generations may be compromised.

Keywords: food security, WEB-Q, academic achievement, Manitoba, Canada, youth, administrative data

Introduction

Food and nutrition security are priority public health issues in Canada, creating barriers to children's physical and mental well-being, academic success, and high-school graduation rates (Faught et al., 2017; Li et al., 2023; McIntyre et al., 2018; Northstone et al., 2012). Food insecurity arises when financial hardship leads to unstable access to adequate food (Li et al., 2023); nutrition insecurity refers to a lack of variety, balance, safety, and essential nutrients in the diet – factors necessary for a healthy and active lifestyle (Food and Agriculture Organization of the United Nations et al., 2020; Slater & Yeudall, 2015). Nutrition security is contingent on the establishment of food security; therefore, this paper will explore the intersection of these issues as they relate to educational outcomes.

Recent statistics highlight the gravity of food insecurity in Canada, with 8.7 million people (22.9%) - including 2.1 million children - living in households struggling to access food [(PROOF Food Insecurity Policy Research (PROOF), 2024)]. In Manitoba, this figure rises to 26.8%, further underscoring the issue (PROOF, 2024). Despite ongoing tracking since 2005, Canadians have seen little to no improvements in rates of food insecurity (Li et al., 2023). Beyond its impact on food choices (Kirkpatrick & Tarasuk, 2008), food insecurity undermines the academic performance of children and youth, particularly in core subjects such as reading and math (Alaimo et al., 2001; Faught et al., 2017; Jyoti et al., 2005). Furthermore, food insecurity has also been linked with psychosocial and mental health issues, such as difficulty establishing peer relationships and depression (McIntyre et al., 2017; Men et al., 2021; Shankar et al., 2017). Food-insecure children are also more likely to require additional educational support (Kleinman et al., 1998), face grade repetition (Alaimo et al., 2001; Kleinman et al., 1998) and be at higher risk for high school dropout (McIntyre et al., 2018).

In Manitoba, youth performance in literacy and numeracy falls below the national average, as highlighted by the 2022 Programme for International Student Assessment (PISA) results (Government of Canada, n.d.). Earlier research in Manitoba has identified links between early childhood vulnerabilities, such as material deprivation—a well-established correlate of food insecurity—and poorer academic outcomes, using routinely collected data (Brownell et al., 2012; Roos et al., 2013). Although food insecurity was not directly examined in these studies, research from the United States demonstrates a clear negative relationship between food insecurity and developmental and academic concerns in children and youth (Alaimo et al., 2001; Jyoti et al., 2005; Shankar et al., 2017). Taken together, these findings underscore the pressing need to better understand how early food insecurity and other social determinants influence children’s academic trajectories.

This paper, as part of the *Food and Nutrition Security (FANS) in Manitoba Youth* research initiative, will examine associations between food security status and academic achievement among Grade 9 youth in Manitoba. By combining routinely collected health and social data with survey results on nutrition and eating behaviours, the study aims to contextualize the relationship between food insecurity and academic achievement in the Manitoba context. Findings will be used to inform targeted policy revisions and program interventions, ensuring equitable access to nutritious food and improved nutrition programming in schools that directly support academic success for all students.

Methods

Setting

The FANS study took place in Canada’s central province of Manitoba, which at the time of data collection had an estimated population of 1.3 million (Statistics Canada, 2023b), and the

majority of residents (approximately 60%) resided in the southern capital city of Winnipeg (Manitoba Health Seniors and Active Living, 2019).

Design & Sampling

Using a cross-sectional design, the study examined how food insecurity, diet quality, eating behaviours, mental health, and social determinants of health (income quintile, income assistance, social housing, and residential mobility) affected students' academic achievement. Grade 9 participants from rural, urban, and northern parts of the province participated in a web-based survey linked to provincial health, social, and education data using the Manitoba Population Research Data Repository (Repository) housed at the Manitoba Centre for Health Policy (MCHP) at the University of Manitoba.

Ethics and project approvals were received from the University of Manitoba Research Ethics Board [Protocol J2018:040 (HS21666)], the Health Information Privacy Committee at Manitoba Health (No. 2018/2019-32), and MCHP (#2019-023).

Data collection took place between October 2018 and May 2019. Manitoba had thirty-seven school divisions during the sampling period (Manitoba Education and Training, 2019), of which nine offered initial letters of support. Following ethics approval, eighteen of the thirty-seven public school divisions were contacted, and fourteen were recruited to participate (six urban, five rural, and three northern). Recruitment was initiated through communication with the superintendent or another appointed individual, and recruitment packages were distributed to schools within the division. Nineteen school divisions were excluded due to small Grade 9 cohorts (i.e., classes with <10 students) and prohibitive travel costs. Additionally, independent/faith-based and francophone schools were excluded due to logistical challenges with engagement, and the survey was only available in English. To mitigate volunteer bias, best

efforts were made to recruit as many schools as possible, including re-inviting those who did not respond to the initial recruitment packages. A graphical representation of the sampling strategy is found in [Appendix N, Supplement 1](#). Further details on the FANS study sampling have been published elsewhere (Slater et al., 2022).

Participants & Study Cohorts

Participants included all consenting Grade 9 students from recruited schools. Parental paper consent forms, which included a unique identifier (i.e., FANS ID) for privacy and student survey login, were distributed by classroom teachers and were required to be returned on or before data collection day. The consent form included two parts: (1) consent for the child to complete the online survey; (2) optional provision of the child's family and personal health identification number (PHIN) for the purpose of data linkage. Consent forms were reviewed for parent signatures by the FANS research team on the data collection day. The forms were then redistributed for students to login. All participants could provide assent when they began the survey. Any student without a consent form were unable to participate. All completed consent forms were returned to the University of Manitoba for proper storage. The total FANS cohort consisted of 1587 participants, and 960 provided a validated PHIN for data linkage. Following data cleaning, the PHIN subsample consisted of 943 participants. Efforts were made to retain as many observations as possible for both participant cohorts; however, sample sizes vary due to missing data (as noted in the tables and figure below). Sample cohorts were compared based on demographic data for statistical differences.

Data Sources

FANS Survey

Students independently completed a web-based survey consisting of three modules that gathered data on demographic characteristics, dietary intake, food behaviours, health indicators and food security status. The survey took approximately 30 to 45 minutes to complete. A FANS research assistant and school staff member oversaw the survey administration and supported students as needed. Students were able to skip questions if they chose, resulting in missing data, which was retained for analysis as its own category. Data were captured using a web-based tool hosted by PeaceWorks Technology Solutions located in Waterloo, Ontario. PeaceWorks housed collected data on a secure server, where nutrient analysis software was used to process the food intake data according to portion sizes defined in the 2001b version of the Canadian Nutrient File database and Canada's Food Guide (2007) (Health Canada, 2019).

Administrative Data Linkage

FANS survey results were linked with routinely collected health, education, and social data using the Repository at MCHP. MCHP is a research centre within the Rady Faculty of Health Sciences at the University of Manitoba with the purpose of carrying out population-based research related to health services, population and public health, and the social determinants of health (University of Manitoba, 2020a). This study includes population registry data, linked at the individual level (except for income quintile, which is linked at the neighbourhood level) using de-identified information (scrambled health number and FANS ID) for consenting participants whose parent or guardian provided their PHIN. The Reporting of Studies Conducted using the Observational Routinely Collected Data (RECORD) checklist for observational studies using administrative health data is presented in [Appendix N, Supplement 2](#).

Exposures

Food security status over the twelve months preceding data collection served as the primary exposure and was measured using the validated Child Food Security Survey Module (CFSSM) (Connell et al., 2004). Using this tool, participants were asked about their individual experience with food insecurity from questions that focused on access to food, concerns about food availability, modified eating behaviours, and hunger levels. Standard scoring was used; each affirmative response (“a lot” or “sometimes”) was given a score of 1, and the sum of affirmative responses gave a total score out of 9. Students with a total score between 0 and 1 were considered food secure, while those with scores between 2 and 9 were food insecure. Anyone with ≥ 2 missing responses for this variable was excluded from analysis.

Diet quality, measured using an adapted version of the 2010 Healthy Eating Index-Canada (HEI-C) tool (Jessri et al., 2017), was a secondary exposure. The HEI-C is a validated diet quality index for Canadians based on components of adequacy (dietary elements that are encouraged) and moderation (dietary elements with recommended limits). Diet quality is scored out of 100, with a perfect score of 100 corresponding to recommendations tailored to age and sex. Scores were derived from survey responses to the Waterloo Eating Behaviour Questionnaire (WEB-Q). Diet quality index scores can also be categorized as *poor* (<50), *needs improvement* (50 to 80), or *good* (>80).

Exposure variable definitions are presented in [Appendix N](#), [Supplement 3a](#) and [3b](#).

Outcome

Using Manitoba Education data from the Registry, the variable *academic achievement* is defined as completing 8 or more Grade 9 credits by the end of the academic year for the study period. This definition is based on the number of credits required to complete Grade 9 (Manitoba

Centre for Health Policy, 2015b) and is correlated with the completion of high school (Manitoba Centre for Health Policy, 2019). The outcome is measured as a binary variable (yes/no).

Covariates

Demographic Characteristics

Geographic regions classified participating schools as urban, rural, or northern in accordance with established parameters used by MCHP (Fransoo et al., 2019). Demographic questions included participants' age, self-reported sex/gender (male/female/other), age of arrival to Canada (Newcomer status), and Indigenous ancestry (Métis, First Nations, Inuit, or Don't Know). Results focusing on Newcomer and Indigenous data have been published elsewhere (Alexiuk et al., 2023; Perchotte et al., 2025). A small number of participants (n = 34) answered "other" when asked about their gender; therefore, only sex was considered for analysis, and these participants were treated as missing observations. However, when analyzing data using the PHIN subsample, sex was imputed from the Registry to include as many observations as possible for sex-specific dietary analysis. Covariate definitions from the FANS survey are found in [Appendix N, Supplement 4a](#).

Food Behaviours and Health Indicators

The WEB-Q also gleaned food behaviours and health indicators of study participants. The tool combines a 24-hour diet recall and food frequency questionnaire, allowing participants to recreate meals and snacks from approximately 800 foods and beverages using a drag-and-drop method with photos. If a meal or snack was unavailable, participants were instructed to either select a similar item or "build" the meal using individual ingredients. Prompts for snacks, beverages, and condiments mimicked a multiple-pass system interview, reducing recall bias, a common limitation of 24-hour diet recalls. At the end of the survey, students confirmed or

revised their selections. Food behaviours included questions about meal and snack frequency, location of meals and snacks, and frequency of family dinners. The health indicators included height and weight (self-reported), and classified body mass index (BMI) in accordance with World Health Organization guidelines (Rodd et al., 2014). Other health indicators included intentional efforts to gain or lose weight, adequate sleep for age (Government of Canada, 2019a) and self-reported health (measured on a Likert scale). Following this portion of the survey, students were provided with a summary of their intake with reference to food guide servings, along with recommendations on areas for improvement. The WEB-Q demonstrated good agreement for total caloric intake [interclass correlation coefficient (ICC) = 0.56], macronutrients (ICC 0.48 to 0.58) and key micronutrients (ICC 0.35 to 0.92) compared to dietitian-administered 24-hour diet recalls among students in Grades 6-8 (n=201) from Ontario (p<0.001 for all nutrients) (Hanning et al., 2009).

Linked Variables

A variety of data sources from the Repository were accessed, pertaining to mental health and social factors, with definitions based on earlier work ([Appendix N, Supplement 4b](#)). Diagnosed depression and/or anxiety were criteria for the variable *mental health* and were defined using ICD (International Classification of Diseases) and ATC (Anatomical Therapeutic Chemical) codes, hospital abstracts, physician claims, and pharmaceutical prescriptions. Social factors included families receiving income assistance, families living in social housing, frequency of residential mobility, and income quintile. Aside from income quintile, all linked variables were treated as dichotomous variables (yes/no) and assessed at the individual/family level.

Data Analysis

SAS version 9.4 (SAS Institute) was used for all statistical analyses (significance recognized at $p \leq 0.05$) on an unweighted sample, as weighting led to analytical instability and a sensitivity analysis did not provide meaningful differences following weighting by demographic variables, sex, and region. The unweighted sample allowed for greater retention of study participants. A test of statistical differences by demographic variables sex ($\chi^2 = 0.13$, $df = 1$, $p = 0.72$), region ($\chi^2 = 0.92$, $df = 2$, $p = 0.63$), and age ($t = 0.24$ (2521), $p = 0.81$) was assessed to determine differences that may affect variable selection for model building and comparison of results by study sample cohorts. Once again, this examination did not yield any meaningful differences between the two cohorts.

Baseline characteristics of the study cohorts were compared using the primary outcome variable, academic achievement, through frequencies, percentages, chi-square tests for association, and an independent sample t-test. When necessary, categorical variables were manipulated to satisfy conditions of the chi-square test (i.e., ensuring all expected cell counts were at least 5). These preliminary steps informed the initial variable selection for the multivariable logistic regression model, which aimed to determine associations with participants' academic achievement. Manual model building began by establishing statistically significant covariates, as well as those that were not significant but relevant according to the literature [e.g., sex (Jyoti et al., 2005), residential mobility (Cowley, Wall-Wieler, & Roos, 2022), and diet quality].

Prior to running the adjusted logistic regression model, a series of multicollinearity checks were completed to assess for potential confounding, which could distort true relationships between the explanatory variables and the outcome (Kleinbaum et al., 2014). Independent

variables were first assessed using a correlation matrix and the Spearman Rho coefficient with parameter thresholds of ≤ -0.8 to ≥ 0.8 followed by an analysis of collinearity statistics - tolerance and the variance inflation factor, with respective thresholds of ≤ 0.1 and > 2.5 (Senaviratna & Cooray, 2019). No concerns were observed ([Appendix N, Supplement 5](#)). Final model building involved examining the unadjusted and adjusted models for the PHIN subsample using odds ratios (OR) and 95% confidence limits (CL) ([Appendix N, Supplement 6](#)). Covariates in the fully adjusted model included: sex, region, food security status, social housing, income assistance, HEI-C score, frequency of breakfast, lunch, and family dinner, income quintile, as well as mental health.

Results

Participant Characteristics

Counts and percentages describe participant characteristics for both the FANS total and PHIN subsample ([Table 5-1](#)). Both cohorts were similarly split by sex, with less than 5% who self-identified their gender as “other” or chose not to identify. Over three-quarters of participants resided in an urban setting, and the rest in rural and northern regions. Just under half the PHIN subsample lived in an affluent neighbourhood as described by income quintiles 4 and 5. Most PHIN subsample participants were from families who had not received income assistance, and few resided in social housing (3%). Approximately one-quarter of participants had moved residences frequently (more than three times) within the ten-year period preceding the study start date.

Table 5-1. Participant characteristics: PHIN subsample and FANS total sample

Variable	PHIN Subsample ^{a,1} n (%)	FANS Total Sample ^{b,1} n (%)
Sex^c		
Male	450 (47.5)	709 (44.7)
Female	493 (52.3)	802 (50.5)
Other	-	10 (0.6)
Missing	-	66 (4.2)
Region		
Urban	744 (78.9)	1230 (77.5)
Rural	120 (12.7)	223 (14.1)
Northern	79 (8.4)	134 (8.4)
Age		
13 years	34 (3.61)	54 (3.4)
14 years	770 (81.7)	1296 (81.7)
15 years	131 (13.9)	225 (14.2)
16 years	5 (0.5)	8 (0.5)
Missing	3 (0.3)	4 (0.3)
Income Quintile		n/a
Q1 (low)	161 (17.1)	
Q2	184 (19.5)	
Q3	167 (17.7)	
Q4	182 (19.3)	
Q5 (high)	249 (26.4)	
Received Income Assistance		n/a
Never	867 (91.9)	
Currently/ In the past 5 years	76 (8.1)	
Ever Lived in Social Housing^d		n/a
Yes	27 (2.7)	
No	916 (97.1)	
Residential Mobility (moved ≥ 3 times in 10 years prior to survey)		n/a
Yes	258 (27.4)	
No	685 (72.6)	

^an=943 unless data missing

^bn=1587 unless data missing

^cdata imputed where possible with registry data

^ddata currently only available up to May 2018

¹sample cohorts can be treated equally as no differences in bivariate analyses were observed by sex ($\chi^2 = 0.13$, $df = 1$, $p = 0.72$), region ($\chi^2 = 0.92$, $df = 2$, $p = 0.63$), and age ($t = 0.24$ (2521), $p = 0.81$)

Academic Achievement by Sex & Region

By the end of the 2019 academic year, most participants met the minimum credits (≥ 8) required to pass Grade 9 ([Table 5-2](#)). No significant difference was observed between pass rates by sex; however, a significant difference was observed by region. Notably, those from rural and northern regions were more likely to be unable to meet their credit requirements compared to those in urban areas.

Table 5-2. Academic achievement by sex and region

Variable	<8 Pass Credits ^a n (%)	≥8 Pass Credits n (%)	p-value
Total^b	82 (8.7)	861 (91.3)	-
Sex^c			0.3706
Male	43 (52.4)	407 (47.3)	
Female	39 (47.6)	454 (52.7)	
Region			<0.001*
Urban	49 (59.8)	695 (80.7)	
Rural	17 (20.7)	103 (12.0)	
Northern	16 (19.5)	63 (7.3)	

^aAcquisition of 8 or more grade 9 credits is predictive of high school completion

^bResults generated using FANS PHIN subsample (n=943), unless data missing

^cBiological sex from registry data

*p-value <0.05: Chi-square test for association with academic achievement

Differences in Academic Achievement

Food-insecure participants were less likely to meet their required academic credits by the end of the academic semester ([Table 5-3](#)). Additionally, a difference existed between those who consumed lunch less than five times per week and those who consumed lunch five or more times per week. This was the only mealtime frequency variable associated with an inability to meet sufficient course credits in the bivariate analysis. Health indicators, including self-reported health, intentional efforts to gain or lose weight, BMI, and adequate sleep for age, did not differ between groups that met or did not meet their credit requirements. Most participants' diets were either in *need of improvement* or considered *poor*. A difference in academic achievement was observed in relation to diet quality, with a greater proportion of those not meeting academic requirements coming from the *poor* diet category. When examining diet quality as a continuous variable, this relationship held constant ([Table 5-4](#)). The mean diet score for participants who were able to meet their credit requirements (91%) was 56.7, compared to 52.0 for those who were unable to meet their credit requirements.

Table 5-3. Differences in academic achievement by food security status, eating behaviours, health indicators, and diet

Food Security, Nutrition, Eating or Health Indicator Variables	Total^a n (%)	<8 Pass Credits^b n (%)	≥8 Pass Credits n (%)	p-value
Food Security Status				<0.001*
Food Secure	727 (79.6)	44 (57.9)	683 (81.6)	
Food Insecure	186 (20.4)	32 (42.1)	154 (18.4)	
Meal Frequency				
Breakfast				0.3049
0-4d/wk	345 (38.0)	33 (43.4)	312 (37.5)	
5-7d/wk	564 (62.1)	43 (56.6)	521 (62.6)	
Lunch				0.0114*
0-4d/wk	161 (19.0)	21 (30.4)	140 (18.0)	
5-7d/wk	687 (81.0)	48 (69.6)	639 (82.0)	
Family Dinner				0.8794
0-4d/wk	218 (24.7)	17 (24.0)	201 (24.8)	
5-7d/wk	665 (75.3)	54 (76.1)	611 (75.3)	
Self-reported Health				0.1866
Excellent/Very Good	538 (59.9)	39 (52.7)	499 (60.6)	
Fair/Poor	360 (40.1)	35 (47.3)	325 (39.4)	
Intentional Weight Loss				0.0609
No	679 (73.8)	52 (65.0)	627 (74.6)	
Yes	241 (26.2)	28 (35.0)	213 (25.4)	
Intentional Weight Gain				0.5112
No	753 (82.7)	64 (80.0)	689 (82.9)	
Yes	158 (17.3)	16 (20.0)	142 (17.1)	
Body Mass Index				0.1939
Underweight	16 (2.1)	1 (1.6)	15 (2.2)	
Normal weight	550 (72.9)	41 (64.1)	509 (73.7)	
Overweight/Obese	189 (25.0)	22 (34.4)	167 (24.2)	
Adequate Sleep for Age				0.6462
Yes	494 (53.7)	41 (51.3)	453 (53.9)	
No	426 (46.3)	39 (48.8)	387 (46.1)	
Healthy Eating Index				0.0350*
Poor (HEI <50)	246 (28.1)	31 (40.8)	215 (26.9)	
Needs Improvement (HEI 50-80)	610 (69.7)	44 (57.9)	566 (70.8)	
Good (HEI >80)	19 (2.2)	1 (1.3)	18 (2.3)	

^aResults generated using PHIN subsample (n=943), unless data missing

^bAcquisition of 8 or more grade 9 credits is predictive of high school completion

*p-value <0.05: Chi-square test for association with academic achievement

Table 5-4. Mean differences in diet quality score between meeting and not meeting grade 9 course credits

Academics	n (%)	Mean HEI-C ¹	Std Dev	Std Error	Min	Max	t (DF) ²	p-value
<8 Pass Credits	76 (9)	52.0	12.829	1.472	22.083	80.761	-3.47 (873)	0.0005*
≥8 Pass Credits	799 (91)	56.7	11.184	0.396	21.594	89.236		

¹Healthy Eating Index – Canada

²Folded F test for equal variances p=0.0863, pooled method for equal variances

*p-value <0.05: Independent samples T-test for association with academic achievement

Academic Achievement, Social Determinants of Health, and Mental Health

Academic achievement did not differ by income quintile ([Table 5-5](#)); however, differences were noted by other markers of SES, such as receiving income assistance or living in social housing. Among participants unable to meet their credit requirements, 27% of families received social assistance at the time of the study, or within five years prior, compared to 6% who met their credit requirements. Eleven percent of participants who had once lived in social housing did not meet their course credit requirements, compared to 2% of those who did meet their credit requirements. While only a small number of students met the criteria for a mood or anxiety disorder (4%), a negative association was present with academic achievement.

Table 5-5. Differences in academic achievement, social determinants of health, and mental health

Variable	Total ^a n (%)	<8 Pass Credits ^b n (%)	≥8 Pass Credits n (%)	p-value
Income Quintile				0.1396
Q1 (low)	161 (17.1)	22 (26.8)	139 (16.1)	
Q2	184 (19.5)	16 (19.5)	168 (19.5)	
Q3	167 (17.7)	13 (15.9)	154 (17.9)	
Q4	182 (19.3)	11 (13.4)	171 (19.9)	
Q5 (high)	249 (26.4)	20 (24.4)	229 (26.6)	
Received Income Assistance				<0.001*
Never	867 (91.9)	60 (73.2)	807 (93.7)	
Currently/over last 5 years	76 (8.1)	22 (26.8)	54 (6.3)	
Ever Lived in Social Housing^c				<0.001*
Yes	27 (2.9)	9 (11.0)	18 (2.1)	
No	916 (97.1)	73 (89.0)	843 (97.9)	
Residential Mobility (moved ≥3 times in 10 years prior to survey)				0.2366
Yes	258 (27.4)	27 (32.9)	231 (26.8)	
No	685 (72.6)	55 (67.1)	630 (73.2)	
Mood or Anxiety Disorder				0.0259*
Yes	37 (3.9)	7 (8.5)	30 (3.5)	
No	906 (96.1)	75 (91.5)	831 (96.5)	

^aResults generated using PHIN subsample (n=943), unless data missing

^bAcquisition of 8 or more grade 9 credits is predictive of high school completion

^cdata currently only available up to May 2018

*p-value <0.05: Chi-square test for association with academic achievement

Associations with Academic Achievement

Following covariate adjustment, participants who were food insecure were 55% less likely to meet their Grade 9 course credit requirements [OR 0.45 (0.25-0.83)] compared to those who were food secure ([Figure 5.1](#)). Other conditions negatively associated with academic achievement for the PHIN subsample cohort included living in a rural [OR 0.37 (0.15-0.72)] or northern [OR (0.38 (0.15-0.78)] region compared to urban; receiving income assistance [OR 0.33 (0.15-0.72)]; and eating lunch less than five days per week [OR 0.49 (0.25-0.97)]. Diet quality [OR 1.02 (1.00-1.05)], living in social housing [OR 0.41 (0.13-1.42)], and having a diagnosis of a mood or anxiety disorder [OR 0.54 (0.200-1.64)] were explanatory variables no longer significant following model adjustment ([Appendix N, Supplement 6](#)).

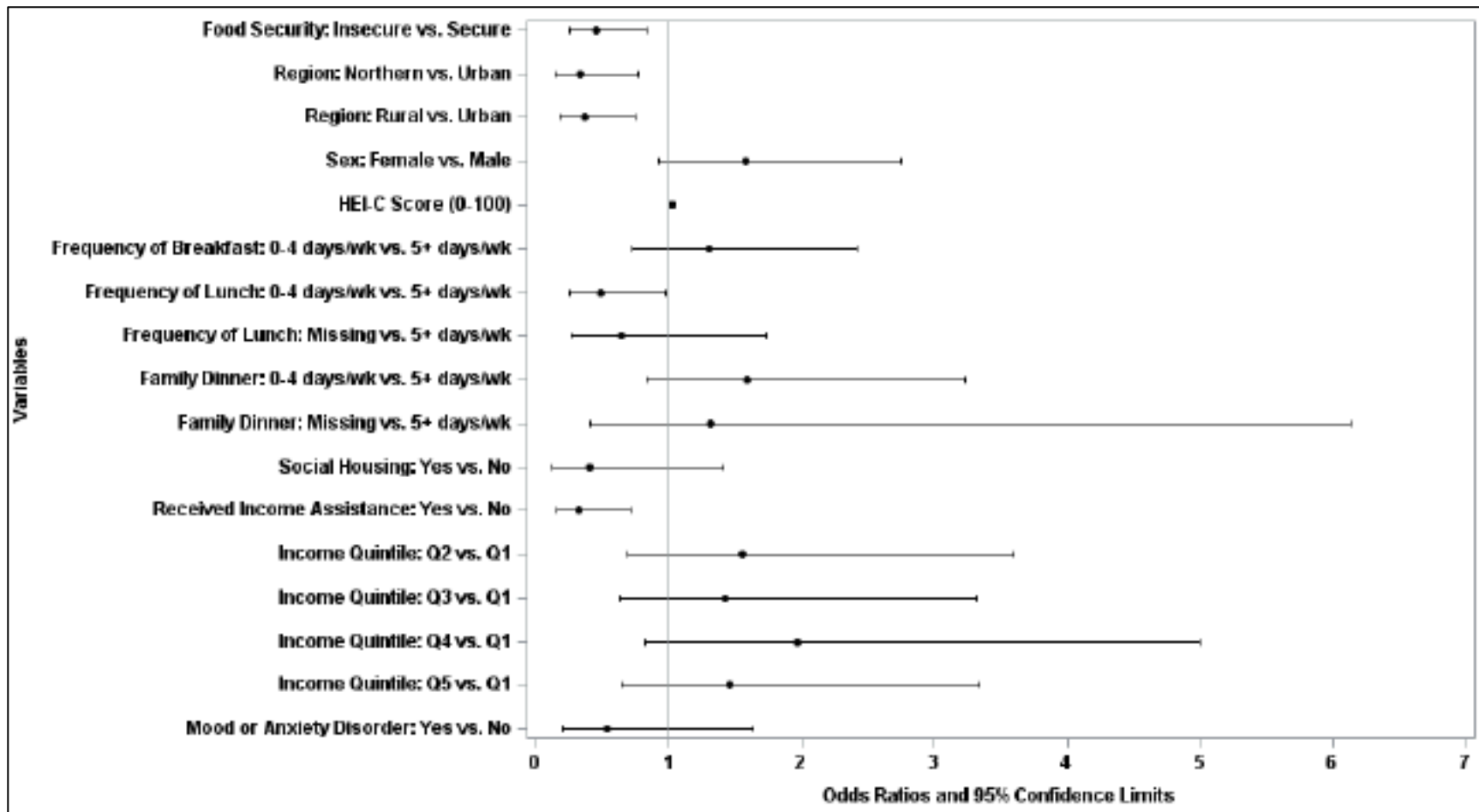


Figure 5.1: Adjusted Multivariable Logistic Regression Model for Academic Achievement. Adjusted multivariable logistic regression model depicting odds ratios (OR) and 95% confidence limits (CL) for the outcome academic achievement as defined by meeting sufficient Grade 9 pass credits (≥ 8) (n=847). Being food insecure compared to food secure, living in northern or rural communities compared to urban, receiving income assistance, and eating lunch less than five days per week were conditions negatively associated with participants' academic achievement. The category 'Missing' for frequency of breakfast vs '5+ days/wk' [OR 2.08 (0.26-44.05)] is not depicted due to wide CLs.

Discussion

The current study examined the intersection of food and nutrition security with academic achievement (measured by the acquisition of eight or more Grade 9 credits), utilizing survey results and routinely collected data. Study findings demonstrate an independent relationship between food security and academic achievement – a predictive measure of high school completion – in a Grade 9 cohort of Manitoba students. No differences were observed in academic achievement based on sex or health indicators such as BMI, self-reported health, or nightly hours of sleep. Preliminary analyses revealed a negative relationship between academic achievement and factors such as living outside an urban centre, receiving income assistance, residing in social housing, having a diagnosed mental mood or anxiety disorder, eating lunch less often, and consuming a poorer diet. After model adjustment, diet quality, social housing status, and a mental health diagnosis were no longer found to be independently associated with academic achievement.

Twenty percent of participants (1 in 5) experienced food insecurity, a finding consistent with adolescent-specific data for Manitoba from the CCHS (2017-2018) (Tarasuk & Mitchell, 2020). The study assessed food insecurity at the individual level, as proxy data from parental or guardian reports have been criticized for underestimating true prevalence (Baer et al., 2015) and the outcome variable is specific to the individual; accordingly household-level measures of food insecurity would be less appropriate. Study findings align with worsening trends in food insecurity in Canada (Li et al., 2023) and concerns about adolescent literacy and numeracy skills, as students in Manitoba perform below the national average (Government of Canada, n.d.). While multiple factors contribute to academic performance, these findings support a plausible and meaningful association whereby food insecurity functions as a barrier to learning. However,

future studies may consider modeling academic achievement as a continuous variable to allow for a more sensitive measure of this relationship and better capture gradients of risk. In this way, it may be reasonable to hypothesize a larger effect size among students who are farther from reaching the minimum credit requirements, rather than a continuous improvement across the linear scale of academic achievement, as there is likely to be a ceiling effect of food security. Furthermore, if the severity of food insecurity is known, a dose-response relationship could be assessed between increasing severity of food insecurity relative to poorer academic outcomes.

Nevertheless, the results are in line with previous research illustrating educational vulnerability of food-insecure children and adolescents (Alaimo et al., 2001; Jyoti et al., 2005; Shankar et al., 2017) and, more importantly, provide a Canadian context to predominantly American-based studies. Furthermore, few studies have investigated this relationship, despite food insecurity remaining a persistent issue in the country.

Sex differences and academic achievement

No sex differences were observed in academic achievement in either the bivariate analyses or the regression models. This finding was not unexpected, as academic markers such as literacy and numeracy were not examined separately, where prior Canadian research has shown sex differences, with females typically outperforming males in reading and males demonstrating an advantage in mathematics (Faught et al., 2017; Government of Canada, n.d.). From this perspective, the null finding may be interpreted as an encouraging indication of shifting trends, potentially reflecting a narrowing of historical disparities in the education system that have limited females' participation and achievement in math and science.

Socioeconomic factors

It is well-documented that households reliant on income and social assistance programs in Canada struggle with food insecurity and are more likely to experience severe food insecurity (Li et al., 2023; Liu et al., 2023; Tarasuk et al., 2019). Study findings contribute to the limited body of literature that demonstrates this relationship and its impact on educational outcomes. The odds of meeting Grade 9 credits were almost two-thirds lower for food-insecure participants after adjusting for other economic variables, such as income and social housing.

While traditional socioeconomic measures such as family income, parental occupation, parental education, and home resources are often used to predict academic performance (Liu et al., 2022; Selvitopu & Kaya, 2023), income quintile did not correlate with academic achievement in this study. This contrasts with findings from another Manitoba study that linked movement between low-income neighbourhoods and poorer literacy and numeracy trajectories in Grade 3 students (Cowley et al., 2022).

Geographic region and academic achievement

Geographic region was significantly associated with academic achievement. Participants from both rural and northern communities had significantly lower odds of meeting course credit requirements. It is well-documented in Canadian literature that food insecurity is far worse in northern communities (Council of Canadian Academies, 2014; Li et al., 2023), where limited employment opportunities, precarious income sources, high unemployment rates, and exorbitant food costs (Food Banks Canada, 2023; Government of Canada, 2021a) hinder food and nutrition security, and academic success (Men et al., 2021).

Diet quality and academic achievement

Canadian and international research indicate that children and youth who consume nutrient-rich diets, low in highly processed foods and refined sugars, perform better cognitively (Florence et al., 2008; Northstone et al., 2012; Nyaradi et al., 2014). Although diet quality was significantly related to academic achievement in bivariate analyses, this association was not maintained in the adjusted regression model. This discrepancy may be due to the homogeneity of diet quality in the sample, as only a small percentage of participants met dietary recommendations. The relationship between food insecurity and nutritional vulnerability has been central to much of the food insecurity literature, suggesting that diet quality declines when food insecurity is present and tends to worsen as food insecurity increases. Current research findings, however, suggest otherwise and indicate that, regardless of food security status, diet quality at the individual level was unfavourable (Webb et al., 2026, unpublished manuscript). This highlights the strength of the relationship between food security status and education, regardless of diet. Additionally, this study did not differentiate between educational competencies, which may explain the lack of alignment with previous research.

Meal frequency and academic achievement

Increased lunch frequency (at least five times per week) was the only eating behaviour associated with academic achievement. Much of the nutrition-focused research emphasizes diet quality (Florence et al., 2008; Northstone et al., 2012; Nyaradi et al., 2014), often overlooking the importance of meal frequency, or has focused solely on breakfast consumption (Adolphus et al., 2013; de Wit, 2012). This finding supports the notion that well-nourished children perform better academically, which can inform advocacy efforts for ongoing school meal programs (Coalition for Healthy School Food, n.d.). However, this study was conducted before the

implementation of universal public-school meals in Manitoba, so the impact of this policy cannot be assessed.

Mental health and academic achievement

Mental illness affects approximately one in four Canadian youth (Centres for Addiction and Mental Health, 2022), with the prevalence of anxiety and depression nearly doubling between 2012 and 2022 (Statistics Canada, 2023c). Food and nutrition insecurity have been linked with poorer mental health outcomes, which may contribute to lower academic achievement among children and youth. A Canadian longitudinal study found an increased risk of major depression and suicidal ideation among youth from moderately and severely food-insecure households (Men et al., 2021), while both observational and prospective studies have correlated poor diets with worse mental health outcomes (O’Neil et al., 2014; Oellingrath et al., 2013). Despite less than 4% of participants meeting the criteria for a mood or anxiety disorder, a significant association was found between mental health status and academic achievement in the Chi-square analysis and unadjusted regression model.

Recent literature advocates for a dual factor measure of mental health that includes both subjective well-being (life satisfaction, positive and negative affect) and psychopathology (psychological symptoms and risk-taking behaviour) in the absence of a diagnosed mental illness (King et al., 2021). Findings by King et al (2021) concluded that mentally unhealthy youth were more likely to come from families of lower SES and lone parent households, two dimensions strongly linked with food insecurity (Li et al., 2023). Limited longitudinal data exist to disentangle the bidirectional relationship between youth mental health and academic performance, and no studies to date have incorporated food and nutrition security into the analysis. A Spanish longitudinal study using the dual factor measure of mental health and

academic performance among a relatively small cohort of secondary students found no bidirectional relationship between academics and mental health (Monzonís-Carda et al., 2023). These findings suggest that higher academic performance at baseline was associated with improved mental health over two years. Still, mental health did not predict academic achievement when adjusting for SES (Monzonís-Carda et al., 2023), conclusions which may support current study findings. Further research is clearly needed in this area within the Canadian context, and the use of the dual factor measure for mental health may ensure that subclinical mental health is captured.

Strengths & Limitations

This study successfully captured individual food security status using a child-specific validated tool on a larger sample of youth than would be possible with secondary data from the CCHS or CIS. Additionally, removing parents and guardians as proxies for children's food security experiences increased confidence in understanding participants' personal experiences, which have been known to be underestimated in the literature for older children by their parents (Baer et al., 2015). The WEB-Q, another valid tool for this population group, enabled efficient and cost-effective data collection for dietary data that was easily translated into an HEI-C score for pattern analysis rather than individual nutrient analysis. This process helps mitigate confounding and enhances the dissemination of public health nutrition data. Lastly, the use of administrative data to objectively examine academic achievement in relation to other covariates will facilitate easier replication of findings for future studies and should be considered as a component of school food program evaluation.

Several limitations have been identified in this research. Despite best efforts to engage with most school divisions within the province, our sample is not representative of all Grade 9

students. Likewise, the study's exclusion criteria, cross-sectional design and narrow age range of participants further limit external validity and generalizability to the broader Grade 9 cohort in the province. Additionally, observational studies cannot completely eliminate unobserved confounding. However, the use of administrative data linked with the FANS survey allows for cross-referencing data over time to support quantifying the situation specific to Manitoba. Unfortunately, there are inherent limitations in using administrative data. First, data are not collected to answer specific research questions, nor are the health inequities of underserved populations well captured, as these individuals are less likely to access healthcare services (Haggerty et al., 2020). It is therefore plausible that data pertaining to the mental health variable underestimates the potential for a clearer relationship between mental health and academic potential compared to if a subclinical diagnosis were included.

Similarly, the study design created challenges when exploring the mental health/academic bidirectional pathway; thus, the use of the dual factor method to assess subclinical mental health concerns would be of value when looking at this relationship, despite the study design, in future research initiatives. There is also an opportunity to look at the potential moderating effect of food security status on the mental health and academic pathway.

Given the connection between food and nutrition insecurity and socioeconomic predictors, future studies should also consider the inclusion of adverse childhood experiences, as youth with an elevated social risk (low SES and adverse childhood experiences) are at increased risk for lower scholastic potential (Duke, 2020; Selvitopu & Kaya, 2023).

Recall bias is likely given the use of self-reported data to assess diets using a 24-hour diet recall, which may reduce the validity of our results, as usual intake was not asked. This type of nutrition assessment tool also fails to account for intake variability and tends to encourage

responses that are deemed the correct answer (Foster & Bradley, 2018). This is also true for parents responding on behalf of their children who want to be seen as providing their children with healthier options (Foster & Bradley, 2018). Parents used as proxies may also inaccurately capture their children's true intake, as they are not always with them (Foster & Bradley, 2018). Use of the WEB-Q was able to mitigate many of these issues as children responded for themselves, reminder prompts encouraged memory recall, use of photos was engaging for children, and research team did their due diligence to inspect the data visually and followed thresholds common in the literature to remove under/over-reporters (Hanning et al., 2007; Woodruff et al., 2014), which increased nutrient analysis accuracy and content validity.

Lastly, school meal programs have been promoted as a means to support food security and student learning success (Coalition for Healthy School Food, n.d.). Unfortunately, school involvement and intensity in meal or snack programs were not assessed, which limits the ability to determine any confounding or mitigating effect on the HEI-C score and academic achievement.

Conclusion

Food and nutrition security among children and youth in Canada must be prioritized, as there are no signs of improvement or alleviation of these issues (Hack et al., 2021; Li et al., 2023, PROOF, 2024). This study represents the largest cohort of youth in Manitoba to explore the intersection of food and nutrition security and its impact on academic achievement. The cross-sectional findings highlight a significant connection between food insecurity, geographic location, social assistance, and students' potential to graduate high school, underscoring the need for ongoing monitoring to better understand these dynamics.

Current programs and policies aimed at addressing food insecurity and nutrition are clearly insufficient, compromising the future success of many younger Canadians. To improve outcomes, it is essential that existing initiatives and new policies, such as federal and provincial investments in school food programming (Government of Canada, 2024; Government of Manitoba, 2024b) consider socioeconomic and geographic vulnerabilities as well as cultural and community differences. These factors will shape how resources are distributed and how staff are trained and educated, ensuring more equitable access to food and nutrition security across regions and demographics.

**CHAPTER 6: SOCIAL AND ECONOMIC FACTORS AFFECTING YOUTH
NUTRITION SECURITY: A CROSS-SECTIONAL STUDY LINKING
ADMINISTRATIVE DATA IN MANITOBA**

Preface

In the absence of regular nutrition surveillance in Canada and Manitoba, this chapter uses survey data to assess diet quality using a validated dietary index. It builds on Chapter 4 results, which suggest that diets are concerning irrespective of food security status. Due to the homogenous nature of the diet quality variable, this chapter treats diet quality as a continuous variable to better understand its relationship with covariates at a population level. It extends previous analyses by examining how current eating behaviours, along with socioeconomic factors linked to food security and academic achievement in Chapters 4 and 5, are shaping nutrition outcomes. Results aim to address critical gaps in youth nutrition surveillance and advocate for the feasibility of using administrative data to inform nutrition program evaluation.

Abstract

Background: Poor nutrition is the leading modifiable risk factor for chronic disease, and Canadian children have the most concerning nutritional profiles compared to all other age groups, which have remained unchanged over the past two decades. While the Canadian government considers a national school food program to, in part, address this issue, a thorough review of youths' dietary habits and determinants of health is necessary to support the successful evaluation of such initiatives, as there has not been a comprehensive population-based nutrition survey in over a decade. **Methods:** Fourteen school divisions participated in a web-based survey assessing the food security status, eating and health behaviours, and diet quality (measured with the Health Eating Index Canada (HEI-C)) of Grade 9 students (n = 1587) across Manitoba during

the 2018-19 school year. A subset (n = 943) of participants' parents and guardians provided their child's personal health identification number (PHIN) for data linkage purposes with routinely collected social and health data. An adjusted general linear model estimated point estimates and 95% confidence limits (CL) for the outcome diet quality. **Results:** The overall average HEI-C score was 56 out of 100, suggesting a diet that needs improvement. Diet quality was higher among females and those who ate lunch at school instead of at home. Conversely, diet quality was lower among individuals with poor self-reported health, diagnosed mood or anxiety disorders, residents of northern communities, recipients of income assistance, and those who ate breakfast and lunch less frequently. **Conclusion:** Findings indicate a concerning number of Manitoba youth are not meeting nutritional recommendations, placing them at risk for future nutrition-related chronic diseases. There is a dire need for government direction to support healthy eating strategies and conduct more frequent nutrition surveillance.

Keywords: food security, diet quality, healthy eating index - Canada, youth, administrative data, Manitoba,

Introduction

Poor nutrition is the leading modifiable risk factor for chronic disease (Afshin et al., 2019a), yet Canadian children and youth have nutrition profiles far worse than any other age group (Hack et al., 2021; Jessri et al., 2016). A staggering 30% of Canadian children are overweight or obese, and diet-related diseases such as type 2 diabetes are rising, with Manitoba youth experiencing disproportionately high incidence and prevalence (Government of Canada, 2023b; Public Health Agency of Canada, 2017; Rao et al., 2016; Sellers et al., 2024). At the same time, 1 in 4 Canadian youth face mental health challenges such as mood and anxiety

disorders, often linked to poor diets, food insecurity, socioeconomic disadvantage, and body dissatisfaction (Bodega et al., 2023; Men et al., 2021; O’Neil et al., 2014).

Adolescence is a critical time to establish eating behaviours that will shape long-term health trajectories (Acton et al., 2018; Tugault-Lafleur & Black, 2020). Yet, nutrition surveillance in Canada is limited. The last comprehensive Canadian nutrition survey is from 2015, and provincial-level data specific to the child and adolescent population is too small for meaningful analysis. This gap limits the ability to evaluate current and emerging nutrition policies, such as Canada’s newly implemented universal school meal program. With roughly one-quarter of dietary calories consumed at lunch on school days (Tugault-Lafleur & Black, 2020), schools are uniquely positioned to influence students’ eating habits, food skills, and long-term health outcomes.

Diet quality indices, such as the Healthy Eating Index-Canada (HEI-C), offer a standard way to assess overall diet quality in relation to national guidelines (Health Canada, 2019). In contrast to early nutrition epidemiology that focused on single nutrients, these indices capture the complexity of eating behaviours, making them more useful for public health policy development (Kourlaba & Panagiotakos, 2009). While important, diet quality is only one component of nutrition security, which also encompasses food diversity, safety, cultural acceptability, and socioeconomic access (FAO et al., 2020; Mozaffarian et al., 2021; Slater & Yeudall, 2015). Nutrition security cannot be achieved in the absence of food security – the consistent access to food without financial constraints (Li et al., 2023). In Manitoba, where 27% of households are food insecure and trends continue to worsen nationwide (PROOF, 2024), there is an urgent need for efficient tools to address these interrelated issues at the population level.

Routinely collected health and social data, when linked with nutrition survey information, can serve as a powerful and cost-effective way to track population-level nutrition, and evaluate interventions in a timely manner. Regional insights will be vital for tailoring programs and policies to meet diverse community needs.

As part of the *Food and Nutrition Security (FANS) in Manitoba Youth* study, this research aims to establish comprehensive nutrition data on youth living in Manitoba and examine social and economic factors that shape food and nutrition security. Findings will inform evidence-based policy reform to improve school food programming.

Methods

Setting

The FANS study took place in Canada's central province of Manitoba, which at the time of data collection had a population of nearly 1.3 million (Statistics Canada, 2023b). and nearly 60% of the provincial population resided in the capital city of Winnipeg (Manitoba Health Seniors and Active Living, 2019). For over two decades, children in Manitoba have been living in graver poverty than those from other provinces (Social Planning Council of Winnipeg, 2020).

Ethics & Approvals

Ethics and project approvals have been received from the University of Manitoba Research Ethics Board [Protocol J2018:040 (HS21666)], the Health Information Privacy Committee at Manitoba Health (No. 2018/2019-32), and MCHP (#2019-023).

Data Sources

Using a cross-sectional design, the study examined how factors such as food security status, health and eating behaviours, mental health, and social determinants of health (income, income assistance, social housing, and residential mobility) impact youth's diet quality

(measured using the HEI-C). Grade 9 students from rural, urban, and northern Manitoba participated in a web-based survey (FANS survey) linked with de-identified provincial health and social data.

FANS Survey

Students completed the FANS survey, which consisted of three modules (demographic characteristics; dietary intake, food behaviours, and health indicators; and food security status), on the data collection day at their school. The survey took approximately 30-45 minutes to complete, and students were instructed to work independently or with their educational assistant. A trained FANS research assistant and school staff member oversaw survey administration and supported students as needed. All survey questions were optional, resulting in missing data, which were retained as a separate category for analyses. Data were captured using a secure third-party server hosted by PeaceWorks Technology Solutions in Waterloo, Ontario. Nutrient analysis software was used to process the food intake data according to portion sizes defined in the 2001b version of the Canadian Nutrient File database and Canada's Food Guide (2007) (Health Canada, 2019). Line-level data was returned to the FANS research team.

Administrative Data Linkage

FANS survey results were linked at the individual level with health and social data (excluding neighbourhood-level income quintiles) using the Manitoba Population Research Data Repository (Repository) for participants whose parent or guardian provided their personal health identification number (PHIN). The Repository is housed at the Manitoba Centre for Health Policy (MCHP), a research unit within the Rady Faculty of Health Sciences, at the University of Manitoba, with the purpose of carrying out population-based research related to health services, population and public health, and the social determinants of health (University of Manitoba,

2020a). The Reporting of Studies Conducted using the Observational Routinely Collected Data (RECORD) checklist for observational studies using administrative health data is presented in [Appendix O, Supplement 1](#).

Sampling & Study Cohorts

During data collection from October to May 2018-2019, Manitoba had 37 school divisions (Manitoba Education and Training, 2019). After ethics approval, 14 of these divisions were recruited to participate (six urban, five rural, and three northern). Recruitment involved communication with the superintendent or another designated person, and information packages were sent to schools within each division. Exclusion criteria included small Grade 9 cohorts (i.e., classes with fewer than 10 students), as well as independent, faith-based, and francophone schools, due to logistical challenges and the fact that the survey was only available in English. Consequently, 19 school divisions were excluded based on these criteria. To minimize volunteer bias, the FANS research team aimed to recruit as many schools as possible, including re-inviting those that did not respond initially. Details about the sampling process for the FANS study have been published elsewhere (Slater et al., 2022).

Participants included all Grade 9 students (aged 13-16 years) from recruited schools who had completed and returned parental consent forms to classroom teachers prior to the data collection day. The two-part consent form consisted of: (1) consent for the child to complete the online survey; (2) optional provision of the child's family and PHIN for data linkage purposes. On the day of data collection, the FANS research team collected the consent forms to verify parental signatures. Once verified, the forms were redistributed to students, as they contained a unique FANS identifier allowing students to log in. All forms were promptly collected again for secure storage at the University of Manitoba. Participants could provide assent at the start of the

web survey. Students without consent forms were ineligible to participate. The total FANS cohort consisted of 1587 participants, of whom 960 provided a validated PHIN for data linkage. Following data cleaning, 943 participants made up the PHIN subsample cohort. The sampling strategy is adapted from Slater et al (2022) and found in [Appendix O, Supplement 2](#). The adjusted general linear model (GLM) for this study uses a smaller PHIN subsample (n = 872) due to incomplete data on food security (n = 34) and diet quality (n = 37).

Outcome

The study's primary outcome was diet quality, measured by participants' HEI-C score. This variable was derived from dietary intake questions in the FANS survey. This part of the survey collected information using the Waterloo Eating Behaviour Questionnaire (WEB-Q), a validated tool used to assess the dietary intake of children and adolescents (Hanning et al., 2009). The tool combines a 24-hour diet recall and a food frequency questionnaire, showing good agreement with dietitian-administered 24-hour diet recalls (Hanning et al., 2009). The engaging and interactive tool enables participants to recreate meals and snacks using pictures, with a drag-and-drop method from approximately 800 food and beverage selections. If a meal or snack was unavailable, students were instructed to select a similar item or "build" the item(s) using individual ingredients. Prompts for snacks, beverages, and condiments mimicked a multiple-pass system interview, mitigating recall bias, a standard limitation of 24-hour diet recalls. At the end, students confirmed or revised their selections and were provided with a nutrition summary based on age- and sex-specific recommendations from the 2007 Canada's Food Guide (Health Canada, 2019). The summary provided insights into nutritional guidelines that were being met, as well as suggestions on how to meet recommendations. WEB-Q results were translated to an HEI-C score using a modified version of the 2010 HEI-C (Jessri et al., 2017).

The HEI-C is a validated diet quality index for Canadians based on ‘adequacy’ (dietary elements that are encouraged) and ‘moderation’ (dietary elements with recommended limits) rather than assessment of individual nutrients. Assessing whole diets compared to individual components can reduce confounding and improve public health messaging. Canada’s Food Guide servings were converted into an HEI-C score out of 100, with 100 equating to a perfect score. Scores are categorized into ‘poor’ (<50), ‘needs improvement’ (50-80), and ‘good’ (>80). Due to the homogenous output from this variable, diet quality was assessed as a continuous variable.

Covariates

Participant Characteristics

All covariate definitions are found in [Appendix O, Supplement 3a](#) (FANS Survey) and [3b](#) (linked administrative variables). Demographic questions included age, self-reported sex/gender (male, female, other), self-reported height and weight for which body mass index (BMI) was calculated, age of arrival to Canada (Newcomer status), Indigenous ancestry (Métis, First Nations, Inuit, don’t know), and geographic region. Newcomer and Indigenous data have been previously published (Alexiuk et al., 2023; Perchotte et al., 2025). Participating schools are classified according to region (urban, rural, northern) in accordance with established parameters used by MCHP (Fransoo et al., 2019). The variable gender was treated as biological sex (male and female) due to the small number of participants (n = 34) who answered “other” for gender. As dietary data for this research is interpreted based on sex-specific recommendations, sex was imputed from the Registry for the otherwise missing observations when running analysis using the PHIN subsample.

Food Security

The Child Food Security Survey Module (CFSSM), a valid and reliable tool, was used to assess participants' individual-level food security status rather than the household's overall food security (Connell et al., 2004). Questions focused on food availability, altered eating behaviours, and hunger levels experienced within the past year. Scores ranged up to nine points, with affirmative answers ('a lot' or 'sometimes') scored as 1, and negative answers ('never') scored as 0. For this study, food security was categorized as a binary variable (food secure vs. food insecure). Participants with a CFSSM score of 0-1 were classified as 'food secure,' and those with scores from 2-9 as 'food insecure.' Participants with more than two missing responses were excluded from analysis (n = 53, FANS total sample; n = 34, PHIN subsample).

Food Behaviours & Health Indicators

The latter part of the WEB-Q assessed participants' food behaviours, including meal and snack frequency, location of meals and snacks, and family dinner frequency. Self-reported height and weight were health indicators used to derive BMI and were classified in accordance with the World Health Organization z-scores (Rodd et al., 2014). Other health indicators included intentional efforts to gain or lose weight, adequate sleep for age (Government of Canada, 2019a) and self-reported health (measured on a Likert scale).

Linked Variables

Multiple data sources from the Repository provided additional information on health and social factors known to be associated with diet. Social factors included families receiving income assistance, families living in social housing, residential mobility, and income quintile (Q1 = lowest – Q5 = highest). Mental health (diagnosed depression and/or anxiety) was defined using ICD (International Classification of Diseases) and ATC (Anatomical Therapeutic Chemical)

codes gleaned from hospital abstracts, physician claims, and pharmaceutical prescription data. Definitions of linked variables based on previous work, including years accessed, are found in [Appendix O, Supplement 3b](#). Except for income quintile, all repository variables are measured at the individual/family level.

Data Analysis

SAS version 9.4 (SAS Institute) was used for all statistical analyses (significance recognized at $p \leq 0.05$) on an unweighted sample, model stability was not maintained following weighting and as a sensitivity analysis did not provide meaningful differences by demographic variables (sex and region). The unweighted sample allowed for greater retention of study participants. Additionally, a test of statistical differences by demographic variables sex ($\chi^2 = 0.07$, $df = 1$, $p = 0.79$), region ($\chi^2 = 1.36$, $df = 2$, $p = 0.51$), and age ($t = 0.51$ (2453), $p = 0.61$) was initially run to ensure confidence that sample cohorts were comparable ahead of variable selection for model building. As the examination yielded null differences, the total FANS cohort was utilized when bivariate relationships examined FANS survey results only.

Descriptive statistics (frequencies and percentages) illustrate participant characteristics across sample cohorts. Both mean and median values are used to represent HEI-C scores, as dietary index scores do not follow a normal distribution. Differences in baseline data for the outcome diet quality are compared by study cohorts using point estimates from a GLM with 95% CL. Results from bivariate analysis, assessment of multicollinearity through a correlation coefficient (Spearman Rho) matrix and collinearity statistics (tolerance and the variance inflation factor), along with theoretical knowledge, were steps in developing the final adjusted GLM. Checks for multicollinearity were also performed to evaluate potential effects of confounding. Thresholds for the initial correlation matrix were ≤ -0.8 - ≥ 0.8 and followed up with an analysis

of collinearity statistics, tolerance and the variance inflation factor with thresholds for a GLM of ≤ 0.1 and > 10 (Senaviratna & Cooray, 2019). No concerns were observed with any of the tests that were run ([Appendix O, Supplement 4](#)). Sex, region, food security status, self-reported health, BMI, income assistance, frequency of breakfast, lunch, and family dinner, location of breakfast and lunch, diet modification for weight loss, adequate sleep for age, and a mental health diagnosis were covariates included in the fully adjusted model.

Results

Participant Characteristics

Demographic data for the entire FANS cohort ($n = 1587$) and the PHIN subsample ($n = 943$) are depicted in [Table 6-1](#). Administrative data is only available for the PHIN subsample. The cohorts were almost evenly split by sex, and less than 5% of participants identified as *other* or chose not to disclose their gender identity. Nearly 80% of participants resided in an urban setting, while the remainder were from rural and northern regions of the province. Just under half the PHIN subsample lived in an affluent neighbourhood as described by income quintiles 4 and 5. Most PHIN subsample participants were from families who had not received income assistance, and few resided in social housing. About one-quarter of the PHIN subsample had moved residences (≥ 3 times) within ten years prior to the study start date.

Table 6-1. Participant characteristics: PHIN subsample and FANS total sample

Variable	FANS Total Sample ^{a,1} n (%)	PHIN Subsample ^{b,1} n (%)
Sex^c		
Male	709 (44.7)	450 (47.5)
Female	802 (50.5)	493 (52.3)
Other	10 (0.6)	-
Missing	66 (4.2)	-
Region		
Urban	1230 (77.5)	744 (78.9)
Rural	223 (14.1)	120 (12.7)
Northern	134 (8.4)	79 (8.4)
Age		
13 years	34 (3.61)	54 (3.4)
14 years	770 (81.7)	1296 (81.7)
15 years	131 (13.9)	225 (14.2)
16 years	5 (0.5)	8 (0.5)
Missing	3 (0.3)	4 (0.3)
Income Quintile		
	n/a	
Q1 (low)		161 (17.1)
Q2		184 (19.5)
Q3		167 (17.7)
Q4		182 (19.3)
Q5 (high)		249 (26.4)
Received Income Assistance		
	n/a	
Never		867 (91.9)
Currently/ In the past 5 years		76 (8.1)
Ever Lived in Social Housing^d		
	n/a	
Yes		27 (2.7)
No		916 (97.1)
Residential Mobility (moved ≥ 3 times in 10 years prior to survey)		
	n/a	
Yes		258 (27.4)
No		685 (72.6)

^an=1587 unless data missing

^bn=943 unless data missing

^cdata imputed where possible with registry data

^ddata currently only available up to May 2018

¹sample cohorts can be treated equally as no differences in bivariate analyses were observed by sex ($\chi^2 = 0.07$, $df = 1$, $p = 0.79$), region ($\chi^2 = 1.36$, $df = 2$, $p = 0.51$), and age ($t = 0.51$ (2453), $p = 0.61$)

Diet Quality by Sex & Region

The average HEI-C score for both cohorts was 56.3/100, indicating a diet that ‘needs improvement’ according to the HEI-C categorization (50-80 points). Female participants had a higher mean HEI-C score (57.0) compared to males (55.6), a significant difference in the unadjusted GLM for the FANS cohort only ([Table 6-2](#)). Differences in diet quality were also observed by region. For both the study cohorts, northern participants had lower diet quality

scores compared to urban participants. No difference was observed in HEI-C scores between rural and urban participants in the bivariate analysis.

Table 6-2. Diet quality by sex and region

Variable	FANS Total (n=1587)						PHIN Subsample (n=943)					
	n (%)	Mean HEI-C ¹	Median HEI-C	Estimate	p-Value	95% CL	n (%)	Mean HEI-C	Median HEI-C	Estimate	p-Value	95% CL
Sex²												
(ref=Male)	732 (46.1)	55.4	55.6				453 (48.0)	55.6	55.6			
Female	821 (51.7)	57.2 ^a	57.0	1.788	0.0023*	0.638-2.937	490 (52.0)	57.0	57.0	1.467	0.0582	-0.051-2.985
Region					0.0016*						0.0008*	
(ref=Urban)	1230 (77.5)	56.8	56.7				744 (78.9)	56.8	56.7			
Rural	223 (14.1)	56.1	55.8	-0.6772	0.4266	-2.347-0.993	120 (12.7)	56.6	56.0	-0.223	0.8495	-2.526-2.081
Northern	134 (8.4)	53.0 ^a	50.8	-3.742	0.0004*	-5.793-(-1.691)	79 (8.4)	51.6 ^a	50.3	-5.214	0.0002*	-7.921-(-2.508)

*p-value ≤0.05: general linear model

¹Healthy Eating Index – Canada

²n=1553 as 34 participants did not select male or female. Sex was imputed for missing data for the PHIN subsample.

^asignificantly different from reference group

Differences in Diet Quality by Food Security Status and Eating/Health Behaviours

Food-insecure participants in the FANS cohort had a lower mean diet quality score (55.0) than food-secure participants (56.8); though, this difference was not observed in the PHIN subsample ([Table 6-3](#)). Across both cohorts, a better diet quality score was associated with more frequent consumption of breakfast and family dinners.

Meal location also influenced diet quality. Eating breakfast at home resulted in a 3-point increase in the HEI-C, while eating lunch at home was associated with a 3-point decrease, compared to eating at school or elsewhere – both differences were significant.

Participation in a home economics class had no impact on diet quality (mean HEI-C remained at 56 regardless of participation).

For both cohorts, positive self-reported health (very good/excellent) and a healthy BMI classification were positively associated with diet quality. No difference was seen between underweight and overweight/obese participants. Conversely, intentionally eating less to lose weight and not meeting sleep recommendations were correlated with a lower diet quality score among both cohorts.

Table 6-3. Diet quality differences by food security status and eating/health-related behaviours

Variable	FANS Total (1587)						PHIN Subsample (n=943)					
	n (%)	Mean HEI-C	Median HEI-C	Estimate	p-Value	95% CL	n (%)	Mean HEI-C	Median HEI-C	Estimate	p-Value	95% CL
Food Security Status					0.0289*						0.2751	
(ref=Food Secure)	1222 (77.0)	56.8	56.6				724 (76.8)	56.6	56.3			
Food Insecure	312 (19.7)	55.0 ^a	54.7	-1.726	0.0199*	-3.178-(-0.273)	185 (19.6)	55.8	56.6	-0.776	0.4266	-2.689-1.138
Missing	53 (3.3)	54.0	52.6	-2.754	0.1411	-6.422-0.915	34 (3.6)	53.2	51.9	-3.395	0.1446	-7.959-1.169
Taken Home Ec Class (ref=Yes)					0.2034						0.2752	
(ref=Yes)	912 (57.5)	56.6	56.4				535 (56.7)	56.6	56.7			
No	552 (34.8)	56.3	56.4	-0.349	0.5774	-1.579-0.880	334 (35.4)	56.3	56.4	-0.343	0.6776	-1.959-1.274
Missing	123 (7.8)	54.5	52.5	-2.084	0.0763	-4.389-0.221	74 (7.8)	54.2	52.7	-2.452	0.1087	-5.449-0.545
Meal Frequency												
Breakfast (ref=5+ days/week)					<0.0001*						<0.0001*	
(ref=5+ days/week)	938 (59.1)	58.0	57.8				561 (59.5)	58.1	57.5			
0-4 days/week	591 (37.2)	53.7 ^a	53.6	-4.254	<0.0001*	-5.434-(-3.074)	334 (35.4)	53.5 ^a	53.3 ^a	-4.560	<0.001*	-6.125-(-2.994)
Missing	58 (3.7)	55.7	54.1	-2.318	0.1838	-5.737-1.012	38 (4.0)	55.3	53.6	-2.819	0.1812	-6.954-1.316
Lunch (ref=5+ days/week)					0.0001*						<0.0001*	
(ref=5+ days/week)	1160 (73.1)	57.0	57.0				684 (72.5)	57.3	57.2			
0-4 days/week	262 (16.5)	53.6 ^a	54.3	-3.403	<0.001*	-4.961-(-1.844)	160 (17.0)	52.7 ^a	52.7	-4.567	<0.0001*	-6.575-(-2.559)
Missing	165 (10.4)	56.1	54.8	-0.894	0.3676	-2.841-1.052	99 (10.5)	55.8	54.1	-1.393	0.2863	-3.954-1.169
Family Dinner Frequency (ref=5+ days/week)					0.0016*						0.0008*	
(ref=5+ days/week)	1134 (71.5)	57.0	56.9				662 (70.2)	57.3	57.1			
0-4 days/week	351 (22.1)	54.6 ^a	54.7	-2.363	0.0009*	-3.753-(-0.973)	218 (23.1)	54.2 ^a	54.0 ^a	-3.102	0.0008*	-4.902-(-1.301)
Missing	102 (6.4)	54.7	54.7	-2.267	0.0786	-4.794-0.259	63 (6.7)	53.7	53.0	-3.597	0.0297*	-6.840-(-0.354)
Previous Day Meal Location												
Breakfast (ref=Home)					<0.0001*						<0.0001*	
(ref=Home)	1308 (82.4)	57.1	56.9				776 (82.3)	57.1	57.1			
School/Other	130 (8.2)	54.1 ^a	54.9	-2.988	0.0047*	-5.056-(-0.9194)	73 (7.7)	55.2	56.3	-1.878	0.1858	-4.661-0.905
Missing	149 (9.4)	50.7 ^a	49.7	-6.369	<0.0001*	-8.414-(-4.323)	94 (10.0)	50.2 ^a	49.6	-6.890	<0.001*	-9.478-(-4.302)
Lunch (ref=School/Other)					0.0001*						0.0021*	
(ref=School/Other)	1153 (72.7)	57.1	56.6				683 (72.4)	57.1	56.8			
Home	343 (21.6)	54.4 ^a	55.1	-2.728	0.0001*	-4.127-(-1.328)	203 (21.5)	54.1 ^a	54.6	-2.994	0.0016*	-4.854-(-1.344)
Missing	91 (5.7)	53.9	53.2	-3.220	0.0211*	-5.956-(-0.485)	57 (6.0)	53.8	52.6	-3.331	0.0549	-6.732-0.070

Dinner (ref=Home)	1400 (88.2)	56.6	56.5		0.0416*			831 (88.1)	56.5	56.5		0.2463	
School/Other	123 (7.8)	55.4	54.4	-1.102	0.3138	-3.247-1.043		75 (8.0)	55.1	53.2	-1.428	0.3163	-4.224-1.368
Missing	64 (4.0)	52.5 ^a	52.3	-4.057	0.0182*	-7.423-(-0.690)		37 (3.9)	53.4	52.6	-3.114	0.1638	-7.500-1.272
Self-reported Health (ref=VG/Excellent)	910 (57.3)	58.5	58.3		<0.0001*			535 (56.7)	58.6	58.4		<0.0001*	
Fair/Poor	591 (37.2)	53.4 ^a	53.5	-5.103	<0.0001*	-6.277-(-3.929)		359 (38.1)	53.3 ^a	53.2	-5.357	<0.0001*	-6.896-(-3.819)
Missing	86 (5.4)	53.7 ^a	51.5	-4.810	0.0006*	-7.552-(-2.068)		49 (5.2)	54.3 ^a	51.9	-4.320	0.0199*	-7.954-(-0.686)
Body Max Index (ref=Healthy weight)	895 (56.4)	57.3	56.8		0.0006*			550 (58.3)	57.1	56.6		0.0420*	
Overweight ^b	310 (19.5)	54.3 ^a	54.0	-2.954	<0.0001*	-4.425-(-1.484)		187 (11.8)	54.4 ^a	54.7 ^a	-2.735	0.0054*	-4.661-(-0.808)
Underweight	37 (2.3)	56.0	57.1	-1.279	0.5006	-5.002-2.444		16 (1.7)	56.1	58.1	-1.063	0.7130	-6.733-4.607
Missing	345 (21.7)	55.5	55.6	-1.817	0.0215*	-3.366-(-0.268)		190 (20.1)	55.7	56.0	-1.402	0.1913	-3.507-0.7024
Intentional Weight Loss (ref=No)	1130 (71.2)	57.1	56.7		0.0005*			676 (71.7)	56.9	56.6		0.0689	
Yes	415 (26.1)	54.5 ^a	54.4	-2.541	0.0002*	-3.858-(-1.223)		240 (25.5)	54.8	54.6 ^a	-2.051	0.0220*	-3.806-(-0.297)
Missing	42 (2.6)	54.4	55.6	-2.676	0.1691	-6.492-1.140		27 (2.9)	55.6	56.9	-1.321	0.5934	-6.172-3.532
Intentional Weight Gain (ref=No)	1264 (79.6)	56.2	56.2		0.3695			751 (79.6)	56.2	56.4		0.8462	
Yes	266 (16.8)	57.1	56.8	0.862	0.2779	-0.696-2.420		158 (16.8)	56.8	56.2	0.586	0.5764	-1.472-2.645
Missing	57 (3.6)	54.9	55.2	-1.387	0.4157	-4.728-1.955		34 (3.6)	56.0	55.7	-0.224	0.9191	-4.548-4.100
Adequate Sleep for Age (ref=Yes)	831 (88.1)	57.3	57.9		0.0029*			491 (52.1)	57.4	57.0		0.0091*	
No	715 (45.1)	55.3 ^a	55.3	-2.028	0.0006*	-3.190-(-0.8663)		425 (45.1)	55.0 ^a	55.1	-2.391	0.0023*	-3.926-(-0.8567)
Missing	41 (2.6)	56.5	57.9	-0.750	0.7100	-4.706-3.206		27 (2.9)	57.1	59.4	-0.360	0.8846	-5.233-4.512

*p-value ≤ 0.05 : general linear model

^asignificantly different from reference group

^bcategory includes overweight/obese participants

Social Determinants of Health, Mental Health, and Diet Quality

Diet quality increased with neighbourhood income quintile, ranging from a mean HEI-C score of 55.3 in the lowest quintile (Q1) to 57.4 in the highest (Q5). However, this difference was not statistically significant (Table 6-4). No differences were found based on living in social housing or residential mobility. However, among PHIN subsample participants, receiving income assistance—either in the five years prior to or at the time of the study—was correlated with a lower diet quality score (HEI-C 52.0 vs 56.7). A notable discrepancy also existed between diet quality scores for participants with a confirmed mood or anxiety disorder (HEI-C 49.9) compared to those without a diagnosis (HEI-C 56.6).

Table 6-4. Social determinants of health, mental health, and diet quality

Variable	n (%)	Mean HEI-C ¹	Median HEI-C	Estimate	p-Value	95% CL
Income Quintile					0.3493	
(ref=Q5 -high)	249 (26.4)	57.4	56.8			
Q1	161 (17.1)	55.3	54.9	-2.080	0.0870	-4.464-0.303
Q2	184 (19.5)	55.4	55.2	-1.980	0.0862	-4.242-0.282
Q3	167 (17.7)	56.4	56.4	-0.926	0.4319	-3.238-1.386
Q4	182 (19.3)	56.7	56.5	-0.680	0.5549	-2.938-1.579
Received Income Assistance (ref=never)	867 (91.9)	56.7	56.5			
Currently/over last 5 years	76 (8.1)	52.0 ^a	50.5	-4.693	0.0013*	-7.547-(-1.838)
Ever Lived in Social Housing (ref=No)	916 (97.1)	56.3	56.2			
Yes	27 (2.9)	57.6	60.3	1.337	0.5880	3.505-6.179
Residential Mobility (moved ≥3 times in 10 years prior to survey (ref=No))	685 (72.6)	56.3	56.3			
Yes	258 (27.4)	56.5	56.1	0.255	0.7701	-1.455-1.964
Mood or Anxiety Disorder (ref=No)	906 (96.1)	56.6 ^a	56.3			
Yes	37 (3.9)	49.9	49.3	-6.681	0.0008*	-10.579-(-2.783)

*p-value ≤0.05: general linear model

¹Healthy eating index- Canada

^asignificantly different from reference group

Adjusted General Linear Model

[Figure 6.1](#) shows results from the adjusted GLM examining the relationship between select study covariates and the diet quality (HEI-C score) of participants.

Females had a higher diet quality score compared to males (+3.4 points, 95% CL: 1.84-4.86). Living in a northern community was associated with a lower HEI-C compared to urban residents (-3.2 points, 95% CL: -5.91 to -0.52), while no difference was noted between rural and urban dwelling participants.

Food security status was not independently associated with diet quality in the adjusted model. However, eating breakfast or lunch fewer than 5 days per week was associated with poorer HEI-C scores. Family dinner frequency was no longer significant in the adjusted model. Eating lunch at home (versus at school or elsewhere) was associated with a 2.3-point decrease in HEI-C score (95% CL: -4.10 to -0.49, and the missing category for breakfast location was associated with a 4.7-point lower score (95% CL: -7.75 to -1.72).

Positive self-rated health was associated with a better diet quality score in both the unadjusted and adjusted models. Participants reporting fair/poor health scored 4.0 points lower compared to those reporting very good/excellent (95% CL: -5.59 to -2.36). Similarly, a diagnosed mood or anxiety disorder was associated with a 4.2-point deficit (95%CL: -7.96 to -0.41).

Finally, receiving income assistance (at the time of the study or previous five years) was associated with a 3.5-point decrease in HEI-C score (95% CL: -5.69 to -2.36).

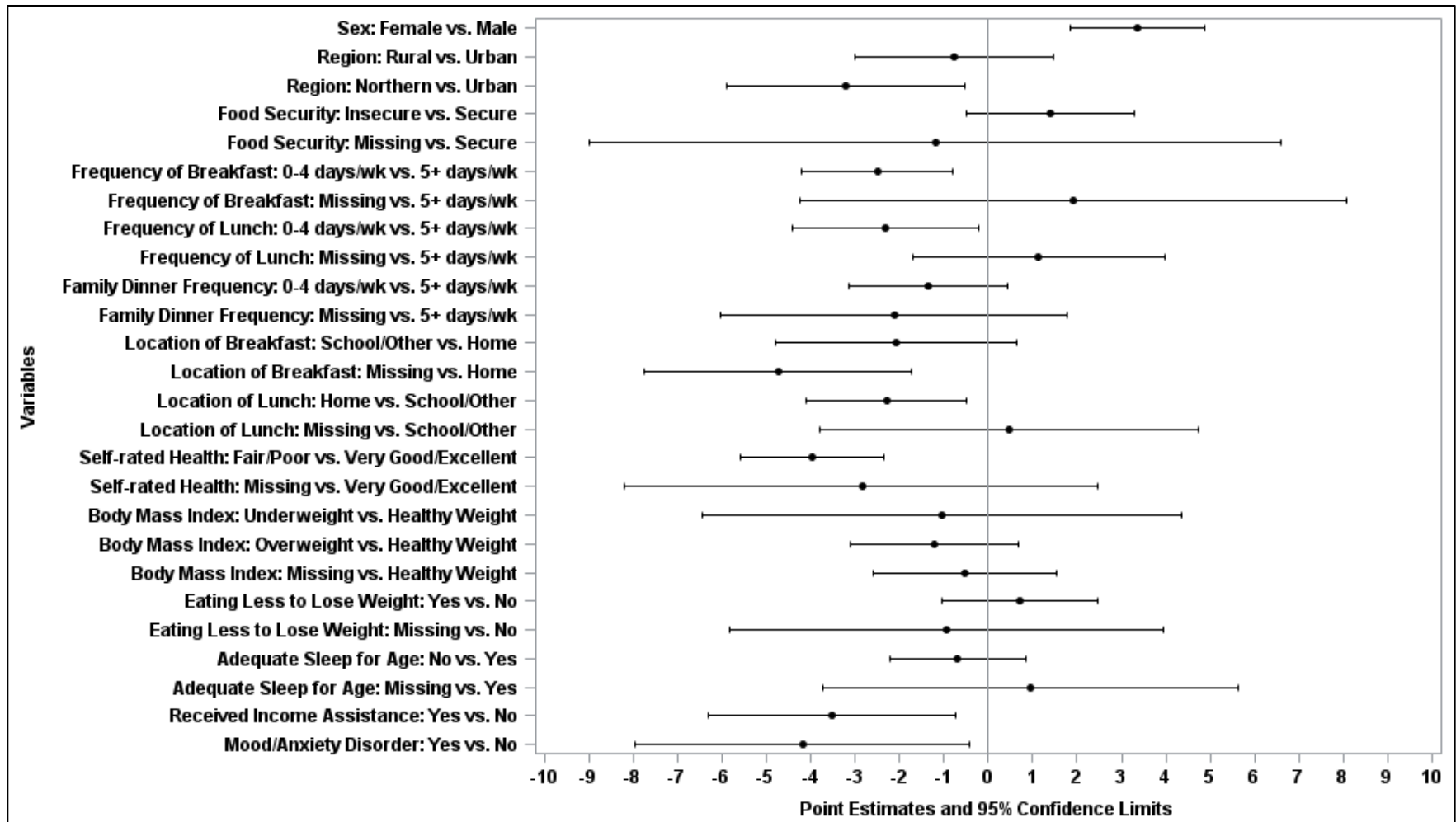


Figure 6.1: Adjusted General Linear Model for Diet Quality. Adjusted general linear model depicting point estimates and 95% confidence limits for the outcome HEI-C score (n=872). Being female compared to male was the only variable positively associated with a higher HEI-C score. Living in a northern community compared to urban, eating breakfast and lunch less than five days a week, eating lunch at home compared to school or elsewhere, reporting health as fair or poor compared to very good or excellent, receiving income assistance, and having a diagnosed mood or anxiety disorder were variables negatively associated with students' HEI-C scores. For breakfast location, the missing category also demonstrated a lower HEI-C score compared to eating at home.

Discussion

As part of the *FANS* study—the most comprehensive review of dietary intake of Manitoba youth to date—this study examined associations between the diet quality (measured by the HEI-C), food security status, demographic characteristics, and eating and health-related behaviours.

Findings revealed an independent association between geographic location and participants' diets, with youth living in northern Manitoba reporting a lower HEI-C score. Likewise, being male, reporting lower self-rated health, and having a diagnosed mental health condition were also associated with poorer diet quality. While income quintile was not associated with diet in either the unadjusted or adjusted models, receipt of income assistance may indicate nutritional vulnerability. Dietary behaviours, including breakfast and lunch frequency, and lunch location, were associated with differences in diet quality. However, after model adjustment, food insecurity, family meal frequency and location, BMI, sleep habits, and intentional weight behaviours were variables no longer associated with diet quality.

Overall Diet Quality

Details of nutrients and food group intake for the entire *FANS* cohort by sex and region have been published elsewhere (Slater et al., 2024, 2022, 2023). This study adds to the growing body of literature, showing that Canadian and Manitoba youth continue to fall short of national nutrition guidelines (Garriguet, 2009; Hack et al., 2021; Slater & Colatruglio, 2016; Slater et al., 2024; Wadsworth et al., 2012). The mean HEI-C score was 55.4 for boys and 57.2 for girls, which corroborates other Canadian literature utilizing diet quality indices (Garriguet, 2009; Government of Canada, 2018c; Panahimoghdam et al., 2025), as well as findings from the 2004 and 2015 CCHS-Nutrition (Garriguet, 2009; Hack et al., 2021). Although a modified version of

the HEI-C (2010) (Woodruff & Hanning, 2010) tool was used in this study to reflect changes to national guidelines, both are based on Canada's Food Guide (2007) (Katamay et al., 2007).

The persistence of suboptimal diet quality, alongside 20% of participants who were overweight or obese, reinforces the longstanding concerns about the dietary trajectories of Canadian youth. A BMI classifying students as overweight or obese was associated with lower HEI-C score among total FANS participants compared to those with a BMI that is considered healthy (Slater et al., 2024). Given Manitoba's elevated risk of type 2 diabetes in children (Sellers et al., 2024), these findings highlight the gravity of childhood obesity risk (Statistics Canada, 2015) and point to a critical need for more effective nutrition interventions.

Geographic and Socioeconomic Disparities

Diet quality varied significantly by region, with participants from northern Manitoba scoring lower on the diet quality metrics compared to their urban peers. Previously published FANS results provide greater detail, showing that median sugar, sodium, and saturated fat intakes were significantly higher among northern participants compared to urban participants, consistent with greater consumption of 'Other' foods not aligned with Canada's Food Guide (Slater et al., 2024). These findings are consistent with previous literature indicating that nutritious diets are more expensive (Bai et al., 2021; Bukambu et al., 2020; FAO et al., 2020) and that food costs are substantially higher in northern and remote areas of Canada (de Souza et al., 2018; Mah et al., 2019; Wendimu et al., 2018), thereby increasing vulnerability to food insecurity (Kirkpatrick & Tarasuk, 2008; Wendimu et al., 2018).

While income quintile was not associated with diet quality, income assistance was independently associated with lower HEI-C scores, suggesting that diets may be compromised as a direct result of severe financial deprivation, rather than relative income ranking alone.

Although food insecurity, a marker of economic deprivation (Li et al., 2023), was associated with a lower HEI-C score in the bivariate analysis, this association did not hold constant in the adjusted regression model – possibly due to the overall homogeneity of poor diet quality data across the sample. These findings suggest that poor nutrition affects not only those who are food insecure. Policies should address overall diet quality, while also targeting the more profound structural and economic inequities that can undermine nutrition, as exposure to socioeconomic vulnerabilities in childhood often persists into adulthood (Faught et al., 2019).

Eating Behaviours

Eating behaviours played a role in diet quality. More frequent consumption of breakfast and lunch was independently associated with higher diet quality scores in the adjusted GLM. Importantly, this was not simply related to higher calorie intake, as earlier FANS data show that students with higher energy intakes were obtaining additional calories from less nutritious sources (Slater et al., 2022).

While family dinner frequency was positively associated with diet quality in the unadjusted model, the association was not significant following covariate adjustment. This may reflect shifts in Canadian trends in meal preparation and consumption. With more adolescents eating meals on the go, which are often higher in nutrients of concern such as salt, saturated fat, and refined sugar (Black & Billette, 2015; Ziauddeen et al., 2018), the protective effects associated with family meals, such as lower rates of obesity and disordered eating and increased self-efficacy for healthy eating (Government of Canada, 2010, 2022b; Hammons & Fiese, 2011; Weikle, 2024; Woodruff & Hanning, 2008, 2009a) are diminished.

Interestingly, eating lunch at school or elsewhere (versus home) was associated with a better diet. This may suggest a positive role for school environments in shaping eating

behaviours; unfortunately, school involvement in provincially or privately funded meal and snack programs was not collected. This limits the ability to assess the impact of school nutrition initiatives and their potential to moderate nutrition-related outcomes (Colley et al., 2019).

Student behavioural factors may also confound this relationship, as students with behavioural issues may be required to eat lunch at home.

Health and Diet

One of the most notable discrepancies in diet quality scores was the lower HEI-C scores among participants with a diagnosed mood or anxiety disorder. Despite the small number of cases captured using administrative data, which only reflects those with a clinical diagnosis, the association remained significant in the adjusted model.

There may be many explanations for this relationship. Youth with mental health conditions are more likely to come from families experiencing socioeconomic disadvantage (King et al., 2021), which can constrain access to nutritious food. Food insecurity in itself is a known stressor that may exacerbate mental health and compromise dietary intake and quality, particularly at more severe levels (Davison & Kaplan, 2012; Mark, Lambert, Loughlin, et al., 2012; Men, Elgar, et al., 2021b). Additionally, adolescence is a time of increased body dissatisfaction often related to changes in physical appearance associated with puberty and augmented pressure to follow social norms amidst the rise in social media use (e.g., Tik Tok, Instagram, and Snapchat) (Vuong et al., 2021). Body dissatisfaction has been shown to be related to depression and body modification behaviours in boys (e.g., eating to bulk) and girls (e.g., moderating intake to lose weight) (Dzielska et al., 2020; Nagata et al., 2019; Paxton et al., 2006), which may explain the observed correlation between participants who reported intentionally reducing food intake to lose weight and a lower diet quality score in the bivariate analysis.

Poor self-rated health was also independently related to lower diet quality in the adjusted model, which may reflect poor self-image or body dissatisfaction. While BMI was not associated with diet quality in the adjusted model, being overweight or obese was associated with lower diet quality in unadjusted analyses. The relationship between diet, body image, and mental health is complex and may involve directional relationships that were not explored in this study; further research is warranted to disentangle these suspected associations.

Strengths & Limitations

This study used two validated, age-appropriate tools – the CFSSM to assess individual food security status and the WEB-Q to capture detailed dietary intake data. Construct validity was increased by asking participants directly about their food security experiences instead of relying on parents or guardians as proxies. Administered to a large and diverse sample of Grade 9 students, the WEB-Q allowed for efficient and precise estimation of diet quality using the HEI-C, an index suited for population-level monitoring and policy assessment.

Using administrative data for health and social variables added depth by linking the FANS survey with objective indicators like income support and diagnosed mental health conditions. However, this study is not without limitations. The cross-sectional design restricts causal inference, and unobserved confounding cannot be fully eliminated. Additionally, the narrow age range of participants introduces selection bias and limits how well the results apply to the broader youth population in Manitoba. Likewise, school division participation was voluntary, and parental consent was necessary for data linking, which introduces volunteer bias and the potential to underestimate the true prevalence of food insecurity as food insecure households may already feel stigmatized, preventing their desire to participate. These shortcomings threaten external validity and further limit the generalizability of study findings.

Administrative data, while valuable, are not collected specifically for research purposes. This restricts their use for answering specific research questions and makes them prone to inherent biases. For instance, vulnerable populations and individuals affected by health inequities may be less likely to access care and, therefore, might be underrepresented in the data. Mental health data only reflect diagnosed cases, which may underestimate the true prevalence. Additionally, administrative data are subject to coding errors, which can affect the accuracy of the measured phenomenon. Likewise, self-reported height and weight to establish BMI – a variable criticized for being subject to recall bias (Shields et al., 2011) – may have underestimated the true prevalence of overweight and obesity as compared to national statistics for this age group from the reporting period (Government of Canada, 2018d). This may explain why the association between BMI and diet quality was not maintained in the adjusted GLM.

Dietary data were based on a 24-hour diet recall and food frequency questionnaire, which are subject to recall and social desirability bias and pose threats to their validity. However, visual cues and prompts from the WEB-Q and use of established cut-offs for over- and under-reporters (Hanning et al., 2007; Woodruff et al., 2014) lessened bias and increased the accuracy of nutrient analysis and content validity. The small effect sizes observed between HEI-C scores and multiple eating behaviours suggest future research is warranted to better understand these relationships and may consider more specific questions. For example, location of meals should be sub-categorized further, as ‘home’ vs ‘school/other’ do not provide insight into restaurant meals or food purchased from convenience stores, which tend to offer provisions lower in nutritional value. This nuance may result in a larger effect size between locations.

Finally, the study was unable to assess participation in school meal or snack programs. This limited the ability to measure any confounding, mediating, or moderating effects between

independent variables, nutrition programming, and diet quality scores. Given the recent rollout of Canada's universal school meal program, there is an opportunity to include routine nutrition surveillance through measures like the WEB-Q in the school system to assess program impact.

Conclusion

Poor nutrition remains a significant public health concern for youth in Manitoba and across Canada. This study adds to the growing body of evidence indicating that many young people, regardless of food security status, are not meeting dietary recommendations. These findings underscore the need for policies to go beyond improving food access. Comprehensive, inclusive, and equitable strategies that consider geographic, financial, and behavioural determinants are necessary to support access to high quality diets and ensure the best health outcomes for all youth.

Youth living in northern communities and those with mental health conditions are particularly vulnerable, highlighting the need for targeted strategies embedded in a universal program. Future research should incorporate questions related to eating disorders, which are not currently captured in Manitoba's administrative health data.

Economic hardship continues to compromise nutrition security for many families. Rising inflation and grocery prices are quickly outpacing existing social safety nets, necessitating immediate policy responses by both the provincial and federal governments. Canada's commitment to a National School Food Program (Government of Canada, 2024) presents an opportunity to remove barriers to food access and prioritize nutrition as a foundation for long-term health and educational success.

To realize the full potential of such programs, a comprehensive understanding of youth's dietary habits and structural factors affecting them is essential. Program success will require

ongoing collaboration across diverse sectors, including governments, school divisions, dietitians, agricultural producers, and community organizations. Key considerations should include sufficient staff hiring and training, culturally relevant and nutritionally adequate menu planning, integrated curriculum, and ongoing monitoring to ensure food programs are effective and sustainable.

CHAPTER 7: GENERAL DISCUSSION

As part of the *FANS* study—the most comprehensive review of dietary intake of Manitoba youth to date – this dissertation is the first Manitoba-specific study to examine the intersecting public health issues of food and nutrition security using primary data linked with routinely collected health, social, and education records. The overarching aim of this work was to generate evidence to support equitable food and nutrition policies and programs.

Research Objectives

This dissertation aimed to:

1. Establish current and comprehensive baseline data on the food and nutrition security status of Grade 9 youth in Manitoba.
2. Describe patterns of food insecurity among Manitoba youth
3. Examine associations with nutrition-related behaviours (i.e., meal location, eating frequency, dietary choices) and key social determinants of health (i.e., income quintile, income assistance, social housing, and residential mobility) that are linked to increasing rates of food insecurity in Manitoba.
4. Assess the impact of food insecurity, nutrition-related behaviours, social determinants of health, and mental health on academic achievement.
5. Identify social and economic factors influencing nutrition security to inform school food and nutrition policy reform.

Study Highlights

Key findings from this research include:

- Food insecurity affected 1 in 5 participants, with geographic location and income deprivation emerging as vulnerabilities across all outcomes – food security, academic achievement, and diet quality.
- Lunch frequency was positively associated with all outcomes, reinforcing the essential role of schools in both nutrition and education.
- While most participants were found to have suboptimal diets, food insecurity was not independently associated with diet quality in adjusted models, suggesting that nutrition insecurity may be widespread regardless of food security status.
- Food insecurity was, however, negatively associated with participants’ academic achievement.
- Sex differences emerged in diet quality only, with girls scoring higher on the HEI-C compared to boys.
- Diagnosed mental health conditions were negatively associated with diet quality, highlighting the intersection of nutrition and mental well-being.

Dissertation Structure

The primary outcomes of this research are addressed through three stand-alone manuscripts:

- Chapter 4 contains the first manuscript addressing in part Objectives 1-3 by examining the individual experiences of food insecurity using a validated, child-specific tool.
- Chapter 5 contains manuscript two and examines the impact of food and nutrition-related factors on academic achievement, answering Objective 4. It builds on earlier research that utilized routinely collected data in Manitoba to link childhood vulnerabilities to educational outcomes.

- Chapter 6 revisits Objective 1 and addresses Objective 5 by filling key nutrition surveillance gaps in Manitoba. It also analyzes how food insecurity, health-related variables, and socioeconomic factors linked with the outcomes in the previous two chapters influence nutrition security.

Patterns of Food Insecurity and Associations with Nutrition and Social Determinants of Health

This section addresses Objectives 1 and 2 by describing the patterns of food insecurity among Grade 9 youth in Manitoba and examining associations with nutrition-related behaviours and key social determinants of health. Drawing on data collected through the FANS survey and linked administrative health and social records, this research offers insights into youth-specific food insecurity, an area with limited empirical data in Manitoba and Canada.

Prevalence and General Patterns

Despite methodological differences from national surveys, the current study found that 1 in 5 youth (20%) experienced food insecurity, a rate comparable with national and provincial child/adolescent estimates of household food insecurity during the same reporting period (Liu et al., 2023; Tarasuk & Mitchell, 2020). This finding confirms that food insecurity remains a persistent issue among Manitoba youth. The use of the CFSSM captured first-hand experiences of food insecurity, enriching the understanding of the issue, which may be underrepresented in household-level assessments.

Geographic Disparities of Food Insecurity

Geographic region emerged as a key determinant of food insecurity for study participants. Associations indicate that youth in northern Manitoba are more likely to experience food insecurity compared to their peers from an urban centre, echoing findings from previous

food-costing studies in the province and regular reports from PROOF (Li et al., 2023; Wendimu et al., 2018). Additional barriers to achieving food security in northern communities include the limited access to affordable, nutritious food, poor infrastructure, supply chain disruptions, and inadequate subsidy programs (Galloway, 2017; Kenny et al., 2018; Veeraraghavan et al., 2016; Wendimu et al., 2018). A 2018 food availability and costing report of Manitoba's northern communities showed that staples such as milk, fresh produce, and meat were nearly double in price compared to the southern capital of Winnipeg (Wendimu et al., 2018).

Although results were not separated by ethnicity or Indigenous identity for this study, a greater proportion of northern residents are Indigenous, and Indigenous households are known to face food insecurity and health disparities at disproportionate rates (Chartier et al., 2020; Shafiee et al., 2022; Tarasuk & Mitchell, 2020). Métis-specific data illustrating differences in food security status compared to the total FANS cohort have been published by Indigenous partners (Perchotte et al., 2025).

Interestingly, rural living appeared protective against food insecurity, with youth from rural communities reporting higher food security compared to those from Winnipeg. This relationship may be explained by more affordable housing and steady employment growth in rural areas of the province (Ashton et al., 2015; Kelly et al., 2021). Rural residents are therefore more likely to own their home and pay less for housing costs, which have been positively associated with being food secure (Li et al., 2023; Statistics Canada, 2025b). Research from the United States has identified stronger social networks among rural community members and increased access to emergency food resources (Bowen et al., 2022; Gundersen et al., 2017), which may offer an explanation for this counterintuitive finding. A deeper investigation, which

incorporate qualitative research methods is needed to fully understand the rural-urban dynamics related to food access and affordability in Manitoba.

Income and Economic Vulnerability

Consistent with the literature, food insecurity was closely tied to markers of material deprivation (Food Matters Manitoba, 2020; Li et al., 2023). In the adjusted model, participants living in the two highest neighbourhood income quintiles were more likely to be food secure compared to those from the lowest quintile. This supports the long-standing evidence of a negative economic gradient with food insecurity (Dietitians of Canada, 2024; Li et al., 2023; Tarasuk et al., 2021; Tarasuk & Mitchell, 2020).

Interestingly, other key socioeconomic variables, such as income assistance, social housing, and residential mobility—a variable often related to renting accommodations—were no longer significant in the adjusted model. This was unexpected as these are known factors to increase the susceptibility of food insecurity (Food Matters Manitoba, 2020; Li et al., 2023). Differences in how food insecurity was assessed (individual-level vs household-level) may have contributed to a deviation from common findings from the literature that align with outcomes from the bivariate analysis. Since food insecurity research in Canada mainly relies on secondary data sources like the CCHS or CIS, replicating the analysis with current methods would help clarify the study findings. Additionally, the impact of public policies such as the Canada Child Benefit, which may influence income-related relationships, was not examined (Brown & Tarasuk, 2019) and should be explored in future research. It is also recommended to include the severity of food insecurity when reviewing social policies. A recent analysis of the Young Child Supplement introduced in 2021 as a supplement to the Canada Child Benefit showed only a modest reduction in household food insecurity and was insufficient to support those most

severely affected (Men, Fafard St-Germain, Ross, Remtulla, & Tarasuk, 2023). Subclassification of food insecurity was not possible due to the sample size of this study, nor were the research objectives aimed at evaluating the effectiveness of existing public policies.

Furthermore, studies incorporating residential mobility should also investigate, a family's reason for moving (e.g., change in employment) and their destination (e.g., shared accommodations, living independently as a family unit, or to a community with increased supports), which would provide additional context to the relationship between these two variables. For example, positive transitions such as to a home with a larger adult membership or family moves for a job promotion may in fact establish a positive or null relationship between residential mobility and food insecurity.

Eating Behaviours and Diet Quality by Food Security Status

Food insecurity was associated with lower frequencies of lunch and family dinners, both of which were independently associated with improved food security in the adjusted logistic regression model. While breakfast consumption also differed by food secure status in bivariate analyses, this relationship did not persist after model adjustment. Notably, 39% of participants reported eating breakfast fewer than five days per week, compared to 19% for lunch and 24% for family dinner, consistent with other research showing that skipping breakfast is a common practice among adolescents (Lillico et al., 2014).

The independent association between greater family dinner frequency and food security alludes to a social nuance of food security research. Family meals have been considered protective against hunger and correlated with improved family communication in a Canadian study (Pickett et al., 2015). This relationship may also be influenced by shielding, a phenomenon in food-insecure households, whereby parents and older siblings will sacrifice meals for younger

family members (Baer et al., 2015; Ovenell, Da Silva, & Elgar, 2022). Future studies should consider incorporating qualitative methods to understand better the underlying factors influencing this relationship. Furthermore, the role of school meal programs, which may have a confounding or moderating role in the association with lunch frequency and food security, could not be assessed due to data limitations, but food security surveys should be included as an evaluation component of Canada's national school food program.

In contrast to expectations and previous research (Kirkpatrick & Tarasuk, 2008; Mark, Lambert, O'Loughlin, et al., 2012), diet quality (HEI-C) was not associated with food insecurity in the adjusted model. Over 90% of participants had HEI-C scores below 80, classifying them in the 'needs improvement' category, regardless of food security status. Although a significant association was observed in unadjusted analyses (mean HEI-C score of 55.0 for food-insecure vs. 56.7 for food-secure), this difference was not large enough to change participants' categorical diet quality rating. These findings suggest that poor nutrition is a widespread issue, not limited to food-insecure youth. Therefore, the narrative and public health messaging around food insecurity and diet should make certain that policies target both food insecurity and improved nutritional quality. Focusing solely on food insecurity will not be enough to improve population diets – contributors to chronic diseases and rising healthcare costs (Afshin et al., 2019b; Loewen et al., 2019).

Health Outcomes Associated with Food Insecurity

Food insecurity was associated with poorer self-reported health, a finding consistent with an earlier longitudinal study of Canadian children and youth using the same health measurement scale (Kirkpatrick et al., 2010). More than half of food-insecure participants rated their health as fair or poor, compared to just over one-third of food-secure youth. This trend

highlights the broader health implications of food insecurity and aligns with research linking it to chronic conditions later in life (Leung et al., 2020). The development of chronic conditions such as obesity and Type 2 diabetes has been theorized in the literature to result from the perpetual cycle of food insecurity, whereby households tend to be reliant on inexpensive, energy-dense foods in addition to food scarcity, leading to rapid weight gain (Laraia, 2013). Secondly, the stress associated with food insecurity could influence visceral fat accumulation through increased release of cortisol and neuropeptide Y, stimulating the desire to consume more energy-dense foods and alter metabolism, leading to subsequent disease development (Adam & Epel, 2007; Groesz et al., 2012).

While no significant relationship between BMI and food insecurity was found in this study, mirroring national survey analyses using propensity score weighting, suggesting no independent relationship between the two variables (Fafard St-Germain, Hutchinson, & Tarasuk, 2024), a higher proportion of food-insecure participants fell into the overweight or obese category. Irrespective of a correlation with food insecurity, the prevalence of overweight/obesity for this cohort was similar to national reports (Government of Canada, 2018d) and contributes to the current belief that elevated BMI remains a public health concern.

A novel and important observation was that food-insecure participants were more likely to report wanting to gain weight, potentially indicating concerns or risk of disordered eating, including binge-eating disorder, which has recently been associated with food insecurity in adolescents (Nagata et al., 2023), an area of research requiring further investigation.

While food insecurity has been associated with diagnosed mood and anxiety disorders in Canadian youth (Men, Elgar, et al., 2021b), this study did not find a significant association, possibly due to the low prevalence of a diagnosed condition (4%) and the use of administrative

data that only captures a clinical diagnosis. It should be noted, however, that 6% of youth with a mental health condition were food insecure, compared to 3.5% who were food secure. It is possible that if subclinical measures of mental health or self-reported data were included, a relationship would have been evident (Men, Elgar, et al., 2021b). Healthcare utilization data (e.g., physician visits), while included as part of the mental health measure in administrative data (Anderson et al., 2023b), were not analyzed as a separate component of the food insecurity context but could be considered for future studies addressing policies related to mental health service access and food insecurity.

The Impact of Food Insecurity, Nutrition, Socioeconomics, and Mental Health on Academic Achievement

This section addresses Objective 4 by evaluating how food insecurity, diet quality, eating behaviours, socioeconomics, and mental health are associated with academic achievement among Grade 9 youth in Manitoba. Academic performance was measured based on students' achievement of eight or more course credits required by the end of the academic year, a validated predictor of high school completion.

Food Insecurity and Academic Achievement

The present study identified an independent association between food insecurity and academic achievement. Specifically, food-insecure participants were less likely to meet the required number of Grade 9 course credits by almost two-thirds, even after controlling for covariates. This finding aligns with existing research from high-income countries (Alaimo et al., 2001; Faught et al., 2017; Jyoti et al., 2005; Shankar et al., 2017), however, contributes new evidence from the Manitoba context, demonstrating this relationship using a child-specific tool, linked with administrative records. Future studies may consider modeling academic achievement

as a continuous variable to allow for a more sensitive measure of this relationship and better capture gradients of risk. In this way, it may be reasonable to hypothesize a larger effect size among students who are farther from reaching the minimum credit requirements, rather than a continuous improvement across the linear scale of academic achievement, as there is likely to be a ceiling effect of food security.

Nevertheless, this finding is particularly important given the persistence of food insecurity in Manitoba coupled with declining adolescent literacy and numeracy skills (Government of Canada, n.d.), and it contributes to the limited Canadian literature examining associations between food insecurity and academic performance among children and adolescents (Cumiskey, 2023; Faught et al., 2017). Although food insecurity was independently associated with academic achievement, this relationship does not necessarily appear to be related to, or explained by, overall diet quality in this cohort. Rather, food insecurity may influence academic outcomes through psychosocial pathways, such as stress and anxiety, which adolescents may experience more directly than younger children who are shielded by parents or older siblings (Baer et al., 2015; Ovenell et al., 2022), potentially affecting their ability to focus at school.

Diet Quality, Eating Behaviours, and Academic Achievement

Contrary to much of the literature linking healthful diets and improved cognitive performance (Florence et al., 2008; Northstone et al., 2012; Nyaradi et al., 2014), this study found no independent association between overall diet quality (HEI-C) and academic achievement. While students who met their academic requirements did have a higher mean HEI-C score (56/100) compared to those who did not (52/100), and despite a positive relationship between the two variables in the bivariate analysis, this difference was not significant in the adjusted regression model.

Several factors may explain this divergence from previous findings. Academic achievement was assessed using credits attained rather than specific cognitive or educational competencies (Florence et al., 2008) or intelligence quotient (Northstone et al., 2012). Dietary assessment tools also vary across studies; however, efforts were made to contextualize the current findings within literature that utilized whole-food dietary measures such as food frequency questionnaires (Northstone et al., 2012; Nyaradi et al., 2014) and diet quality indices (Florence et al., 2008). Additional methodological differences such as younger study populations (Florence et al., 2008; Northstone et al., 2012), parent-reported dietary data (Northstone et al., 2012), longitudinal designs (Nyaradi et al., 2014), and country-specific contexts (Northstone et al., 2012; Nyaradi et al., 2014) may further account for this discordance. Finally, the addition of food security status as a covariate may have attenuated the association between diet quality and academic achievement due to conceptual overlap. Future research should continue to examine these relationships in the Manitoba context.

Lunch frequency was the only eating behaviour found to be associated with academic achievement in the bivariate analyses and the adjusted model. Eating lunch at least five times per week increased the likelihood of meeting sufficient course credits. This finding is difficult to contextualize within the present research landscape, which focuses on hunger (Alaimo et al., 2001), malnutrition (Zerga, Tadesse, Ayele, & Ayele, 2022), food groups or dietary patterns (Florence et al., 2008; Nyaradi et al., 2014), and breakfast consumption (Widenhorn-Müller, Hille, Klenk, & Weiland, 2008) in relation to academic performance and cognition. It is argued that well-fed children perform better at school (Coalition for Healthy School Food, n.d.); therefore, this finding should support advocacy efforts for sustained school food programming that aligns with national eating guidelines. The absence of data on school participation in meal

and snack programs (which could act as a confounder or moderator) limits the interpretation of these findings. Given the emerging evidence linking free lunch provision to improved academic performance (Cohen, Hecht, Mcloughlin, Turner, & Schwartz, 2021), coupled with Canada's newly implemented school meal program, evaluation criteria must include educational outcomes.

Sex, Socioeconomic, and Geographic Associations with Academic Achievement

Sex differences were not observed in either the bivariate analysis or when controlling for other factors in the regression model. It is possible that sex differences similar to those found in other Canadian studies (Faught et al., 2017; Government of Canada, n.d.) might have been seen if literacy and numeracy markers had been assessed separately.

While no sex differences were observed, region and socioeconomic factors played a key role in educational outcomes. Despite income quintile alone not showing an association, families receiving income assistance and those living outside an urban centre were less likely to meet their academic achievement marker. These findings support existing literature highlighting the impact of familial SES and geographic differences on academic success (PROOF, 2024).

Notably, both rural and northern Manitoba participants were less likely to meet their course credit requirements. Given the higher rates of food insecurity in northern regions (Li et al., 2023) and the established relationship between food insecurity and academics, this was expected. Chronic distress related to food insecurity and socioeconomic hardship can distract from school work and impair long-term academic engagement (Men et al., 2021). The associated risk of chronic stress should be considered in future studies. Since rural living was protective against food insecurity in this study population, alternative explanations for this relationship may include lower-quality teaching staff due to challenges with staff retention, higher operating costs, and less stable budgets due to smaller enrolments, which impose challenges to infrastructure

development and the availability of material resources in rural schools (Echazarra & Radinger, 2019).

The lack of significance observed for income quintile contrasts previous Canadian literature that found an independent association with household income and academic achievement among grade 5 and 6 students in Nova Scotia (Faught et al., 2017) and another that linked movement between low-income neighbourhoods and poorer literacy and numeracy (Cowley et al., 2022), but aligns with others showing null effects for income after adjusting for broader SES markers (Liu et al., 2022). Ongoing research should ensure a multidimensional approach to understanding the role of SES and academics, which includes variables like income assistance, social housing, and geographic region.

Mental Health and Academic Outcomes

While mood and anxiety disorders were conditions associated with poorer academic achievement in bivariate analysis, this relationship did not hold in the adjusted logistic regression model. This is notable given the rise in prevalence of mood and anxiety disorders among Canadian youth over the last decade (Statistics Canada, 2023c), now affecting approximately 1 in 4 (Centres for Addiction and Mental Health, 2022). Relative to Canadian statistics, the much smaller percentage (4%) of participants with a clinical diagnosis of a mood or anxiety disorder may have attenuated the relationship with academic achievement in the adjusted model. It is possible that if subclinical measures were included, this relationship would have prevailed.

Emerging research supports a dual-factor approach to mental health, which includes subjective wellbeing alongside psychopathology in the absence of a clinical diagnosis (King et al., 2021). Using this approach, mental health disparities have been linked to low SES and single-parent households; both of which are closely connected to food insecurity (Li et al., 2023).

Additional research by Monzonis-Carda et al. (2023) suggests a bidirectional relationship between academic performance and mental health, indicating that mental health does not predict academic potential, but rather better academic performance enhances mental health outcomes over time.

Results remain inconclusive on the topic, and current study findings imply there are limitations to relying solely on diagnostic data to understand the impacts of mental health on youth's academic outcomes. Future research should include both clinical and subclinical measures of mental health to address this knowledge gap and consider the accessibility of community mental health supports when drawing conclusions.

Social and Economic Implications and Eating Behaviours affecting Nutrition Security in Youth

The fifth main outcome assessed in this dissertation was to identify how social and economic factors, along with eating patterns, influence youth's nutrition security, to fill nutrition surveillance gaps and inform policy strategies – particularly school-based food and nutrition programs. A core component of nutrition security in this study was diet quality, assessed using the HEI-C. Overall, findings indicate that participants' diets were far from meeting national guidelines, echoing longstanding concerns in Canadian literature that adolescent dietary behaviours have shown little improvement over the past two decades (Garriguet, 2009; Hack et al., 2021).

Adolescence is a critical transitional period marked by increased autonomy over food choices. Youth are known to opt for food choices that are highly palatable but nutrient-poor, influenced by a contemporary food environment dominated by convenience, fast-food, and food delivery platforms (Doggui et al., 2021; Skalkos & Kalyva, 2023). These patterns are further

exacerbated by diminishing food and nutrition literacy skills, limited physical activity, and regional and socioeconomic discrepancies in access to healthy foods (Government of Canada, 2020; PROOF, 2024; Wendimu et al., 2018), all of which threaten long-term positive dietary trajectories and nutrition-related health outcomes.

Sex Differences in Diet Quality

Consistent with previous national studies, female participants in this study had significantly higher HEI-C scores compared to males, a difference that persisted in the adjusted GLM. This trend has been a constant narrative in Canadian literature, as assessed by the 2004 (Garriguet, 2009) and 2015 (Polsky & Garriguet, 2020) CCHS nutrition, and may relate to sex differences in food choices, including higher fruit and vegetable consumption and lower sodium intake among girls (Government of Canada, 2021c; Slater et al., 2022; Statistics Canada, 2019b). The slight variation in diet quality indices used may also be an influencing factor (Panahimoghadam et al., 2025).

Geographic and Socioeconomic Disparities in Diet Quality

The geographic and economic context had a clear impact on youth diet quality. Notably, participants living in northern communities had poorer HEI-C scores compared to those from urban centres, an association that remained in multivariable models. This aligns with evidence showing that remote and northern regions face disproportionately high food costs and reduced access to perishable, nutrient-dense foods, while being inundated with shelf stable ultra-processed foods (de Souza et al., 2018; Kenny et al., 2018; Mah et al., 2019). Although northern communities included in this study were accessible by car and had more than one grocery store, the observed diet quality disparities suggest even greater challenges would be expected in fly-in communities where food costs can be even higher (Burnett et al., 2017). The observed

differential in HEI-C scores, despite few participating northern communities, strengthens the call for improvements in northern food provisions and federal food subsidy reforms, as current mechanisms are insufficient to support nutrition equity or Indigenous food sovereignty (Fafard St. Germain, Galloway, & Tarasuk, 2019; Galloway, 2017).

In relation to socioeconomic indicators, reliance on income assistance was an indicator of poorer diet quality among participants. This aligns with previous literature illustrating the long-term effects of low SES on dietary trajectories of children (Faught et al., 2019; Garriguet, 2009; Gasser et al., 2017). This finding insinuates that social policies aimed at supporting families with young children, such as the Canada Child Benefit, are not fully effective in closing equity gaps in Manitoba.

Neighbourhood income quintile was not associated with HEI-C scores, contrary to expectations and previous findings (Minaker et al., 2016; Panahimoghadam et al., 2025). Canadian food environment research has shown compromised diets in children from materially deprived areas as a result of an increased density of less nutritious retail locations (Minaker et al., 2016; Panahimoghadam et al., 2025) with a closer proximity to schools (Díez et al., 2019; Engler-Stringer et al., 2014; Hanning et al., 2019; Ravensbergen et al., 2016). The current study's findings may suggest that, at a population level, the pervasive poor diet quality among youth overshadows income gradients, or that additional variables, such as retail food environment proximity, are more explanatory than income alone. Future studies should explicitly integrate food environment data to investigate this disconnect further.

Eating Behaviours

Skipping meals has been linked to lower diet quality in adolescents (Doggui et al., 2021); therefore, it was no surprise that participants who ate breakfast and lunch more often had higher

HEI-C scores. Earlier published FANS results on calorie distribution confirm that this relationship is not simply due to consuming more calories (Slater et al., 2022). Notably, eating lunch outside of the home, including at school, was associated with better diet quality in the adjusted GLM. While this cannot be definitively attributed to school food programs due to data limitations, it indicates potential protective effects of structured meal environments and reinforces the possibility that school-based food interventions have in improving dietary behaviours and nutrition knowledge (Colley et al., 2019; Hoyer et al., 2025).

Interestingly, no association was found between family meals and diet quality. While previous literature has linked regular family meals to healthier diets (do Amaral e Melo et al., 2020), greater self-efficacy for healthy eating (Woodruff & Hanning, 2009a) and lower rates of disordered eating and obesity (Hammons & Fiese, 2011; Woodruff & Hanning, 2008), temporal changes in eating habits and increased meals outside of the home (Black & Billette, 2015; Ziauddeen et al., 2018) may explain this null effect. This shift in food culture must be accounted for in future policy directives.

Physical and Mental Health Factors

Although long-term health outcomes of diet are difficult to assess in youth, the high proportion of participants with inadequate diets suggests heightened risk for chronic diseases such as Type 2 diabetes and cardiovascular disease later in life (Afshin et al., 2019a). Based on self-reported height and weight, 20% of participants were classified as overweight or obese. While only associated with diet in the unadjusted model, this finding is still of relevance, especially in Manitoba, where children experience disproportionately high rates of Type 2 diabetes (Sellers et al., 2024).

Moreover, over 25% of participants reported eating less to lose weight, a behaviour associated with lower HEI-C scores. While not an independent relationship, this finding may reflect growing body image concerns and disordered eating patterns related to social media use in adolescence (Bodega et al., 2023; Dzielska et al., 2020; Vuong et al., 2021), and aligns with associations found between poorer diet and negative self-reported health and mental health diagnoses in the adjusted model. The relationships between diet, mental health, and disordered eating highlight the significance of integrating mental health and body image education into nutrition interventions, with the objective of fostering holistic health. The most effective school food programs focused on nutrition and health outcomes are comprehensive and customized to meet community needs (Colley et al., 2019; Hoyer et al., 2025; Veugelers & Fitzgerald, 2005).

Nutrition policies must come from a position of equity and go beyond simply improving access to food. Nutrition security must be recognized as a multidimensional issue, shaped by geography, social policy, food environments, and behavioural factors. As Manitoba evaluates the newly implemented universal school food program, the results can inform assessment and evaluation criteria, ultimately shaping school nutrition policy. The success of this type of large-scale intervention will be dependent on intersectoral collaboration between governments, school administration, dietitians, food retailers, local agricultural producers, and community organizations to ensure that nutrition programming is relevant, tailored to the local context, and grounded in current evidence.

Conceptualizing Results Utilizing the Theoretical Framework

Utilizing the theoretical framework for this study as described in Chapter 3, it was expected that numerous individual, social, and political factors would act as upstream determinants of food and nutrition security of youth and impact downstream outcomes related to

health and education. The multidirectional pathways by which public health issues such as food and nutrition insecurity function within the broader system were viewed using a *systems thinking* approach (RAHPSR & WHO, 2009). Consideration for how current programs and policies flow through the system to mitigate food and nutrition insecurity was also a component of this approach. The findings of this dissertation support the study framework.

Results demonstrate that food insecurity remains a pervasive issue for youth in Manitoba and that nutrition security, while related, represents a distinct concern for study participants. These findings point to shortcomings in current public policies, including such as reliance on food charity (Martorell, 2017), inadequate wages and income supports (Men, Urquia, & Tarasuk, 2021), inequitable delivery of income benefits such as the Canada Child Benefit (Brown & Tarasuk, 2019), and ineffective food cost subsidies like Nutrition North Canada (Fafard St. Germain et al., 2019). Food insecurity was negatively associated with participants' academic achievement, while diet quality was independently linked to mental health outcomes. Disparities observed among youth from lower socioeconomic backgrounds and northern communities suggest inequitable social supports. Overall, these findings align with the WHO Commission on Social Determinants of Health Theory, which emphasizes how SEP shapes exposure to determinants of health and contributes to unequal health outcomes.

Study findings suggest that Canada and the province of Manitoba lack targeted policies to prevent or reduce food and nutrition insecurity. At the population level, the province urgently needs large-scale policy interventions to tackle the severity and prevalence of food insecurity, rather than relying on ad hoc measures like food banks, which are insufficient to address the issue comprehensively. Lastly, it cannot be inferred that policies aimed at addressing food insecurity will resolve nutrition insecurity. Multi-pronged approaches delivered equitably are

warranted and should involve relevant stakeholder voices in development, implementation, and evaluation.

Dissertation Strengths and Limitations

This quantitative study combined survey data with linkable administrative records. While primary data collection is often time-consuming and costly, it allows for operationalization of theoretical constructs and a tailored research design, optimizing the strategy to answer specific research questions (Hox & Boeije, 2004). On the contrary, secondary data is more cost-effective and efficient but can be harder to interpret, given that the data were initially collected for a different purpose (Hox & Boeije, 2004). Linkable administrative data offers even greater advantages to secondary data use, including population-based samples with minimal attrition, regularly updated longitudinal data, and the ability to examine individuals across multiple domains (e.g., health, education, and social risk factors) (Roos et al, 2017). However, a notable limitation is that administrative data is not collected for the purpose of research; therefore, the ability to answer specific research questions is limited.

The following sections will address more specifically the strengths and limitations of this study in the context of the data sources utilized.

Study Strengths

One of the main strengths of this study is the larger sample of provincial youth that would not have been possible with secondary data sources such as the CCHS or CIS. Furthermore, the FANS study is the first to conduct food security analysis at sub-provincial levels (urban, rural, northern), providing new insights into regional disparities.

Unlike other studies that use proxies (e.g., parents or guardians), this study directly assessed individual-level food security, which is crucial for understanding experiences of older

children who may sacrifice food for younger siblings, an aspect overlooked in proxy-based assessments (Baer et al., 2015).

The use of validated tools for assessing food security, eating behaviours and diet quality for this age group adds reliability to the results. The CFSSM has been validated in the North American context (Connell et al., 2004) and the WEB-Q among children of diverse backgrounds in Canada (Hanning et al., 2009). The WEB-Q has demonstrated good agreement with dietitian-administered diet recalls (Hanning et al., 2009), and by using prompts, the tool ensures more accurate reporting of portion sizes and food items like snacks and condiments, which improves the overall accuracy of nutrient analysis. Prior to nutrient analysis, the research team visually inspected line-level data and removed under-/over-reporters following thresholds from the literature (Hanning et al., 2007; Woodruff et al., 2014), improving content validity. Converting the dietary data from the WEB-Q into an HEI-C score was another strength of this study. Dietary pattern analysis has been shown to reduce issues of confounding compared to individual nutrient analysis (Kourlaba & Panagiotakos, 2009). A diet quality index also enables interpretation as either a categorical or continuous variable, making public health messages more understandable.

The innovative use of administrative data alongside primary data collection is another major strength, as it aids in reducing recall bias through data linkage with the Manitoba Population Research Data Repository. Additionally, imputing sex data from the Repository for participants who did not identify as male, or female enhanced the usability of the data. Furthermore, administrative data related to participants' SES allowed the study findings to be understood within the socioeconomic context of food and nutrition insecurity without the need to survey parents or guardians. There is also capacity for future research to utilize administrative data for cost-effective longitudinal analysis of study outcomes. For example, students'

educational outcomes can be tracked over time, alongside their movement into and out of food insecurity to determine long-term impacts on educational and health outcomes.

Study Limitations

This study has several limitations that must be considered when interpreting the findings. Overall, the cross-sectional design and narrow age range of participants introduce selection bias and limit generalizability to the adolescent population in Manitoba. The design also limits interpretations to correlations only; causation cannot be inferred, nor can unobserved confounding be completely eliminated. Similarly, the study's exclusion criteria, which eliminated approximately fifty percent of eligible school divisions reduces external validity as the sample is not representative of all Grade 9 students within the province. The study also faced selection bias due to voluntary participation and parental consent requirements, which may skew results. For example, there may be over-representation of families interested in nutrition research and who have above average dietary habits and an under-representation of families who are food insecure due to the stigma associated it. Caution should be used when interpreting food insecurity results in relation to national statistics, as questions pertaining to food security status pertain to individual experiences rather than those of a household.

Self-reported data from the 24-hour diet recall introduces the potential for recall bias. This limitation affects the overall content validity as answers may not represent usual intake. The 24-hour recall does not account for variability in intake, and dietary assessment tools in general are criticized for encouraging responses deemed as socially acceptable (Foster & Bradley, 2018), which could have impacted study findings. Self-reported height and weight may have skewed BMI results for this sample as adolescents are found to overestimate their height, while female adolescents and individuals who are overweight weight tend to underestimate their true weight

(Sherry et al., 2007), which may reflect underestimates of overweight and obesity, leading to the null relationship between BMI and the HEI-C in the fully adjusted model.

Furthermore, the HEI-C allows for the possibility of achieving a higher score despite overconsumption and does not consider food processing directly, a factor known to affect diet quality in Canada (Moubarac, 2017). However, given that it penalizes for nutrients of concern (excessive sodium, refined sugars, and saturated fat), the criteria used to assess moderation can be used as a proxy for highly processed foods, which contain these nutrients in greater quantity. Additionally, had the survey asked specifically about *where* food was consumed outside the household, this would have provided further insight into the *type* and *amount* of food processing, and should be considered in future studies utilizing the tool.

While sex data was able to be imputed for participants who did not identify with the male/female binary, the study did not capture the experiences of food and nutrition insecurity for the gender diverse community, an important subgroup known to experience higher rates of food insecurity and mental health challenges (Ferrero et al., 2023; Russomanno et al., 2019). The incomplete gender data limited the exploration of food and nutrition insecurity among this group. Future studies should use more inclusive questionnaires to collect sex and gender data (Linsenmeyer & Waters, 2021; Schier, Gunther, Landry, Ohlhorst, & Linsenmeyer, 2023).

While administrative data offers many advantages, it comes with limitations such as coding errors, which can affect the true prevalence of variables. Moreover, underserved groups who are less likely to access healthcare services may be underrepresented in administrative records (Haggerty et al., 2020), which could skew findings. The mental health variable used in this study only captures diagnosed or treated mood/anxiety disorders, subclinical conditions or eating disorders, which are emerging as relevant considerations to the food security narrative are

not captured. Furthermore, the study design did not account for the bidirectional pathway between mental health and the outcome variables, a critical area for future research (King et al., 2021; Monzonís-Carda et al., 2023). Additionally, adverse childhood experiences were not included in this study. Given the relevance of SES to all study outcomes, future work should incorporate adverse childhood experiences, as youth with elevated social risk have demonstrated poorer academic outcomes and food insecurity (Duke, 2020; Roos et al., 2013; Selvitopu & Kaya, 2023).

Lastly, school involvement in provincial meal or snack programs was not established; thus, any potential confounding or moderating effects on food security, nutrition, or academic outcomes of participation in such programs could not be determined.

Implications & Future Directions

Using the theoretical framework for this study to untangle the complex relationship between food and nutrition security, it is suggestive that structural determinants – such as financial vulnerabilities, geographic location, and public health policy – have a profound impact on individual assets, notably health and education outcomes of Manitoba youth. Existing literature confirms that current policies and programs targeting food and nutrition insecurity have largely been ineffective, leaving younger generations vulnerable to preventable health risks and missed opportunities to succeed.

The findings support a shift away from fragmented or income-only solutions and toward harmonized approaches to address these issues. While income-based interventions are essential, they do not adequately address nutrition-specific concerns for everyone. This study contributes to the growing body of evidence showing stagnant or worsening trends in food and nutrition

insecurity. It provides new insights into its associations with academic achievement and mental health, relationships not previously well-documented in the Manitoba context.

Until recently, Manitoba and Canada have been reliant on a patchwork of initiatives to curb child hunger and provide nutritious food in schools. The recent rollout of the highly anticipated Universal School Meal Program in Manitoba represents a significant policy shift. The findings from this study may serve as foundational baseline data to guide ongoing development and implementation, and evaluation of this initiative. However, to ensure the program's success, greater integration of dietitians into federal and provincial planning is indisputable. Dietitians are recognized as key components to successful school food programs internationally (Hoyer et al., 2025) and play a pivotal role in supporting menu development, food and nutrition literacy education, culturally appropriate food offerings, and staff education. At present, the limited number of dietitians employed through the Child Nutrition Council of Manitoba and the absence of any in provincial public health nutrition roles pose a risk to the long-term sustainability and effectiveness of this initiative. In addition, this policy opens the door to reintegrating food and nutrition literacy education in schools. The experiential opportunity to engage with school meal programs can positively influence lifelong relationships with food revive food skills that are diminishing in younger generations (Slater, 2013). However, it must be made clear that while a universal school food program can *support* the resolution to food and nutrition insecurity; it will not be the solution. Improvements to strengthen the social safety net to promote equity (not just equality) must be considered alongside school-based nutrition programming. Study findings show that material deprivation was associated to some degree with all study outcomes. Therefore, enhancements to income supports such as the Canada Child Benefit should be explored, including capping the income threshold and redistributing funds back to targeted

benefits for the lowest-income earners (Brown & Tarasuk, 2019). Similarly, social assistance programs, such as pensions, should be indexed to inflation; however, only two provinces and one territory have adopted this practice (PROOF, n.d.). Moreover, governments should establish measurable targets for food insecurity reduction. Prince Edward Island is currently the only province capturing this information (Poverty Elimination Strategy Act, 2021; PROOF, 2021).

Future research should address the limitations of this study. There is an opportunity to use more comprehensive and relevant sex and gender demographic questions to ensure gender-diverse individuals are represented in the data, as updated tools like the HEFI-2019 no longer adhere to sex-specific nutrient recommendations (Brassard et al., 2022). Future studies should also incorporate subclinical mental health outcomes and eating disorders, which are understudied in the context of food and nutrition security in Manitoba. Finally, future research should consider an examination of adverse childhood experiences as a component of the intersection of food, nutrition, and education, given their established link to long-term well-being (Duke, 2020; Roos et al., 2013; Selvitopu & Kaya, 2023).

Conclusion

This study confirms that food and nutrition insecurity are prominent challenges for youth in Manitoba. Notably, food insecurity was associated with academic achievement irrespective of diet quality. Furthermore, most participants had poor diets, whether they were food insecure or not, highlighting that solutions to food insecurity will not necessarily improve diet.

Geographic inequities, particularly for those in northern communities and income-related vulnerabilities emerged as clear barriers to both food and nutrition security and academic achievement. Despite the relatively small number of participants with a diagnosed mental health

disorder, mental health was negatively associated with diet quality, pointing toward the need for a deeper exploration of this phenomenon.

Taken together, this study establishes that current programs and policies require substantial reform. Manitoba must prioritize comprehensive, equity-driven, and evidence-based strategies to reverse the concerning trajectories of food and nutrition insecurity among children and youth.

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Appendices

Appendix A: Healthy Eating Index- C 2005

Component	Range of scores	Scoring criteria
Adequacy†	0 to 60 points	
Total vegetables and fruit	0 to 10 points	Minimum: 0 Maximum: 4 to 10 servings*
Whole fruit	0 to 5 points	Minimum: 0 Maximum: 0.8 to 2.1 servings (21% of recommendation for total vegetables and fruit)*
Dark green and orange vegetables	0 to 5 points	Minimum: 0 Maximum: 0.8 to 2.1 servings (21% of recommendation for total vegetables and fruit)*
Total grain products	0 to 5 points	Minimum: 0 Maximum: 3 to 8 servings*
Whole grains	0 to 5 points	Minimum: 0 Maximum: 1.5 to 4 servings (50% of recommendation for total grain products)*
Milk and alternatives	0 to 10 points	Minimum: 0 Maximum: 2 to 4 servings*
Meat and alternatives	0 to 10 points	Minimum: 0 Maximum: 1 to 3 servings (75 to 225 grams)*
Unsaturated fats	0 to 10 points	Minimum: 0 Maximum: 30 to 45 grams*
Moderation‡	0 to 40 points	
Saturated fats	8 to 10 points	Minimum 7% to 10% of total energy intake
	0 to 8 points	10% to maximum 15% of total energy intake
Sodium	8 to 10 points	Adequate intake to tolerable upper intake level
	0 to 8 points	Tolerable upper intake level to twice tolerable upper intake level
"Other food"	0 to 20 points	Minimum: 5% or less of total energy intake Maximum: 40% or more of total energy intake

* according to age and sex, as specified in *Canada's Food Guide*

† for adequacy components, 0 points for minimum or less, 5 or 10 for maximum or more, and proportional for amounts between minimum and maximum

‡ for moderation components, 10 or 20 points for minimum or less, 0 points for maximum or more, and proportional for amounts between minimum and maximum

Appendix B: Healthy Eating Index-C 2009

Component	HEIC-2009		Considerations for subsequent HEIC calculations
	Maximum scores	Minimum scores	
Grains (10 points)	≥6 servings	0 servings	Half of daily intake should be from whole grains Grain products should be lower in fat, sugar or salt
Vegetables/fruit (20 points)	≥6 servings	0 servings	One dark green vegetable daily One dark orange vegetable daily Vegetables and fruit should be prepared with little or no added fat, sugar or salt Have vegetables and fruit more often than juice
Milk (10 points)	≤6694 kJ (≤1600 kcal): 3 servings 6694–9205 kJ (1600–2200 kcal): 3-5 servings ≥9205 kJ (≥2200 kcal): 4 servings	0 servings	Drink skimmed, 1 % or 2 % milk daily Select lower-fat milk alternatives
Meat (10 points)	≤6694 kJ (≤1600 kcal): 1 serving 6694–9205 kJ (1600–2200 kcal): 1-5 servings ≥9205 kJ (≥2200 kcal): 2 servings	0 servings	Have meat alternatives often Eat at least two servings of fish each week Select lean meat and alternatives prepared with little or no added fat or salt
Other (10 points) ^t	≤6694 kJ (≤1600 kcal): ≤4 servings 6694–9205 kJ (1600–2200 kcal): ≤6 servings ≥9205 kJ (≥2200 kcal): ≤8 servings	≤6694 kJ (≤1600 kcal): >8 servings 6694–9205 kJ (1600–2200 kcal): >11 servings ≥9205 kJ (≥2200 kcal): >14 serving	
Total fat (10 points) ^t	≤30 % of energy from fat	≥45 % of energy from fat	Current Dietary Reference Intakes have changed (e.g. 20–35 % total fat is acceptable) Include 2–3 tbsp of unsaturated fat each day
Saturated fat (10 points) ^t	≤10 % of energy from saturated fat	≥15 % of energy from saturated fat	
Cholesterol (10 points) ^t	<300 mg	≥450 mg	
Variety (10 points) ^t	At least one serving from each food group	Failure to eat a serving from any food group	
Total score	100	0	

HEI-C, Canadian Healthy Eating Index; HEIC-2009, HEI-C adapted with Canada's new food guide recommendations (2009).

^tIndividuals with servings between the minimum and maximum cut-offs are assigned a proportional score for the category.

^tScore calculations are not different between HEI-C and HEIC-2009.

Appendix C: Healthy Eating Index- C 2010

Canadian Modification to the HEI-2010^{1,2}

Component	Max pts	Standard for max score	Standard for min score (0)
Adequacy Sub-score	60		
Total fruits and vegetables ³	10	4-10 servings	No servings
Whole fruit ^{4,5}	5	0.84-2.1 servings	No servings
Greens and beans ⁵	5	0.42-1.05 servings	No servings
Whole grains ⁶	10	1.5-4 servings	No servings
Dairy	10	2-4 servings	No servings
Total protein foods	5	1-3 servings	No servings
Seafood and plant proteins ⁷	5	0.32-0.96 servings	No servings
Fatty acids	10	(PUFA + MUFA)/SFA ≥ 2.5	(PUFA + MUFA)/SFA ≤ 1.2
Moderation Sub-score	40		
Refined grains ⁸	10	<50% of grains refined	≥50% of grains refined
Sodium ⁹	8 to 10	AI to UL	2x UL
Empty calories ¹⁰	20	≤ 19% of energy	≥ 50% of energy
Total HEI-C 2010 Score	100		

¹Scoring criteria for the HEI-2010 was converted to servings based on the age and sex-specific recommendations found in CFG 2007. ²Scores between the maximum and minimum were assigned proportionally. ³Includes fruit juice. ⁴Excludes fruit juice. ⁵The standard for max scores of the “whole fruit” and “greens and beans” components represent 21% of the “vegetables and fruit” recommendation in CFG. ⁶The standard for max score of the “whole grains” component is 50% of the “grain products” recommendation in CFG. ⁷The standard for max score of the “seafood and plant proteins” component represents 32% of the “meat and alternatives” recommendation in CFG. ⁸The minimum score standard for the refined grains component is ≥50% of grain products consumed as refined grains based on CFG recommendations. ⁹Respondents scored 10 points if their sodium consumption was at or less than their adequate intake, 8 points if their sodium consumption was at their upper intake level and 0 points if their consumption was twice their upper intake level. ¹⁰Includes calories from solid fats, alcohol and added sugars.

Appendix D: FANS Parental Consent Form



UNIVERSITY
OF MANITOBA

Faculty of Agricultural
and Food Sciences
Food and Human Nutritional Sciences

CODE: _____

FANS Study Parent/Guardian Informed Consent Form

For more information about this study, please contact the Research Coordinator:

Email: [REDACTED]

Dear Parents/Guardians:

Your child is being asked to participate in **FANS: Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth**, a research study conducted by Dr. Joyce Slater, an Associate Professor in the Faculty of Agricultural and Food Sciences at the University of Manitoba. The purpose of this study is to describe the nutritional status of grade 9 students living in Manitoba, including challenges with accessing healthy food, and how these impact health and educational outcomes, in order to inform programs and policies to improve the health of Manitoban children and youth.

For your child to participate in this study, you must give permission or “consent”. This consent form is only part of the process of informed consent. It should give you the basic idea of what the research is about and what is involved in participation. Please take the time to read this carefully and be sure you understand the information. If you would like more information, please contact Joyce Slater (Joyce.Slater@umanitoba.ca) or the study coordinator (contact information listed above).

Study purpose:

The purpose is to conduct a study to describe the nutritional status of grade 9 students in Manitoba. This includes a description of Manitoban youths’ dietary intake (nutrients and food groups); ability to access healthy food regularly; their health and well-being; and food and eating behaviours. This study will examine how these relate to health, social and educational outcomes in order to inform programs and policies to improve the health of Manitoba’s young people.

Procedures for the study:

There are two parts to this study:

- 1) Your child will complete an online *Food Behaviour Questionnaire* in their school computer lab. In this survey, your child will be asked questions about:
 - Basic demographic information (age, sex, weight, height, ethnicity)
 - Food intake (food and beverages consumed the previous day)
 - Sleep habits
 - Meal consumption patterns
 - Ability to access and eat healthy food regularly
 - Frequency of caffeine/energy drink/sports drink consumption
 - Their health including physical, psychological and emotional well-being

Upon completion of the survey, an analysis of your child's dietary information will be generated for them.

- 2) If you agree to provide your child's Manitoba Health PHIN (more information at the end of this form), survey responses will be linked to health, social and education data through the secure computing facilities of the Manitoba Centre for Health Policy at the University of Manitoba. NO ONE involved in this study will have access to your child's medical, social service or education records. We will be looking at health services accessed (e.g. diagnosis for mental health issues and visits to specialists); social services accessed (income and housing assistance) and number of credits achieved at the end of grade 9. Further, as your child's health number will be scrambled by Manitoba Health before being used in the study, there is NO WAY any of the study researchers will know which data belongs to your child. All the data is completely de-identified at Manitoba Health before being transferred to the Manitoba Centre for Health Policy.
- 3) **The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.**

Benefits of taking part in this study:

Potential benefits of this study include the generation of information that could improve our understanding of the nutritional status and needs of Manitoban children and youth. Each participant will automatically receive a print out of their dietary intake which they can choose to make individual improvements on. Finally, this study will be used to advocate for programs and policies to improve food and nutrition security for young Manitobans.

Risks of taking part in the study:

There are very minimal risks to conducting this research. There may be questions that participants do not feel comfortable answering or do not understand. Students will be reminded that they do not have to answer a question and can ask for clarification at any time during the survey. As well, students will be reminded that their responses are confidential and are free to withdraw from answering the questionnaire at any time without consequence. Even after completing the questionnaire, you or your child can ask to have their data removed from the study up until July 31, 2019 after which it will not be possible to find their individual data for removal. Please contact Dr. Slater at [REDACTED] or [REDACTED] if you would like your child's data removed.

Confidentiality:

Participants' privacy will be strictly maintained as no names will be collected or recorded, and all data is de-identified. All electronic data will be stored in secure facilities at the University of Manitoba (secure University server and Manitoba Centre for Health Policy offices), and consent forms will be stored in a locked cabinet in a secure, locked room (403a) Human Ecology Building at the University of Manitoba). Any identifiable information will be destroyed by July 2024. Your child's non-identifiable survey results will be kept indefinitely. If you provide your child's Personal Health Information Number and Family Registration Number, the research team will **not** have access to ANY of your child's identifiable data, as this information will be de-identified and encrypted by Manitoba Health before it is used in any of our analyses.

Payment:

There is no payment for participating in this study.

Voluntary nature of study:

Taking part in this study is completely voluntary. This means that you may choose that your child does not take part in it. As well, if you decide to allow your child to take part now, you can change your mind at any point in the future. There are no negative consequences for you or your child if you decide you no longer wish for them to participate in the study. Please see “Risks” section for information on how to remove your child’s data.

Assent (child):

Your child can decide whether or not to participate in the survey by answering the following question at the beginning of the on-line survey: “Do you agree to participate in this survey?”

Results:

Results of this study will be summarized and published in various formats. Examples include:

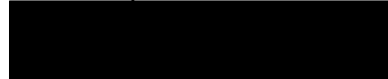
- Reports that will be provided to the participating schools and School Division, as well as other stakeholders, including community agencies and government departments who work with youth and food/nutrition issues.
- Presentations at scientific conferences and papers published in scientific journals.

You are being asked for permission to allow us to use the information, or data, that is collected from the survey. You are also being asked to provide your child’s Manitoba Health number, so we can link their de-identified and encrypted survey data to health, social service and educational data. This is done **confidentially** in the secure computing facilities of the Manitoba Centre for Health Policy, according to the research protocols established by the Government of Manitoba and the University of Manitoba. **Your child’s personal health information will NOT be accessible by any of the research team members.**

This study has been approved by the Joint-Faculty Research Ethics Board and if you have any concerns or complaints, please contact the Human Ethics Coordinator at

Human Ethics Coordinator

University of Manitoba



Please read and sign the attached page if you consent to have your child participate in this study. Thank you for your consideration of this request!

UNIQUE ID: _____

Consent (Parent/Guardian): Please complete both parts:

By signing below, you give permission for the information gathered to be used as outlined above. You give permission for the information to be inspected and used by research staff at the University of Manitoba Research Ethics Board. **Please note:** you can consent to #1 below without consenting to #2 below. Please sign both copies and send ONE back with your child in the envelope provided, and keep the other for your records.

1. If you choose to provide consent for your child to participate in the Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth (FANS) Survey, please sign below:

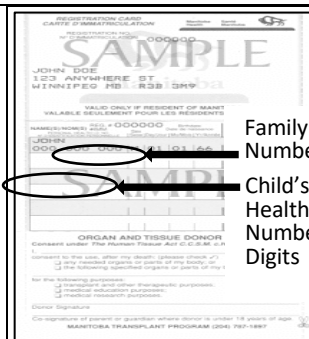
Child Name (please print): _____ Postal Code: _____

Parental/Guardian Signature: _____ Date: _____

2. I agree to allow my child's Manitoba Health number to be used to link their FANS survey data to health, social and education data (please fill in number below). I understand that this will be done **confidentially** and my child will not be identified. *Please indicate your agreement by checking YES or NO, and signing below. Also note, your child can complete the FANS survey without providing their Manitoba Health numbers.*

- YES I agree to allow my child's Manitoba Health number to be used to link their FANS survey data to health, social and education data
- NO I do not agree to allow my child's Manitoba Health number to be used to link their FANS survey data to health, social and education data

Parental/Guardian Signature: _____ Date: _____



Family Registration Number-6 Digits
Child's Personal Health Identification Number (PHIN) - 9 Digits

From your child's Manitoba Health Card:

1. Family Registration Number – 6 digits:

2. Child's Personal Health Identification (PHIN) Number - 9 digits:

Research delegate signature: _____

If you would like to receive a summary of the results please indicate this below.

I want to receive a summary of findings:

Yes ___ No ___

Please send it to the following email or ground mail address: _____

Appendix E: FANS Survey Code Book

FANS Survey Code Book

[2177] How old are you?

[1] Select...

[2] 12

[3] 13

[4] 14

[5] 15

[6] 16

[2178] Are you:

[1] Select...

[2] Male

[3] Female

[4] Other

[2179] If you were not Born in Canada, how old were you when you moved to Canada?

[1] Select...

[2] 1

[3] 2

[4] 3

[5] 4

[6] 5

[7] 6

[8] 7

[9] 8

[10] 9

[11] 10

[12] 11

[13] 12

[14] 13

[15] 14

[16] 15

[17] 16

[2180] If you were born in Canada, are you an Indigenous person?

[1] Select...

[2] Yes

[3] No

[4] Don't know

[2181] If you are an Indigenous person, are you First Nations, Metis/Métis or Inuk (Inuit)?

[1] Select...

[2] First Nations (First Nations includes Status and Non-Status)

[3] Metis/Métis

[4] Inuk/Inuit

[5] Don't know

[6] None

[2183] How many hours of sleep did you get last night?

[1] Select...

[2] 0

[3] 1

[4] 2

[5] 3

[6] 4

[7] 5

[8] 6

[9] 7

[10] 8

[11] 9

[12] 10

[13] 11

[14] 12

[15] 13

[16] 14

[17] 15

[18] 16

[19] 17

[20] 18

[21] 19

[22] 20

[23] 21

[24] 22

[25] 23

[26] 24

[2184] How many hours of sleep do you usually get each night?

[1] Select...

[2] 0

[3] 1

[4] 2

[5] 3

[6] 4

[7] 5

[8] 6

[9] 7

[10] 8

[11] 9

[12] 10

[13] 11

[14] 12

[15] 13

[16] 14

[17] 15

[18] 16

[19] 17

[20] 18

[21] 19

[22] 20

[23] 21

[24] 22

[25] 23

[26] 24

[2185] Do you feel you get enough sleep regularly?

[1] Select...

[2] Yes

[3] No

[2186] If you feel you do NOT get enough sleep, what is the main reason?

[1] Select...

[2] Homework

[3] Work

[4] Screen activities

[5] Chores

[6] Other reasons

[2187] How much do you weigh? (indicate if lbs or kg)

AS IS

[2188] How tall are you? (indicate feet/inches or centimeters)

AS IS

[2189] I am eating less than usual to try and lose weight:

[1] Select...

[2] Definitely Not

[3] Not Really

[4] Kind of

[5] Yes

[2190] I am eating more than usual to try and gain weight:

[1] Select...

[2] Definitely Not

[3] Not Really

[4] Kind of

[5] Yes

[2182] How many hours of sleep did you get last night?

[1] 0

[2] 1

[3] 2

[4] 3

[5] 4

- [6] 5
- [7] 6
- [8] 7
- [9] 8
- [10] 9
- [11] 10
- [12] 11
- [13] 12
- [14] 13
- [15] 14
- [16] 15
- [17] 16
- [18] 17
- [19] 18
- [20] 19
- [21] 20
- [22] 21
- [23] 22
- [24] 23
- [25] 24

How often do you eat the following meals?

[2191] Breakfast

- [1] Every day
- [2] 5-6 days a week
- [3] 2-4 days a week
- [4] 0-1 day a week

[2192] Lunch

- [1] Every day
- [2] 5-6 days a week
- [3] 2-4 days a week
- [4] 0-1 day a week

Where did you eat yesterday?

[2193] Breakfast

- [1] Home
- [2] School
- [3] Away from Home or School

[2194] Morning snack

- [1] Home
- [2] School
- [3] Away from Home or School

[2195] Lunch

- [1] Home
- [2] School
- [3] Away from Home or School

[2196] Afternoon snack
[1] Home
[2] School
[3] Away from Home or School

[2197] Dinner/Supper
[1] Home
[2] School
[3] Away from Home or School

[2198] Evening snack
[1] Home
[2] School
[3] Away from Home or School

[2199] Typically, how many days per week do you eat dinner/supper with at least one parent/guardian?
[1] Select...
[2] Every day
[3] 5-6 days a week
[4] 2-4 days a week
[5] 0-1 day a week

Think about your experience with food over the past year, and choose one answer for each question:

[2200] Did you worry that food at home would run out before your family got money to buy more?

- [1] A Lot
- [2] Sometimes
- [3] Never

[2201] Did the food that your family bought run out, and you didn't have money to get more?

- [1] A Lot
- [2] Sometimes
- [3] Never

[2202] Did your meals only include a few kinds of cheap foods (i.e. instant or canned noodles, boxed macaroni and cheese, etc.) because your family was running out of money to buy food?

- [1] A Lot
- [2] Sometimes
- [3] Never

[2203] How often were you not able to eat a balanced meal because your family didn't have enough money?

- [1] A Lot
- [2] Sometimes
- [3] Never

[2204] Did you have to eat a lot less because your family didn't have enough money to buy food?

- [1] A Lot
- [2] Sometimes

- [3] Never
- [2205] Has the size of your meals been cut because your family didn't have enough money for food?
- [1] A Lot
[2] Sometimes
[3] Never
- [2206] Did you have to skip a meal because your family didn't have enough money for food?
- [1] A Lot
[2] Sometimes
[3] Never
- [2207] Were you hungry, but didn't eat because your family didn't have enough food?
- [1] A Lot
[2] Sometimes
[3] Never
- [2208] Did you not eat for a whole day because your family didn't have enough money for food?
- [1] A Lot
[2] Sometimes
[3] Never
- [2211] How do you rate your health?
- [1] Select...
[2] Excellent
[3] Very Good
[4] Fair
[5] Poor
- [2229] Have you taken a Home Economics/Human Ecology course with a focus on food and nutrition in school?
- [1] Select...
[2] Yes
[3] No
- Rate the following statements from strongly disagree to strongly agree:
- [2224] In most ways my life is close to my ideal
- [1] Strongly disagree
[2] Disagree
[3] Slightly disagree
[4] Neither agree nor disagree
[5] Slightly agree
[6] Agree
[7] Strongly agree
- [2225] The conditions of my life are excellent
- [1] Strongly disagree
[2] Disagree
[3] Slightly disagree
[4] Neither agree nor disagree

- [5] Slightly agree
 - [6] Agree
 - [7] Strongly agree
- [2226] I am satisfied with my life
- [1] Strongly disagree
 - [2] Disagree
 - [3] Slightly disagree
 - [4] Neither agree nor disagree
 - [5] Slightly agree
 - [6] Agree
 - [7] Strongly agree
- [2227] So far, I have gotten the most important things I want in life
- [1] Strongly disagree
 - [2] Disagree
 - [3] Slightly disagree
 - [4] Neither agree nor disagree
 - [5] Slightly agree
 - [6] Agree
 - [7] Strongly agree
- [2228] If I could live my life over, I would change almost nothing
- [1] Strongly disagree
 - [2] Disagree
 - [3] Slightly disagree
 - [4] Neither agree nor disagree
 - [5] Slightly agree
 - [6] Agree
 - [7] Strongly agree
- How often do you eat meals/snacks purchased at school?
- [2212] From school cafeteria (including pizza days and other special meals)
- [1] Once a day
 - [2] 2-6 times a week
 - [3] Once a week
 - [4] Rarely/Never
- [2213] From school vending machines
- [1] Once a day
 - [2] 2-6 times a week
 - [3] Once a week
 - [4] Rarely/Never
- [2214] From school canteen/snack bar/tuck shop
- [1] Once a day
 - [2] 2-6 times a week
 - [3] Once a week
 - [4] Rarely/Never

How often do you eat or drink the following?

- [2215] Energy shots (like 5 hr. energy, etc.)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2216] Energy drinks (like NOS, Monster, Red Bull, etc.)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2217] Carbonated energy drinks (like Pepsi Max, Jolt, etc.)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2218] Coffee-based energy drinks (like Rock Star roasted, Starbucks Double Shot, Java Monster)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2219] Coffee and Tea (like hot coffee, black tea, etc.)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2220] Blended or iced coffee beverages (Frappuccinos, lattes, cappuccinos, etc.)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2221] Protein shakes or drinks (like Monster Milk, Pure Protein Shake or made from powder)
- [1] At least once a day
 - [2] 5-6 times a week
 - [3] 2-4 times a week
 - [4] 2-4 times a month
 - [5] Rarely/Never
- [2222] Power/protein bars (like Six Star Muscle, Power bars)

- [1] At least once a day
- [2] 5-6 times a week
- [3] 2-4 times a week
- [4] 2-4 times a month
- [5] Rarely/Never

[2223] Rate this statement: It is important to learn about food and nutrition in school.

- [1] Select...
- [2] Strongly agree
- [3] Agree
- [4] Neither agree or disagree
- [5] Disagree
- [6] Strongly disagree

Appendix F: FANS Survey Variables Used in this Study

Participant Characteristics			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Sex ^a	Categorical	Male Female Other	Male Female
Region ^b	Categorical	Urban Rural Northern	Urban Rural Northern
Health Variables			
Variable	Variable Type	Survey Response Options	Categories for Analysis
BMI ^c	Categorical	n/a	Underweight Healthy Weight Overweight/Obese
Self-rated Health	Categorical	Excellent Very good Fair Poor	Excellent/Very Good Fair/Poor
Intentional Weight Loss ^d	Categorical	Definitely not Not really Kind of Yes	No Yes
Intentional Weight Gain ^d	Categorical	Definitely not Not really Kind of Yes	No Yes
Adequate Sleep for Age ^e	Categorical	0-24 hours	Yes No
Food Behaviours			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Frequency of Breakfast	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week

Frequency of Lunch	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Family Dinner Frequency	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Location of Breakfast	Categorical	Home School Away from home or school	Home School/Other
Location of Lunch	Categorical	Home School Away from home or school	Home School/Other
Location of Dinner	Categorical	Home School Away from home or school	Home School/Other
Location of Morning Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Afternoon Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Evening Snack	Categorical	Home School Away from home or school	Home School/Other
Diet Quality & Food Security			
Variable	Variable Type	Survey Response Options	Categories for Analysis
HEI-C ^{f,2}	Continuous (0-100)	n/a	n/a
HEI-C ^{f,2}	Categorical	n/a	Poor (HEI Score <50) Needs Improvement (HEI Score 50-80) Good (HEI Score >80)
Food Security Status ^g	Categorical	Response options to 9-item CFSSM ¹ A lot	Food Secure Food Insecure

		Sometimes Never	
--	--	--------------------	--

^aCategory 'other' had too few responses for stratified analysis (n=34). When analyzing entire FANS sample, this category was treated as missing but retained for bivariate analysis. Missing data points were imputed from the MCHP Repository when analyzing the PHIN subsample to retain as many observations as possible.

^bFANS survey responses utilized for analysis of both FANS and PHIN cohorts. Region established based on school postal code the participant completed the survey.

^cDerived from self-reported height and weight and categorized using WHO z-scores.

^dResponses 'Definitely not' and 'not really' collapsed to category 'no', 'kind of' and 'yes' collapsed to category 'yes'.

^eYes correlates with meeting Government of Canada minimum recommendations for age (9-11 hours/night for 5-13 years old, 8-10 hours/night for 14-17 years old).

^fExcept for some descriptive analysis, the continuous HEI score variable was utilized due to the small number of respondents in the 'good' category.

^g0-1 affirmative responses ('a lot' or 'sometimes') on the 9-item CFSSM were considered 'food secure', >1 affirmative response and participants were categorized as 'food insecure'.

¹Child Food Security Survey Module

²Healthy Eating Index

Appendix G: FANS Revised HEI-C

Table: Healthy Eating Index-Canada (HEI-C) adaptation for the FANS study categorized by age and sex

Component	Range of Scores	Scoring Criteria				
		Female		Male		
		9-13 years	14-18 years	9-13 years	14-18 years	
Adequacy	0 to 60 points					
			<i>servings</i>			
Total vegetables and fruit	0 to 10 points	Min:	0	0	0	0
		Max:	6	7	6	8
Whole fruits ^a	0 – 5 points	Min:	0	0	0	0
		Max:	1.3	1.5	1.3	1.7
Dark green & orange vegetables ^a	0 – 5 points	Min:	0	0	0	0
		Max:	1.3	1.5	1.3	1.7
Total grain products	0 – 5 points	Min:	0	0	0	0
		Max:	6	6	6	7
Whole grain products ^b	0 – 5 points	Min:	0	0	0	0
		Max:	3	3	3	3.5
Milk and alternatives	0 – 5 points	Min:	0	0	0	0
		Max:	3	3	3	3
Low fat Vit-D fortified milk and dairy-free beverage alternatives	0 – 5 points	Min:	0	0	0	0
		Max:	2	2	2	2
Meat and alternatives	0 – 5 points	Min:	0	0	0	0
		Max:	1	2	2	3
Seafood and plant-based proteins	0 – 5 points	Min:	0	0	0	0
		Max:	1	2	2	3
			<i>grams</i>			
Unsaturated fats ^d	0 to 10 points	Min:	0	0	0	0
		Max:	30	30	30	45
Moderation	0 to 40 points					
Saturated fats	8 – 10 points	Min:	10% of total energy intake			
		Max:	7% of total energy intake			
	0 – 8 points	Min:	15% or more of total energy intake			
		Max:	10% of total energy intake			
Sodium ^e	8 – 10 points	Min:	2200 mg	2300 mg	2200 mg	2300 mg
		Max:	1500 mg	1500 mg	1500 mg	1500 mg
	0 – 8 points	Min:	4400 mg	4600 mg	4400 mg	4600 mg
		Max:	2200 mg	2300 mg	2200 mg	2300 mg
"Other food"	0 – 20 points	Min:	5% or less of total energy intake			
		Max:	40% or more of total energy intake			

^a 21% of total vegetables of fruit (explanation provided separately)

^b 'Make at least half of your grain products whole grain each day'

^c 'Select lower fat milk alternatives' and specific items include 0%, 1%, 2% milk

^d consumption of unsaturated fats (poly- and mono-unsaturated fats) used to calculate the oil component. Amount in accordance with age and sex recommendations, as specified by *Canada's Food Guide* version 2007.

^e 8-10 points assigned to if intake is between 'Adequate intake to UL' and 0-8 points if intake is between UL to twice UL (adequate intake and Tolerable Upper Intake Level from <https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/sodium.html>)

Appendix H: Data Repository Variables and Definitions

Database: Healthcare				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Mood/Anxiety Disorder	1) Manitoba Adolescent Treatment Centre (MATC) 2) Medical Services (Physician Claims, Hospital Abstracts) 3) Drug Program Information Network (DPIN)	1) 2012-2018/19 2) 2008-2018/19 3) 2007-2018/19	<ul style="list-style-type: none"> 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 296.1-296.8, 300.0, 300.2, 300.3, 300.4, 300.7, 309 or 311; ICD-10: F31-F33, F34.1, F38.0, F38.1, F40, F41.0, F41.1, F41.2, F41.3, F41.8, F41.9, F42, F43.1, F43.2, F43.8, F53.0, or F93.0); OR 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 300; ICD-10: F32, F34.1, F40, F41, F42, F44, F45.0, F45.1, F45.2, F48, F68.0 or F99) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 1 or more physician visits with one of the following diagnosis codes (ICD-9: 296, 311); OR 1 or more physician visits with the following diagnosis code (ICD-9: 300) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 3 or more physician visits with one of the following diagnosis codes (ICD-9: 300, 309). (Mariette Chartier et al., 2016). 	Yes No
Database: Social				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Social Housing	Housing - Tenant Management System (TMS)	2004-2018	<ul style="list-style-type: none"> Participants' contacts with the TMS in any year since 2004. 	Yes No

			<ul style="list-style-type: none"> • TMS is used to manage and track clients that reside in social housing managed by Manitoba Housing and Community Development. • Approximately 14,000 residential dwelling units, providing housing to more than 31,000 individuals, families, and seniors in Manitoba. • Data only available up to May 2018. (University of Manitoba, 2018) 	
Employment/Income Assistance (IA) – Family	Social Allowances Management Information Network (SAMIN)	2004-2018/19	<ul style="list-style-type: none"> • Information on employment and income assistance recipients in Manitoba. • All participants living within a family unit that was receiving IA at the time of the study (2018/19), had ever received IA, or received IA at any point over the 5 years preceding the study. • The data set contains one record per person (client) and/or family (case) for each month they are present in the SAMIN database by fiscal year. (University of Manitoba, 2020b) 	Never Currently/over the last 5 years
Database: Education				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Education Achievement	Enrollment, Marks, and Assessments	2018-June 2019	<ul style="list-style-type: none"> • Information on enrollment, courses, marks, standard tests, assessments, graduation status, funding, and demographics for MB students from K-12 (University of Manitoba, 2020c). • Assessing completion of ≥ 8 credits in a student's first year of grade 9, a predictor of high school completion. 	Yes No
Database: Registries				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Residential Mobility	Manitoba Health Insurance Registry	2008-2018/19	<ul style="list-style-type: none"> • Movement of a Manitoba Health insurance registrant within the province resulting in a change of postal code but does not affect continuity of eligibility for health insurance (University of Manitoba, 2008). 	Yes No

			<ul style="list-style-type: none"> Affirmative rating if participants' family moved residences ≥ 3 times within 10-person-years prior to the start of the of the study. 	
Income Quintile	Canada Census	2006-2018/19	<ul style="list-style-type: none"> Income quintiles are identified using postal codes, which are linked to the median neighbourhood income. This information is divided into rural and urban and given a score of 1-5, with 1 representing the lowest income quintile and 5 the highest. Quintiles are based on dissemination area (DA)-level average household income. Each person within a DA is "attributed" the average household income of the DA. Area-level (not individual) income measure. (University of Manitoba, 2013) 	Q1 (lowest) Q2 Q3 Q4 Q5 (highest)

Appendix I: Initial University of Manitoba Ethics Certificate



Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

PROTOCOL APPROVAL

TO: Joyce Slater
Principal Investigator

FROM: Kevin Russell, Chair
Joint-Faculty Research Ethics Board (JFREB)

Re: Protocol J2018:040 (HS21666)
FANS: Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth

Effective: August 30, 2018

Expiry: August 30, 2019

Joint-Faculty Research Ethics Board (JFREB) has reviewed and approved the above research. JFREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*.

This approval is subject to the following conditions:

1. Approval is granted only for the research and purposes described in the application.
2. Any modification to the research must be submitted to JFREB for approval before implementation.
3. Any deviations to the research or adverse events must be submitted to JFREB as soon as possible.
4. This approval is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
5. A Study Closure form must be submitted to JFREB when the research is complete or terminated.
6. The University of Manitoba may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans*.

Funded Protocols:

- Please mail/e-mail a copy of this Approval, identifying the related UM Project Number, to the Research Grants Officer in ORS.

Research Ethics and Compliance is a part of the Office of the Vice-President (Research and International)
umanitoba.ca/research

Appendix J: University of Manitoba Ethics Certificate Renewal



University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2
T: 204 474 8872
humanethics@umanitoba.ca

RENEWAL APPROVAL

Effective: August 4, 2021

New Expiry: August 30, 2022

Principal Investigator: Joyce Jasmine Slater
Protocol Number: HS21666 (J2018:040)
Protocol Title: *FANS: Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth*

Andrea L. Szwajcer, Chair, REB2

Research Ethics Board 2 has reviewed and renewed the above research. The Human Ethics Office is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans- TCPS 2 (2018)*.

This approval is subject to the following conditions:

- i. Any changes to this research must be approved by the Human Ethics Office before implementation.
- ii. Any deviations to the research or adverse events must be reported to the HEO immediately through an REB Event.
- iii. This renewal is valid for one year only. A Renewal Request must be submitted and approved prior to the above expiry date.
- iv. A Protocol Closure must be submitted to the HEO when the research is complete or if the research is terminated.

Appendix K: Initial Health Information Privacy Committee Certificate



May 7, 2019

Joyce Slater
University of Manitoba
409 Human Ecology, Winnipeg MB R3T 2N2
Joyce.Slater@umanitoba.ca

HIPC No. 2018/2019 – 32
File number to be quoted on correspondence

Re: FANS: Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth

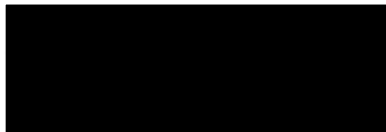
Dear Ms. Slater,

The Health Information Privacy Committee has considered and *approved* your request for access to data for the purposes of the above named project.

Any significant changes to the proposed study design should be reported to the Chair/HIPC for consideration in advance of their implementation. Also, please be reminded that any manuscripts and presentation materials resulting from this study must be submitted to Manitoba Health, Seniors and Active Living for review. Specifically, manuscripts must be submitted *at least 30 calendar days* prior to the intended publication and presentation materials must be submitted *at least 10 calendar days* prior to the presentation.

Researcher Agreement will need to be completed before work on this project can commence. This will be initiated by MCHP. If you have any questions or concerns, please do not hesitate to contact Saila Parveen, Committee Coordinator at (204)786-7204.

Yours truly,



Teresa Cavett, B.Sc., M.D., C.C.F.P., F.C.F.P., M.Ed.
Chair, Health Information Privacy Committee

c.c. D. Malazdrewicz



Appendix L: Updated Health Information Privacy Committee Certificate



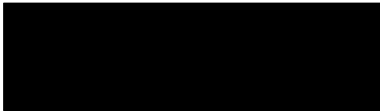
HIPC No. 2018/2019 – 32 <i>(File number to be quoted on correspondence)</i>	
Submission date: June 18, 2020	Approval date: June 22, 2020
Researcher name: Dr. Joyce Slater	Project title: FANS: Building Evidence to Inform Policies and Programs for Food and Nutrition Security in Manitoba Youth

Dear Dr. Slater,

Thank you for submitting the protocol amendment form dated on **June 17, 2020** for the proposed protocol changes for this project. HIPC has **approved** your revisions and please consider this message as official notification of approval.

If you have any questions or concerns, please do not hesitate to contact Saila Parveen, Committee Coordinator at 204-786-7204.

Yours truly,



Teresa Cavett, B.Sc., M.D., C.C.F.P., F.C.F.P., M.Ed.
Chair, Health Information Privacy Committee

c.c. N. Hoepfner

Appendix M: Supplemental Material, Chapter 4

Supplement 1. RECORD checklist of recommendations for the reporting of studies conducted using routinely collected data

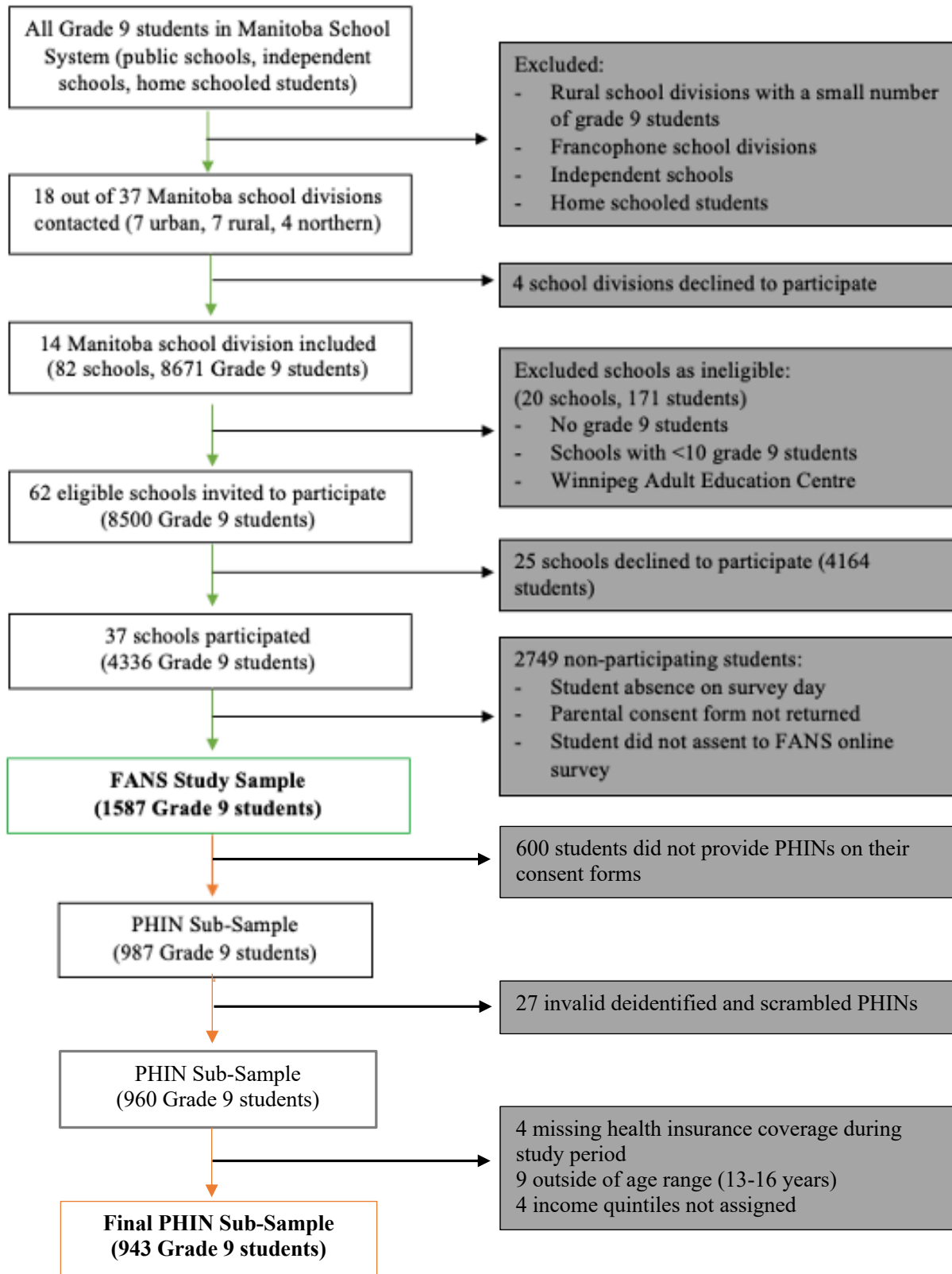
	Item No.	Recommendations	Location in manuscript where items are reported
Title and abstract			
	1	1.1 The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.	Title and abstract (page 90)
		1.2 If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.	Abstract (page 90)
		1.3 If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Title and Abstract (page 90-91)
Introduction			
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction (pages 92-93)
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction (page 93)
Methods			
Study Design	4	Present key elements of study design early in the paper	Methods (pages 94-96)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (pages 93-96)
Participants	6	6.1 The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.	Appendix M, Supplement 2 (page 276)
		6.2 Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	Appendix M, Supplement 4b (pages 281-283) for definitions of linked variables n/a for FANS cohort
		6.3 If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	Appendix M, Supplement 2 (page 276)
Variables	7	A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Appendix M, Supplement 3a, 3b, 4a, 4b (pages 277-281)
Data sources/measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods (pages 96-99) Appendix M, Supplement 3a, 3b, 4a, 4b (pages 277-281)

Bias	9	Describe any efforts to address potential sources of bias	Methods (page 95, 98)
Study size	10	Explain how the study size was arrived at	Methods (page 96) Appendix M, Supplement 2 (page 276)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	Methods (pages 96-99) Appendix M, Supplement 3a, 3b, 4a, 4b (pages 277-281)
Statistical methods	12	12.1 Describe all statistical methods, including those used to control for confounding	Methods (page 99-101) Appendix M, Supplement 5 (page 284) and 6 (page 286)
		12.2 Describe any methods used to examine subgroups and interactions	Methods (page 96)
		12.3 Explain how missing data were addressed	Methods (page 96-98)
		12.4 If applicable, explain how loss to follow-up was addressed	Not applicable
		12.5 If applicable, explain how matching of cases and controls was addressed	Not applicable
		12.6 If applicable, describe analytical methods taking account of sampling strategy	Methods (pages 96)
		12.7 Describe any sensitivity analyses	Methods (page 99-100)
Data access and cleaning methods		12.8 Authors should describe the extent to which the investigators had access to the database population used to create the study population.	Appendix M, Supplement 4b (page 281)
		12.9 Authors should provide information on the data cleaning methods used in the study.	Methods (pages 96) Appendix M, Supplement 3a, 3b, 4a (pages 277-280)
Linkage		12.10 State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	Methods (page 99) Appendix M, Supplement 4b (page 281)
Results			
Participants	13	Describe in detail the selection of the persons included in the study (<i>i.e.</i> , study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Appendix M, Supplement 2 (page 276)
Descriptive data	14	14.1 Give characteristics of study participants (<i>e.g.</i> , demographic, clinical, social) and information on exposures and potential confounders	Results (pages 101) Tables 4-1 (page 102), 4-2 (page 103)
		14.2 Indicate the number of participants with missing data for each variable of interest	Table 4-2 (page 103), Table 4-3 (page 105), Table 4-4 (page 106), Table 4-6 (page 107)

		14.3 Summarize follow up time (average and total)	Not applicable
Outcome data	15	Report numbers of outcome events or summary measures	Table 4-2 (page 103), Table 4-4 (page 106), Table 4-5 (page 106)
Main results	16	16.1 Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results (pages 107-108) Figure 4.1 (page 109) Appendix M, Supplement 6 (page 286)
		16.2 Report category boundaries when continuous variables were categorized	Table 4-4 (page 106)
		16.3 If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion (pages 110-112)
Limitations	19	Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Discussion (pages 114)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion (pages 110-115)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Discussion (page 113)
Other Information			
Funding	22	22.1 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable for this dissertation
Accessibility of protocol, raw data, and programming code		22.2 Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Not applicable for this dissertation

Notes: Checklist Reference: Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press. Checklist is protected under Creative Commons Attribution (CC BY) license.

Supplement 2. Sampling strategy and study cohorts



Supplement 3a. Outcome variable - nine-item child food security survey module^a

Status ^b	Raw Score	Interpretation	Categories for Analysis
Food Secure	0-1	No concerns related to food access	Food Secure
Moderately Food Insecure	2-5	Some indication of concern of food quantity and compromised quality due to financial constraints, hunger not present	Food Insecure
Severely Food Insecure	≥6	Disrupted eating pattern and/or reduced food intake, hunger is evident	

^aValid and reliable tool for measuring food security in children ≥12 years of age in North America (Connell et al., 2004)

^bParticipants with more than two missing responses were excluded from analysis

Supplement 3b. Outcome variable – diet quality

Variable	Variable Type	Categories for Analysis
HEI-C ^a	Continuous (0-100)	n/a
HEI-C ^a	Categorical	Poor (HEI Score <50) Needs Improvement (HEI Score 50-80) Good (HEI Score >80)

^aHealthy Eating Index Canada

Supplement 4. Covariate Definitions

Supplement 4a. FANS Survey Variables

Participant Characteristics			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Sex ^a	Categorical	Male Female Other	Male Female
Region ^b	Categorical	Urban Rural Northern	Urban Rural Northern
Health Indicators			
Variable	Variable Type	Survey Response Options	Categories for Analysis
BMI ^c	Categorical	n/a	Underweight Healthy Weight Overweight/Obese
Self-rated Health	Categorical	Excellent Very good Fair Poor	Excellent/Very Good Fair/Poor
Intentional Weight Loss ^d	Categorical	Definitely not Not really Kind of Yes	No Yes
Intentional Weight Gain ^d	Categorical	Definitely not Not really Kind of Yes	No Yes
Adequate Sleep for Age ^e	Categorical	0-24 hours	Yes No
Food Behaviours			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Frequency of Breakfast	Categorical	Every day 5-6 days a week 2-4 days a week	0-4 days/week 5-7 days/week

		0-1 days a week	
Frequency of Lunch	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Family Dinner Frequency	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Location of Breakfast	Categorical	Home School Away from home or school	Home School/Other
Location of Lunch	Categorical	Home School Away from home or school	Home School/Other
Location of Dinner	Categorical	Home School Away from home or school	Home School/Other
Location of Morning Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Afternoon Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Evening Snack	Categorical	Home School Away from home or school	Home School/Other
Diet Quality			
Variable	Variable Type	Survey Response Options	Categories for Analysis
HEI-C ^{f,2}	Continuous (0-100)	n/a	n/a
HEI-C ^{f,2}	Categorical	n/a	Poor (HEI Score <50) Needs Improvement (HEI Score 50-80) Good (HEI Score >80)

^aCategory 'other' had too few responses for stratified analysis (n=34). When analyzing entire FANS sample, this category was treated as missing but retained for bivariate analysis. Missing data points were imputed from the MCHP Repository when analyzing the PHIN subsample to retain as many observations as possible.

^bFANS survey responses utilized for analysis of both FANS and PHIN cohorts. Region established based on school postal code the participant completed the survey.

^cDerived from self-reported height and weight and categorized using WHO z-scores.

^dResponses 'Definitely not' and 'not really' collapsed to category 'no', 'kind of' and 'yes' collapsed to category 'yes'.

^eYes correlates with meeting Government of Canada minimum recommendations for age (9-11 hours/night for 5-13 years old, 8-10 hours/night for 14-17 years old).

^fExcept for some descriptive analysis, the continuous HEI-C score variable was utilized due to the small number of respondents in the 'good' category.

¹Child Food Security Survey Module

²Healthy Eating Index Canada

Supplement 4b. Linked Administrative Variables

Database: Healthcare				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Mood/Anxiety Disorder	1) Manitoba Adolescent Treatment Centre (MATC) 2) Medical Services (Physician Claims, Hospital Abstracts) 3) Drug Program Information Network (DPIN)	1) 2012-2018/19 2) 2008-2018/19 3) 2007-2018/19	<ul style="list-style-type: none"> 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 296.1-296.8, 300.0, 300.2, 300.3, 300.4, 300.7, 309 or 311; ICD-10: F31-F33, F34.1, F38.0, F38.1, F40, F41.0, F41.1, F41.2, F41.3, F41.8, F41.9, F42, F43.1, F43.2, F43.8, F53.0, or F93.0); OR 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 300; ICD-10: F32, F34.1, F40, F41, F42, F44, F45.0, F45.1, F45.2, F48, F68.0 or F99) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 1 or more physician visits with one of the following diagnosis codes (ICD-9: 296, 311); OR 1 or more physician visits with the following diagnosis code (ICD-9: 300) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 3 or more physician visits with one of the following diagnosis codes (ICD-9: 300, 309). (Mariette Chartier et al., 2016). 	Yes No
Database: Social				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Social Housing	Tenant Management System (TMS)	2004-2018	<ul style="list-style-type: none"> Participants' contacts with the TMS in any year since 2004. 	Yes No

			<ul style="list-style-type: none"> • TMS is used to manage and track clients that reside in social housing managed by Manitoba Housing and Community Development. • Approximately 14,000 residential dwelling units, providing housing to more than 31,000 individuals, families, and seniors in Manitoba. • Data only available up to May 2018. (University of Manitoba, 2018) 	
Employment/Income Assistance (IA) – Family	Social Allowances Management Information Network (SAMIN)	2004-2018/19	<ul style="list-style-type: none"> • Information on employment and income assistance recipients in Manitoba. • All participants living within a family unit that was receiving IA at the time of the study (2018/19), had ever received IA, or received IA at any point over the 5 years preceding the study. • The data set contains one record per person (client) and/or family (case) for each month they are present in the SAMIN database by fiscal year. (University of Manitoba, 2020b) 	Never Currently/over the last 5 years
Database: Registries				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Residential Mobility	Manitoba Health Insurance Registry	2008-2018/19	<ul style="list-style-type: none"> • Movement of a Manitoba Health insurance registrant within the province resulting in a change of postal code but does not affect continuity of eligibility for health insurance (University of Manitoba, 2008). • Affirmative rating if participants' family moved residences ≥ 3 times within 10-person-years prior to the start of the study. 	Yes No
Income Quintile	Canada Census	2006-2018/19	<ul style="list-style-type: none"> • Income quintiles are identified using postal codes, which are linked to the median neighbourhood income. This information is divided into rural and urban and given a score of 1-5, with 1 representing the lowest income quintile and 5 the highest. 	Q1 (lowest) Q2 Q3 Q4 Q5 (highest)

			<ul style="list-style-type: none">• Quintiles are based on dissemination area (DA)-level average household income. Each person within a DA is “attributed” the average household income of the DA.• Area-level (not individual) income measure. (University of Manitoba, 2013)	
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Supplement 5. Multicollinearity checks for the outcome variable food security

Correlation coefficient matrix

Variables	Region	Sex	Social Housing	Residential Mobility	Income Quintile	Income Assistance	Location PM Snack ¹	Frequency of Family Dinner	Frequency of Breakfast	Frequency of Lunch	Self-reported Health
Region	1	-0.068	-0.021	0.064	-0.084	-0.076	-0.040	0.059	-0.050	0.020	-0.015
Sex	-0.068	1	0.012	-0.043	-0.046	-0.012	0.016	0.086	0.211	0.045	0.168
Social Housing	-0.021	0.012	1	0.106	-0.116	0.440	-0.027	0.046	0.007	-0.009	0.055
Residential Mobility	0.064	-0.043	0.106	1	-0.091	0.168	0.016	0.049	0.042	0.017	0.097
Income Quintile	-0.084	-0.046	-0.116	-0.091	1	-0.188	-0.008	0.025	-0.028	-0.002	-0.054
Income Assistance	-0.076	-0.012	0.440	0.168	-0.188	1	0.016	-0.008	0.060	-0.072	0.059
Location PM Snack ¹	-0.04	0.016	-0.027	0.016	-0.008	0.016	1	0.018	0.020	-0.013	-0.058
Frequency of Family Dinner	0.059	0.086	0.046	0.049	0.025	-0.008	0.018	1	0.248	0.255	0.159
Frequency of Breakfast	-0.050	0.211	0.007	0.042	-0.028	0.060	0.020	0.248	1	0.234	0.179
Frequency of Lunch	0.020	0.045	-0.009	0.017	-0.002	-0.072	-0.013	0.255	0.234	1	0.141
Self-reported Health	-0.015	0.168	0.055	0.097	-0.054	0.059	-0.058	0.159	0.179	0.141	1

Cell value: Spearman rho correlation coefficients.

¹Afternoon snack

Collinearity statistics for the outcome variable food security

Variables	Collinearity Statistics	
	Tolerance	VIF¹
Region	0.949	1.054
Sex	0.927	1.080
Social Housing	0.775	1.291
Residential Mobility	0.952	1.050
Income Quintile	0.927	1.079
Income Assistance	0.730	1.370
Location PM Snack ²	0.988	1.012
Frequency of Family Dinner	0.947	1.055
Frequency of Breakfast	0.920	1.087
Frequency of Lunch	0.960	1.042
Self-reported Health	0.920	1.087

¹Variance Inflation Factor

²Afternoon snack

Supplement 6. Unadjusted and adjusted multivariable logistic regression models of youth food security status (PHIN Subsample cohort, n=909¹)

Covariates	Unadjusted OR (95% CL)	Fully Adjusted OR (95% CL)
Region (ref=urban)		
Northern	0.352 (0.216-0.573)*	0.212 (0.115-0.389)*
Rural	2.081 (1.113-3.890)*	2.101 (1.107-4.325)*
Sex (ref=male)		
Female	1.002 (0.725-1.384)	1.259 (0.866-1.836)
Social Housing (ref=no)		
Currently/over last 5 yrs	0.206 (0.094-0.453)*	0.375 (0.136-1.018)
Self-reported Health (ref= Excellent/Very good)		
Fair/Poor	0.485 (0.349-0.675)*	0.641 (0.438-0.938)*
Residential Mobility (ref=no)		
Yes	0.482 (0.343-0.677)*	0.698 (0.476-1.030)
Income Quintile (ref=Q1)		
Q2	0.960 (0.589-1.564)	0.833 (0.482-1.431)
Q3	1.474 (0.871-2.496)	1.136 (0.637-2.031)
Q4	2.029 (1.178-3.494)*	2.315 (1.239-4.403)*
Q5	1.991 (1.207-3.283)*	2.566 (1.409-4.726)*
Receiving Income Assistance (ref=never)		
Currently/over last 5 yrs	0.348 (0.211-0.574)*	0.705 (0.365-1.397)
Frequency of Breakfast (ref=5+ days/wk)		
0-4d/wk	0.787 (0.565-1.096)	1.11 (0.750-1.652)
Missing	0.402 (0.115-1.398)	0.905 (0.182-6.756)
Frequency of Lunch (ref=5+ days/wk)		
0-4d/wk	0.477 (0.322-0.707)*	0.563 (0.357-0.895)*
Missing	0.465 (0.271-0.798)*	0.501 (0.267-0.967)*
Family Dinner Frequency (ref=5+ days/wk)		
0-4d/wk	0.424 (0.297-0.606)*	0.470 (0.314-0.706)*
Missing	0.292 (0.141-0.604)*	0.299 (0.130-0.711)*
Location of Afternoon Snack (ref=home)		
School/Other	0.666 (0.468-0.947)*	0.589 (0.397-0.870)*
Missing	1.117 (0.688-1.815)	1.483 (0.866-2.615)

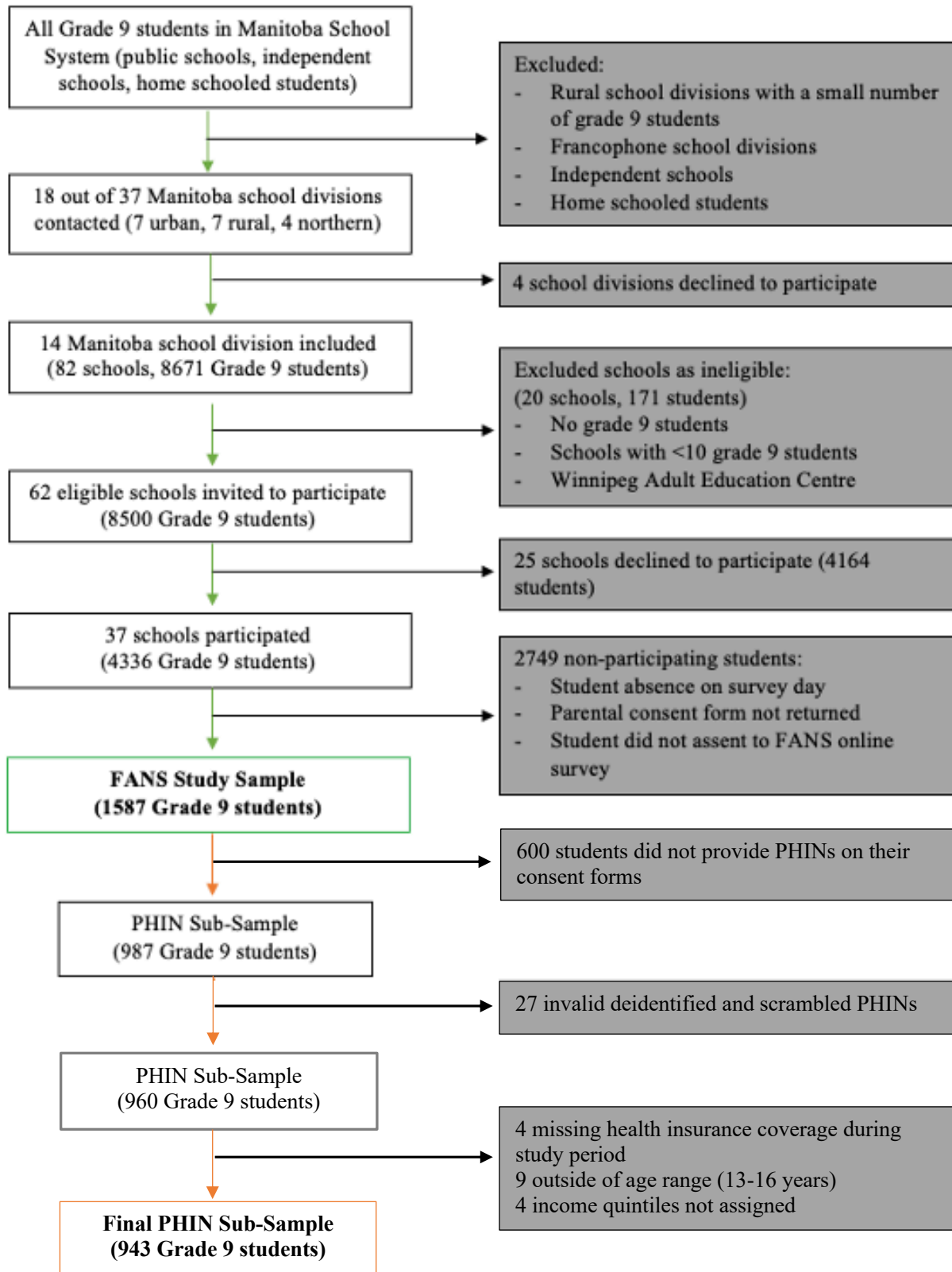
PHIN, Personal health identification number; OR, Odds ratio; CL, confidence limit

¹total n reduced from 943 due to incomplete food security composite scores

*Significant (p≤0.05)

Appendix N: Supplemental Material, Chapter 5

Supplement 1. Sampling strategy and study cohorts



Supplement 2. RECORD checklist of recommendations for the reporting of studies conducted using routinely collected data

	Item No.	Recommendations	Location in manuscript where items are reported
Title and abstract			
	1	1.1 The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.	Title and abstract (page 116-118)
		1.2 If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.	Abstract (page 117-118)
		1.3 If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Title and Abstract (page 116-118)
Introduction			
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction (pages 119-120)
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction (page 119)
Methods			
Study Design	4	Present key elements of study design early in the paper	Methods (pages 121-122)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (page 121-123)
Participants	6	6.1 The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.	Appendix N, Supplement 1 (page 287)
		6.2 Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	Appendix N, Supplement 4b (pages 295-297) for definitions of linked variables n/a for FANS cohort variables
		6.3 If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	Appendix N, Supplement 1 (page 287)

Variables	7	A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Appendix N, Supplement 3a, 3b, 4a, 4b (pages 292-297)	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods (pages 121-123) Appendix N, Supplement 3a, 3b, 4a, 4b (pages 292-297)	
Bias	9	Describe any efforts to address potential sources of bias	Methods (pages 121,124)	
Study size	10	Explain how the study size was arrived at	Methods (page 121) Appendix N, Supplement 1 (page 287)	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	Methods (pages 124-126) Appendix N, Supplement 3a, 3b, 4a, 4b (pages 292-297)	
Statistical methods	12	12.1 Describe all statistical methods, including those used to control for confounding	Methods (pages 127-128) Appendix N, Supplement 5 (page 298-299) and 6 (300)	
		12.2 Describe any methods used to examine subgroups and interactions	Methods (page 122)	
		12.3 Explain how missing data were addressed	Methods (pages 124-125)	
		12.4 If applicable, explain how loss to follow-up was addressed	Not applicable	
		12.5 If applicable, explain how matching of cases and controls was addressed	Not applicable	
		12.6 If applicable, describe analytical methods taking account of sampling strategy	Methods (page 122)	
		12.7 Describe any sensitivity analyses	Methods (page 127)	
		Data access and cleaning methods	12.8 Authors should describe the extent to which the investigators had access to the database population used to create the study population.	Appendix N, Supplement 4b (page 295-297)
			12.9 Authors should provide information on the data cleaning methods used in the study.	Methods (page 122) Appendix N, Supplement 3a, 3b, 4a (pages 292-294)
		Linkage		12.10 State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.

Results			
Participants	13	Describe in detail the selection of the persons included in the study (<i>i.e.</i> , study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Appendix N, Supplement 1 (page 287)
Descriptive data	14	14.1 Give characteristics of study participants (<i>e.g.</i> , demographic, clinical, social) and information on exposures and potential confounders	Results (pages 128-133) Tables 5-1 (page 129), 5-2 (page 130), 5-3 (page 131), 5-4 (132), 5-5 (133)
		14.2 Indicate the number of participants with missing data for each variable of interest	Tables 5-1 (page 129), 5-2 (page 130), 5-3 (page 131), 5-5 (133)
		14.3 Summarize follow up time (average and total)	Not applicable
Outcome data	15	Report numbers of outcome events or summary measures	Tables 5-1 (page 129), 5-2 (page 130), 5-3 (page 131), 5-5 (133)
Main results	16	16.1 Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (<i>e.g.</i> , 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Figure 5.1 (page 134) Appendix N, Supplement 6 (page 300)
		16.2 Report category boundaries when continuous variables were categorized	Table 5-4 (page 132)
		16.3 If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done— <i>e.g.</i> , analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion (page 135)
Limitations	19	Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Discussion (pages 140-141)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses,	Discussion (pages 135-141)

		results from similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	Discussion (page 140)
Other Information			
Funding	22	22.1 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable for this dissertation
Accessibility of protocol, raw data, and programming code		22.2 Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Not applicable for this dissertation

Notes: Checklist Reference: Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press. Checklist is protected under Creative Commons Attribution (CC BY) license.

Supplement 3a. Exposure variable - nine-item child food security survey module^a

Status ^b	Raw Score	Interpretation	Categories for Analysis
Food Secure	0-1	No concerns related to food access	Food Secure
Moderately Food Insecure	2-5	Some indication of concern of food quantity and compromised quality due to financial constraints, hunger not present	Food Insecure
Severely Food Insecure	≥6	Disrupted eating pattern and/or reduced food intake, hunger is evident	

^aValid and reliable tool for measuring food security in children ≥12 years of age in North America (Connell et al., 2004)

^bParticipants with more than two missing responses were excluded from analysis

Supplement 3b. Exposure variable – diet quality

Variable	Variable Type	Categories for Analysis
HEI-C ^a	Continuous (0-100)	n/a
HEI-C ^a	Categorical	Poor (HEI Score <50) Needs Improvement (HEI Score 50-80) Good (HEI Score >80)

^aHealthy Eating Index Canada

Supplement 4. Covariate Definitions

Supplement 4a. FANS survey variables

Participant Characteristics			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Sex ^a	Categorical	Male Female Other	Male Female
Region ^b	Categorical	Urban Rural Northern	Urban Rural Northern
Health Indicators			
Variable	Variable Type	Survey Response Options	Categories for Analysis
BMI ^c	Categorical	n/a	Underweight Healthy Weight Overweight/Obese
Self-rated Health	Categorical	Excellent Very good Fair Poor	Excellent/Very Good Fair/Poor
Intentional Weight Loss ^d	Categorical	Definitely not Not really Kind of Yes	No Yes
Intentional Weight Gain ^d	Categorical	Definitely not Not really Kind of Yes	No Yes
Adequate Sleep for Age ^e	Categorical	0-24 hours	Yes No
Food Behaviours			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Frequency of Breakfast	Categorical	Every day 5-6 days a week 2-4 days a week	0-4 days/week 5-7 days/week

		0-1 days a week	
Frequency of Lunch	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Family Dinner Frequency	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Location of Breakfast	Categorical	Home School Away from home or school	Home School/Other
Location of Lunch	Categorical	Home School Away from home or school	Home School/Other
Location of Dinner	Categorical	Home School Away from home or school	Home School/Other
Location of Morning Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Afternoon Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Evening Snack	Categorical	Home School Away from home or school	Home School/Other

^aCategory 'other' had too few responses for stratified analysis (n=34). When analyzing entire FANS sample, this category was treated as missing but retained for bivariate analysis. Missing data points were imputed from the Repository when analyzing the PHIN subsample to retain as many observations as possible.

^bFANS survey responses utilized for analysis of both FANS and PHIN cohorts. Region established based on school postal code the participant completed the survey.

^cDerived from self-reported height and weight and categorized using WHO z-scores.

^dResponses 'Definitely not' and 'not really' collapsed to category 'no', 'kind of' and 'yes' collapsed to category 'yes'.

^eYes correlates with meeting Government of Canada minimum recommendations for age (9-11 hours/night for 5-13 years old, 8-10 hours/night for 14-17 years old).

¹Child Food Security Survey Module

²Healthy Eating Index Canada

Supplement 4b. Linked administrative variables

Database: Healthcare				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Mood/Anxiety Disorder	1) Manitoba Adolescent Treatment Centre (MATC) 2) Medical Services (Physician Claims, Hospital Abstracts) 3) Drug Program Information Network (DPIN)	1) 2012-2018/19 2) 2008-2018/19 3) 2007-2018/19	<ul style="list-style-type: none"> 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 296.1-296.8, 300.0, 300.2, 300.3, 300.4, 300.7, 309 or 311; ICD-10: F31-F33, F34.1, F38.0, F38.1, F40, F41.0, F41.1, F41.2, F41.3, F41.8, F41.9, F42, F43.1, F43.2, F43.8, F53.0, or F93.0); OR 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 300; ICD-10: F32, F34.1, F40, F41, F42, F44, F45.0, F45.1, F45.2, F48, F68.0 or F99) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 1 or more physician visits with one of the following diagnosis codes (ICD-9: 296, 311); OR 1 or more physician visits with the following diagnosis code (ICD-9: 300) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 3 or more physician visits with one of the following diagnosis codes (ICD-9: 300, 309). (Mariette Chartier et al., 2016). 	Yes No
Database: Social				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Social Housing	Tenant Management System (TMS)	2004-2018	<ul style="list-style-type: none"> Participants' contacts with the TMS in any year since 2004. 	Yes No

			<ul style="list-style-type: none"> • TMS is used to manage and track clients that reside in social housing managed by Manitoba Housing and Community Development. • Approximately 14,000 residential dwelling units, providing housing to more than 31,000 individuals, families, and seniors in Manitoba. • Data only available up to May 2018. (University of Manitoba, 2018) 	
Employment/Income Assistance (IA) – Family	Social Allowances Management Information Network (SAMIN)	2004-2018/19	<ul style="list-style-type: none"> • Information on employment and income assistance recipients in Manitoba. • All participants living within a family unit that was receiving IA at the time of the study (2018/19), had ever received IA, or received IA at any point over the 5 years preceding the study. • The data set contains one record per person (client) and/or family (case) for each month they are present in the SAMIN database by fiscal year. (University of Manitoba, 2020b) 	Never Currently/over the last 5 years
Database: Registries				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Residential Mobility	Manitoba Health Insurance Registry	2008-2018/19	<ul style="list-style-type: none"> • Movement of a Manitoba Health insurance registrant within the province resulting in a change of postal code but does not affect continuity of eligibility for health insurance (University of Manitoba, 2008). • Affirmative rating if participants' family moved residences ≥ 3 times within 10-person-years prior to the start of the study. 	Yes No
Income Quintile	Canada Census	2006-2018/19	<ul style="list-style-type: none"> • Income quintiles are identified using postal codes, which are linked to the median neighbourhood income. This information is divided into rural and urban and given a score of 1-5, with 1 representing the lowest income quintile and 5 the highest. 	Q1 (lowest) Q2 Q3 Q4 Q5 (highest)

			<ul style="list-style-type: none">• Quintiles are based on dissemination area (DA)-level average household income. Each person within a DA is “attributed” the average household income of the DA.• Area-level (not individual) income measure. (University of Manitoba, 2013)	
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Supplement 5. Multicollinearity checks of explanatory variables of the outcome variable academic achievement

Correlation coefficient matrix

Variables	Region	Sex	Social Housing	Income Quintile	Income Assistance	Frequency of Family Dinner	Food Security	HEI ¹	Frequency of Breakfast	Frequency of Lunch	Mood/Anxiety Disorder
<u>Region</u>	1	-0.068	-0.021	-0.084	-0.076	0.059	0.043	0.093	-0.050	0.021	-0.039
<u>Sex</u>	-0.068	1	0.012	-0.046	-0.012	0.086	-0.001	0.068	0.211	0.045	0.074
<u>Social Housing</u>	-0.021	0.012	1	-0.116	0.440	0.046	-0.126	0.018	0.007	-0.009	0.031
<u>Income Quintile</u>	-0.084	-0.046	-0.116	1	-0.188	0.025	0.118	0.064	-0.028	-0.002	0.002
<u>Income Assistance</u>	-0.076	-0.012	0.440	-0.188	1	-0.008	-0.128	-0.113	0.060	-0.072	0.040
<u>Frequency of Family Dinner</u>	0.059	0.086	0.046	0.025	-0.008	1	0.064	-0.070	0.248	0.255	0.084
<u>Food Security</u>	0.043	-0.001	-0.126	0.118	-0.128	0.064	1	0.039	0.097	0.095	-0.041
<u>HEI¹</u>	0.093	0.068	0.018	0.064	-0.113	-0.070	0.039	1	-0.158	-0.091	-0.106
<u>Frequency of Breakfast</u>	-0.050	0.211	0.007	-0.028	0.060	0.248	0.097	-0.158	1	0.234	0.072
<u>Frequency of Lunch</u>	0.021	0.045	-0.009	-0.002	-0.072	0.255	0.095	-0.091	0.234	1	0.093
<u>Mood/Anxiety Disorder</u>	-0.039	0.074	0.031	0.002	0.040	0.084	-0.041	-0.106	0.072	0.093	1

Cell value: Spearman rho correlation coefficients.

¹Healthy Eating Index

Collinearity statistics for the outcome variable academic achievement

Variables	Collinearity Statistics	
	Tolerance	VIF¹
Region	0.935	1.070
Sex	0.943	1.061
Social Housing	0.822	1.217
Income Quintile	0.925	1.081
Income Assistance	0.793	1.261
Frequency of Family Dinner	0.886	1.128
Food Security	0.903	1.108
HEI ²	0.918	1.089
Frequency of Breakfast	0.827	1.209
Frequency of Lunch	0.886	1.129
Mood/Anxiety Disorder	0.966	1.035

¹Variance Inflation Factor

²Healthy Eating Index

Supplement 6. Unadjusted vs adjusted multivariable logistic regression model of youth academic achievement (PHIN Subsample cohort, n=847)

Outcome academic achievement¹ Reference = \geq8 Grade 9 Credits	Unadjusted OR (95% CL)	Adjusted OR (95% CL)
Food Security (ref=Food secure) Food insecure	0.341 (0.205-0.569)*	0.452 (0.250-0.831)*
Region (ref=urban) Northern Rural	0.280 (0.144-0.543)* 0.392 (0.209-0.738)*	0.338 (0.150-0.779)* 0.367 (0.185-0.755)*
Sex (ref=Male) Female	1.334 (0.816-2.179)	1.583 (0.922-2.747)
Receiving Income Assistance (ref=never) Currently/over last 5 years	0.178 (0.096-0.328)*	0.327 (0.154-0.720)*
Social Housing (ref=no) Currently/over last 5 years²	0.165 (0.064-0.424)*	0.405 (0.125-1.417)
Healthy Eating Index	1.032 (1.010-1.055)	1.024 (1.000-1.050)
Family Dinner Frequency (ref=5+ days/week) 0-4d/week Missing	1.151 (0.633-2.093) 0.831 (0.244-2.832)	1.589 (0.828-3.236) 1.323 (0.401-6.139)
Frequency of Breakfast (ref=5+ days/week) 0-4 days/week Missing	0.874 (0.529-1.444) 0.767 (0.095-6.237)	1.311 (0.724-2.422) 2.076 (0.285-44.047)
Frequency of Lunch (ref=5+ days/week) 0-4d/week Missing	0.508 (0.287-0.900)* 0.521 (0.234-1.162)	0.489 (0.252-0.972)* 0.646 (0.270-1.734)
Income (ref=Q1) Q2 Q3 Q4 Q5	1.979 (0.924-4.239) 1.874 (0.874-4.016) 2.486 (1.115-5.542) 1.937 (0.970-3.869)	1.554 (0.689-3.602) 1.422 (0.626-3.319) 1.971 (0.818-4.996) 1.461 (0.647-3.339)
Mood/Anxiety Disorder (ref=no) Yes	0.312 (0.130-0.746)*	0.542 (0.200-1.638)

PHIN, Personal health identification number; OR, Odds ratio; CL, Confidence limit

¹Total number of observations = 847 (not meeting credits =70, meeting credits =777)

²Relative to the study period (October 2018-May 2019)

*Significant ($p \leq 0.05$)

Appendix O: Supplemental Material, Chapter 6

Supplement 1. RECORD checklist of recommendations for the reporting of studies conducted using routinely collected data

	Item No.	Recommendations	Location in manuscript where items are reported
Title and abstract			
	1	1.1 The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.	Title and abstract (page 143-144)
		1.2 If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.	Abstract (page 143-144)
		1.3 If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Title and abstract (page 143-144)
Introduction			
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction (pages 144-146)
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction (page 146)
Methods			
Study Design	4	Present key elements of study design early in the paper	Methods (pages 146-148)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (page 148)
Participants	6	6.1 The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.	Appendix O, Supplement 2 (page 308)
		6.2 Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	Appendix O, Supplement 3b (pages 308-309) for definitions of linked variables n/a for FANS cohort variables
		6.3 If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	Appendix O, Supplement 2 (page 308)

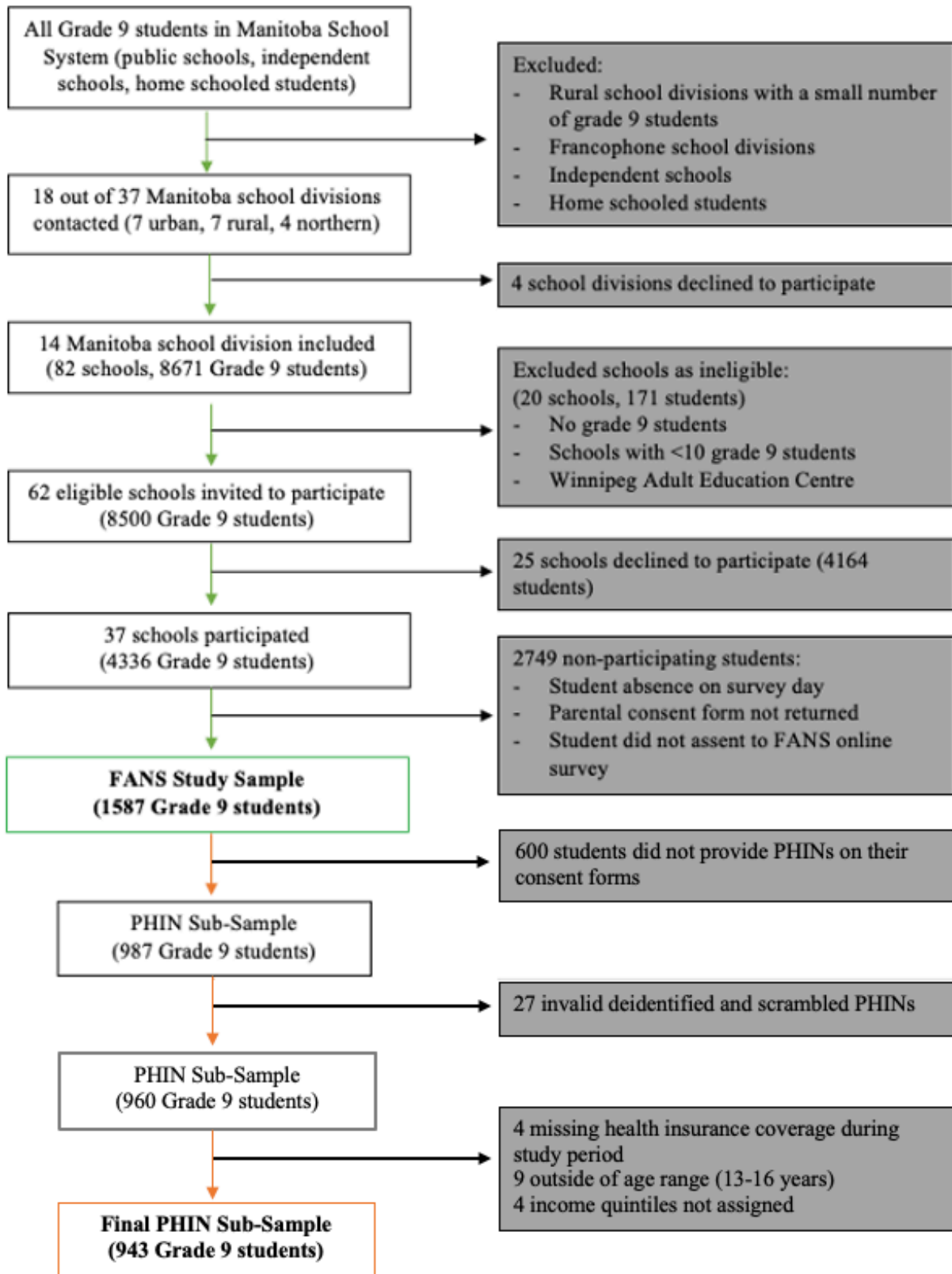
Variables	7	A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Methods (pages 149-152) Appendix O, Supplement 3a, 3b (pages 306-309)
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods (pages 149-152) Appendix O, Supplement 3a, 3b (pages 306-309)
Bias	9	Describe any efforts to address potential sources of bias	Methods (page 149-152)
Study size	10	Explain how the study size was arrived at	Methods (page 149) Appendix O, Supplement 2 (page 305)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	Methods (pages 149-152)
Statistical methods	12	12.1 Describe all statistical methods, including those used to control for confounding	Methods (page 148-149), Appendix O, Supplement 4 (page 310-311)
		12.2 Describe any methods used to examine subgroups and interactions	Methods (page 149)
		12.3 Explain how missing data were addressed	Methods (pages 149-152)
		12.4 If applicable, explain how loss to follow-up was addressed	Not applicable
		12.5 If applicable, explain how matching of cases and controls was addressed	Not applicable
		12.6 If applicable, describe analytical methods taking account of sampling strategy	Methods (page 149)
		12.7 Describe any sensitivity analyses	Methods (page 152)
Data access and cleaning methods		12.8 Authors should describe the extent to which the investigators had access to the database population used to create the study population.	Appendix O, Supplement 3b (pages 308-309)
		12.9 Authors should provide information on the data cleaning methods used in the study.	Appendix O, Supplement 3a, 3b (pages 306-309)
Linkage		12.10 State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and	Methods (pages 151-152) Appendix O, Supplement 3b (pages 308-309)

		methods of linkage quality evaluation should be provided.	
Results			
Participants	13	Describe in detail the selection of the persons included in the study (<i>i.e.</i> , study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Appendix O, Supplement 2 (page 305)
Descriptive data	14	14.1 Give characteristics of study participants (<i>e.g.</i> , demographic, clinical, social) and information on exposures and potential confounders	Results (pages 153-159) Tables 6-1 (page 154), 6-2 (page 156), 6-3 (pages 158-159), 6-4 (160)
		14.2 Indicate the number of participants with missing data for each variable of interest	Tables 6-1 (page 154), 6-2 (page 156), 6-3 (pages 158-159), Supplement 2 (page 305)
		14.3 Summarize follow up time (average and total)	Not applicable
Outcome data	15	Report numbers of outcome events or summary measures	Tables 6-1 (page 154), 6-2 (page 156), 6-3 (pages 158-159), 6-4 (160)
Main results	16	16.1 Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (<i>e.g.</i> , 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 6-2 (page 156), 6-3 (pages 158-159), 6-4 (160), Figure 6-1 (page 162)
		16.2 Report category boundaries when continuous variables were categorized	Not applicable
		16.3 If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done— <i>e.g.</i> , analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion (page 163)
Limitations	19	Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Discussion (pages 167-168)

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion (pages 167-168)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Discussion (page 167)
Other Information			
Funding	22	22.1 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable for this dissertation
Accessibility of protocol, raw data, and programming code		22.2 Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Not applicable for this dissertation

Notes: Checklist Reference: Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press. Checklist is protected under Creative Commons Attribution ([CC BY](https://creativecommons.org/licenses/by/4.0/)) license.

Supplement 2. Sampling strategy and study cohorts



Supplement 3. Covariate Definitions

Supplement 3a. FANS survey variables

Participant Characteristics			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Sex ^a	Categorical	Male Female Other	Male Female
Region ^b	Categorical	Urban Rural Northern	Urban Rural Northern
Food Security^c			
Classification	Variable Type	Survey Response Options	Categories for Analysis
Food Secure	Count	0-1 Affirmative Responses	Food Secure
Moderately Food Insecure	Count	2-5 Affirmative Responses	Food Insecure
Severely Food Insecure	Count	≥6 Affirmative Responses	
Health Indicators			
Variable	Variable Type	Survey Response Options	Categories for Analysis
BMI ^d	Categorical	n/a	Underweight Healthy Weight Overweight/Obese
Self-rated Health	Categorical	Excellent Very good Fair Poor	Excellent/Very Good Fair/Poor
Intentional Weight Loss ^e	Categorical	Definitely not Not really Kind of Yes	No Yes
Intentional Weight Gain ^e	Categorical	Definitely not Not really Kind of Yes	No Yes
Adequate Sleep for Age ^f	Categorical	0-24 hours	Yes No

Food Behaviours			
Variable	Variable Type	Survey Response Options	Categories for Analysis
Frequency of Breakfast	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Frequency of Lunch	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Family Dinner Frequency	Categorical	Every day 5-6 days a week 2-4 days a week 0-1 days a week	0-4 days/week 5-7 days/week
Location of Breakfast	Categorical	Home School Away from home or school	Home School/Other
Location of Lunch	Categorical	Home School Away from home or school	Home School/Other
Location of Dinner	Categorical	Home School Away from home or school	Home School/Other
Location of Morning Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Afternoon Snack	Categorical	Home School Away from home or school	Home School/Other
Location of Evening Snack	Categorical	Home School Away from home or school	Home School/Other

^aCategory 'other' had too few responses for stratified analysis (n=34). When analyzing entire FANS sample, this category was treated as missing but retained for bivariate analysis. Missing data points were imputed from the Repository when analyzing the PHIN subsample to retain as many observations as possible.

^bFANS survey responses utilized for analysis of both FANS and PHIN cohorts. Region established based on school postal code the participant completed the survey.

^cMeasured using valid and reliable tool for assessing food security in children ≥ 12 years of age in the North American Context (Connell et al., 2004). Question responses included 'a lot', 'sometimes', 'never'. 'A lot' = affirmative response.

^dDerived from self-reported height and weight and categorized using WHO z-scores.

^eResponses 'Definitely not' and 'not really' collapsed to category 'no', 'kind of' and 'yes' collapsed to category 'yes'.

^fYes correlates with meeting Government of Canada minimum recommendations for age (9-11 hours/night for 5-13 years old, 8-10 hours/night for 14-17 years old).

Supplement 3b. Linked administrative variables

Database: Healthcare				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Mood/Anxiety Disorder	1) Manitoba Adolescent Treatment Centre (MATC) 2) Medical Services (Physician Claims, Hospital Abstracts) 3) Drug Program Information Network (DPIN)	1) 2012-2018/19 2) 2008-2018/19 3) 2007-2018/19	<ul style="list-style-type: none"> 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 296.1-296.8, 300.0, 300.2, 300.3, 300.4, 300.7, 309 or 311; ICD-10: F31-F33, F34.1, F38.0, F38.1, F40, F41.0, F41.1, F41.2, F41.3, F41.8, F41.9, F42, F43.1, F43.2, F43.8, F53.0, or F93.0); OR 1 or more hospitalizations with one of the following diagnosis codes (ICD-9: 300; ICD-10: F32, F34.1, F40, F41, F42, F44, F45.0, F45.1, F45.2, F48, F68.0 or F99) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 1 or more physician visits with one of the following diagnosis codes (ICD-9: 296, 311); OR 1 or more physician visits with the following diagnosis code (ICD-9: 300) AND 1 or more prescriptions for an antidepressant or mood stabilizer (ATC codes N05AN01, N05BA, N06A, N05BE01); OR 3 or more physician visits with one of the following diagnosis codes (ICD-9: 300, 309). <p>(Mariette Chartier et al., 2016).</p>	Yes No
Database: Social				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Social Housing	Tenant Management System (TMS)	2004-2018	<ul style="list-style-type: none"> Participants' contacts with the TMS in any year since 2004. TMS is used to manage and track clients that reside in social housing managed by Manitoba Housing and Community Development. Approximately 14,000 residential dwelling units, providing housing to more than 31,000 individuals, families, and seniors in Manitoba. 	Yes No

			<ul style="list-style-type: none"> Data only available up to May 2018. (University of Manitoba, 2018) 	
Employment/Income Assistance (IA) – Family	Social Allowances Management Information Network (SAMIN)	2004-2018/19	<ul style="list-style-type: none"> Information on employment and income assistance recipients in Manitoba. All participants living within a family unit that was receiving IA at the time of the study (2018/19), had ever received IA, or received IA at any point over the 5 years preceding the study. The data set contains one record per person (client) and/or family (case) for each month they are present in the SAMIN database by fiscal year. (University of Manitoba, 2020b) 	Never Currently/over the last 5 years
Database: Registries				
Variable	Datasets	Years Accessed	Description	Categories for Data Analysis
Residential Mobility	Manitoba Health Insurance Registry	2008-2018/19	<ul style="list-style-type: none"> Movement of a Manitoba Health insurance registrant within the province resulting in a change of postal code but does not affect continuity of eligibility for health insurance (University of Manitoba, 2008). Affirmative rating if participants’ family moved residences ≥ 3 times within 10-person-years prior to the start of the of the study. 	Yes No
Income Quintile	Canada Census	2006-2018/19	<ul style="list-style-type: none"> Income quintiles are identified using postal codes, which are linked to the median neighbourhood income. This information is divided into rural and urban and given a score of 1-5, with 1 representing the lowest income quintile and 5 the highest. Quintiles are based on dissemination area (DA)-level average household income. Each person within a DA is “attributed” the average household income of the DA. Area-level (not individual) income measure. (University of Manitoba, 2013) 	Q1 (lowest) Q2 Q3 Q4 Q5 (highest)

Supplement 4. Multicollinearity checks of explanatory variables of the outcome variable diet quality

Correlation coefficient matrix

Variables	Region	Sex	Income Assistance	Adequate Sleep	Food Security	Breakfast Location	Lunch Location	BMI ¹	Self-reported Health	Frequency of Breakfast	Frequency of Lunch	Frequency of Family Dinner	Eating Less to Lose Weight	Mood/Anxiety Disorder
<u>Region</u>	1	-0.068	-0.076	0.033	0.043	0.045	0.028	-0.109	-0.017	-0.050	0.020	0.059	-0.001	-0.039
<u>Sex</u>	-0.068	1	-0.012	0.154	-0.001	0.042	0.025	-0.088	0.153	0.211	0.045	0.086	0.117	0.074
<u>Income Assistance</u>	-0.076	-0.012	1	-0.033	-0.128	0.025	0.022	0.048	0.034	0.060	-0.072	-0.008	0.009	0.040
<u>Adequate Sleep</u>	0.033	0.154	-0.033	1	-0.072	0.034	-0.014	0.027	0.187	0.210	0.109	0.133	0.090	0.025
<u>Food Security</u>	0.043	-0.001	-0.128	-0.072	1	-0.060	0.016	-0.013	0.042	0.097	0.095	0.064	-0.037	-0.041
<u>Breakfast Location</u>	0.045	0.042	0.025	0.034	-0.060	1	0.117	0.027	-0.050	0.144	0.022	-0.013	0.028	-0.036
<u>Lunch Location</u>	0.028	0.025	0.022	-0.014	0.016	0.117	1	-0.014	-0.019	-0.014	0.028	-0.04	0.055	0.023
<u>BMI¹</u>	-0.109	-0.088	0.048	0.027	-0.013	0.027	-0.014	1	-0.008	0.010	0.074	0.033	-0.140	0.064
<u>Self-reported Health</u>	-0.017	0.153	0.034	0.187	0.042	-0.050	-0.019	-0.008	1	0.286	0.253	0.268	0.151	0.091
<u>Frequency of Breakfast</u>	-0.050	0.211	0.060	0.210	0.097	0.144	-0.014	0.010	0.286	1	0.234	0.248	0.076	0.072
<u>Frequency of Lunch</u>	0.020	0.045	-0.072	0.109	0.095	0.022	0.028	0.074	0.253	0.234	1	0.255	0.056	0.093
<u>Frequency of Family Dinner</u>	0.056	0.086	-0.008	0.133	0.064	-0.013	-0.040	0.033	0.268	0.248	0.255	1	0.003	0.084
<u>Eating Less to Lose Weight</u>	-0.001	0.117	0.009	0.090	-0.037	0.028	0.055	-0.140	0.151	0.076	0.056	0.003	1	0.028
<u>Mood/Anxiety Disorder</u>	-0.039	0.074	0.040	0.025	-0.041	-0.036	0.023	0.064	0.091	0.072	0.093	0.084	0.028	1

Cell value: Spearman rho correlation coefficients.

¹Body Mass Index

Collinearity statistics for the outcome variable academic achievement

Variables	Collinearity Statistics	
	Tolerance	VIF¹
Region	0.950	1.052
Sex	0.909	1.100
Income Assistance	0.940	1.064
Adequate Sleep	0.907	1.103
Food Security	0.945	1.058
Breakfast Location	0.951	1.051
Lunch Location	0.977	1.023
BMI ²	0.952	1.050
Self-reported Health	0.877	1.140
Frequency of Breakfast	0.873	1.146
Frequency of Lunch	0.941	1.062
Frequency of Family Dinner	0.922	1.084
Eating Less to Lose Weight	0.952	1.051
Mood/Anxiety Disorder	0.962	1.040

¹Variance Inflation Factor

²Body Mass Index