# University of Alberta

The Relationship Between Diet Quality and Mental Health in Canadian Children

by

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## Abstract

Mental health disorders are a significant problem facing children. Emerging research suggests there is a link between nutrition and mental health. This thesis examines the association between diet quality and mental health in children.

The first objective was to examine the cross-sectional relationship between feeling worried, sad or unhappy and diet quality in grade 5 students. This study found that diet quality was significantly associated with lower odds of feeling worried, sad or unhappy. The second objective was to determine the directionality of the relationship, which examined the relationship between diet quality and internalizing disorders over a period of three years. This study found that children with greater variety in their diet had significantly lower rates of internalizing disorder in subsequent years

The present findings suggest that quality of the diet rather than specific nutrients may be implicated in the development of mental health disorders. This has important implications due to the modifiable nature of individual diet. Intervention and longitudinal studies are needed to expand on the present findings.

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| | |
|---|---|
| WHO | World Health Organization |
| FFQ | Food Frequency Questionnaire |
| DQI-I | Diet Quality Index-International |
| CBCL | Canadian Behaviour Checklist |
| REAL Kids Study | Raising Healthy Eating and Active Living Kids Study |
| CLASS | Children's Lifestyle and School Performance Study |
| HBSC | Health Behaviour in School-Aged Children Survey |
| YAQ | Harvard Food Frequency Questionnaire for Children and Youth |
| HRQOL | Health Related Quality of Life |
| PAQ-C | Physical Activity Questionnaire for Children |
| VAS | Visual Analogue Scale |

# Chapter 1: Introduction

## 1.1.0 Introduction

Mental health disorders are a significant problem facing children across Canada[1] and the globe[2]. These disorders may take many forms and encompass a wide range of disorders ranging from mood and anxiety disorders to hyperactivity disorders and psychosis[3]. Mental health disorders are defined by subjective distress or disability associated with impairment of an individual's normal cognitive, emotional or behavioural functioning [3]. Mental health disorders in children are associated with many short and long term consequences. Poor mental health in childhood has been linked to aggressive behaviour, substance use and abuse, suicidal behaviour and poor sexual health in adolescence[1,2,4]. In addition, mental health disorders have been shown to have adverse effects on the child's social development and educational achievement[2]. Therefore, mental health disorders in childhood and early adolescence may result in many personal and social costs[5].

### 1.1.1 Epidemiology of Mental Health Disorders

According to the WHO, mental health disorders are the leading cause of disability in the United States and Canada[6]. Mental health disorders account for 28% of the total number of years of life lost to illness, disability or premature death[6]. This is a pertinent issue in today's society considering the total economic and personal burden associated with mental health disorders[7]. Mental health

disorders are common across all ages, ethnic groups and gender. There is evidence that the prevalence of mental health disorders in children and youth is increasing[8]. Mental health disorders can be extremely disabling, especially in this age group. In a study from Victoria, Australia, approximately 35-47% of the total years of life lost due to illness, disability or premature death in men and women aged 15-34 years was due to mental health disorders[9]. Therefore, mental health disorders have a large impact on the disease burden in young people.

Three separate studies performed in the United States and Australia found the prevalence of mental health disorders among adolescents to be between 3 and 14%[10-12]. There is evidence that suggests many adults suffering from mental health disorders first experienced mental health problems in late childhood and adolescence[2 ,13-16]. This suggests that childhood and adolescent mental health disorders are important predictors for future mental illness. It is important to focus research in the area of childhood and adolescent mental health to not only improve quality of life but also help prevent future disability from poor mental health.

Mood disorders are complex disorders with no known cause. They affect the way an individual feels and have the potential to change the way they think, act and how the body functions[17]. According to the WHO, unipolar depression is the leading cause of disability in the United States and Canada[18]. Unipolar depression accounts for 7.5% of the total number of years lost to illness, disability or premature death in this region[18]. Therefore, depression alone has a large impact on the quality of life of Canadians. In the 2002 Mental Health and Well-

being survey by Statistics Canada, 5.3% of Canadians over the age of 15 had reported symptoms of a mood disorder in the previous twelve months and 4.8% for major depression[19]. Survey results also report 1 in 7 Canadian adults had symptoms of depression at some point during their lifetime[19].

In the past, people believed that children and adolescents were not affected by mental health disorders. This is a common misconception and research now supports that depression is prevalent among children and adolescents. From a nationally representative study performed in the United States the lifetime prevalence of any anxiety or major depressive disorder in adolescents aged 13-18 years old to be 31.9% and 11.7%, respectively[20]. Therefore, depression and anxiety disorders contribute largely to the burden of mental health disorders in adolescents[21]. Mood disorders are a serious concern because of their high prevalence, increased risk for suicide, economic burden and reduced quality of life[19]. Therefore, research needs to focus on improving the mental health of Canadians.

### 1.1.2 Measuring Mental Health Disorders in Children

Over the past twenty years the realization that children are capable of providing reliable information about their own mental health has resulted in changes in the assessment of mental health disorders in children[22]. The main categories of mental health disorders affecting children include emotional and disruptive disorders. Emotional disorders in children are similar to those of adults including depression, anxiety, phobias and obsessive-compulsive disorder[23]. Disruptive disorders including conduct disorders and hyperactivity disorders are

more limited to children[23]. Measuring mental health disorders in specific groups for example, children, elderly, or cognitively impaired require special considerations. Diagnostic assessments, instruments or rating scales need to be tailored to accommodate the needs of the particular group[3].

Mental health disorders in children and adolescents is assessed through interviews and observing the child's behavior as well as self-report and screening questionnaires. Younger children often rely on the parents and/or guardians to report on the child's mental health status[3]. However, older children and adolescents can often undergo the diagnostic interview on their own[3]. Research demonstrates that most children under the age of nine are not capable of providing reliable information regarding the timing, onset, duration and severity of symptoms[22]. However, they have been shown to provide reliable information about mood, feelings and anti-social behaviour[22]. There are numerous semi-structured interviews that are used and have been designed to identify mental health disorders among children[3]. These typically fall into two categories: those designed for use in a clinical setting and thus need a clinician to perform the interview and those designed only for epidemiological research and do not need a clinician[3].

Another effective tool for identifying mental health disorders among children is self-report and screening questionnaires[3]. Self-report and screening questionnaires are very effective because they are quick and relatively easy to administer[3]. These may be completed by the child, or when examining younger children by the parent/guardian or teacher[3].

### 1.2.0 Nutrition of Canadian Children

Over the past four decades there has been a gradual change in the dietary habits of children. There has been an abundance of high calorie and low nutrient foods available to children[24]. Eating Well with Canada's Food Guide is an education tool developed by Health Canada to ensure Canadians are meeting nutrient standards thereby preventing nutrition-related chronic diseases[25]. Canada's food guide was first developed in 1942 where its focus was on malnutrition and ensuring Canadians were receiving key nutrients[25]. Since then, it has undergone many revisions to focus on the current nutrition-related issues facing Canadians as well as to make recommendations based on age and gender[25]. Canada's Food Guide recommendations were changed in 2007 and recommend children aged 9 to 13 receive at least 6 servings of fruits and vegetables[25]. Unfortunately, many children are not meeting these requirements. In 2004, the Canadian Community Health Survey found that the majority of Canadian children and adolescents are not receiving adequate nutrition[26]. Of all children aged 4 to 8, 70% were not consuming the recommended number of servings of vegetables and fruits, and one third did not meet the recommendations for milk products [26].

Additional studies among schools in Canadian provinces have also demonstrated that the majority of students are not meeting these recommendations[27-29]. A web-based survey of grade 7-10 students in Alberta and Ontario, Canada, found that almost half, 43% and 47% of students, were considered to have a poor or average diet, respectively [27]. Among grade 5

students in Nova Scotia, 42.3% did not meet the minimum recommendations of Canada's Food Guide for milk products, 49.9% for vegetable and fruit, 54.4% for grain products and 73.7% for meat and alternatives[28]. In 2008, only 27% of grade five students in Alberta, Canada reported consuming at least 6 servings of vegetable and fruit [30]. These results are consistent with a report by the WHO. Based on the Canadian results from the WHO Health Behaviour in School-Aged Children Survey (HBSC), less than 50% of youth reported consuming vegetable and fruit more than once a day[31]. In addition to not meeting recommendations for fruits and vegetables children are also having higher intakes of fat, sugar, salt and calories than what is recommended[28].

Children are not only receiving inadequate servings from each food group but they also have poor eating habits. Students with poor diet quality had a higher frequency of skipping meals and consuming foods away from home[27]. There is also a greater consumption of fast foods, pre-prepared meals, soft drinks and candy among children[32]. Adolescents who frequently consume meals from Fast Food restaurants had higher intakes of energy and fat, along with lower intakes of fruits and vegetables[33]. Numerous studies in the United States have reported that children and adolescents frequently skip breakfast[34-37]. More recently a study from Nova Scotia identified that 3.6% of grade 5 students skip breakfast and that this eating habit was associated with an increased risk of having poor diet quality[28]. Literature supports the concept that individuals who consume breakfast tend to have a better overall diet[38]. As well, several studies suggest that breakfast may play an important role in maintaining normal weight status in children and

youth[38]. Not only are children not meeting nutrition standards established by Health Canada, they also prefer larger portions of unhealthy foods and smaller portions of vegetables than what is recommended[39]. These changes in the eating habits of Canadian children may be contributing to the increase in childhood overweight and obesity.

Unhealthy diets in childhood may impede proper growth and development[40,41]. Therefore, it is important to ensure that Canadian children are receiving adequate nutrition so that they can develop to their full potential. Provinces in Canada are beginning to implement policies to ensure proper nutrition among children and adolescents. School nutrition policies may have a positive impact on students' eating habits and help reduce the rates of childhood overweight and obesity[42,43]. Poor eating habits tend to follow children into adolescence and adulthood[40,41]. This may be influencing the tendency for obesity to persist into adulthood as well[44]. Therefore, early interventions for improving nutrition and dietary habits among children may have important implications for the future adult population.

### 1.3.0 Nutritional Assessment

The area of nutritional epidemiology emerged based on the idea that certain characteristics of the diet or dietary habits may influence disease[45]. The primary focus of nutritional epidemiology has been to evaluate the relationship between diet and major chronic diseases affecting the Western world, particularly its relationship with heart disease and various cancers[45]. However, this area of research has grown and more recently researchers have studied the relationship

between diet and other diseases. For this reason it is important to develop valid and reliable tools to assess diet quality.

Many aspects of the diet can now be measured efficiently and with greater accuracy[45]. These methods include: food intake and biomarkers[45]. Biomarker measurements have most commonly been used as an alternative to actual dietary intake. Specifically, biomarkers are used for nutrients that may vary in their concentrations within foods and when food composition tables are not accurate[45]. Nutrient requirements may differ between individuals based on genetics and lifestyle characteristics[45]. Therefore, biomarker measurement is also useful for identifying whether an individual meets the physiologic requirement for that nutrient[45]. However, the most common methods for assessing diet quality involve food intake measurements.

Information on food consumption is collected for several reasons, for example, estimating whether populations are meeting dietary needs, to examine the relationship between diet and health status and to evaluate the effectiveness of nutrition education and intervention programs[46]. Data on dietary intake is often converted to intakes of specific nutrients either by analyzing foods consumed directly or using food composition tables and nutrient databases[46]. Since epidemiological studies often involve the participation of large populations, directly analyzing foods consumed often isn't feasible, instead food composition tables or nutrient databases are more appropriate[46].

There are several methods used to measure dietary intakes in larger populations. Considering the different methods for assessing diet quality in

epidemiological studies, Food Frequency Questionnaires (FFQ) are most commonly used[45]. FFQs are designed to assess usual dietary intake and eating habits over a period of time. These questionnaires vary in length as well as the number of nutrients or foods they are assessing[45]. Questionnaires are a useful tool because they are consistent, inexpensive and can be administered with ease[45]. The disadvantages of using food frequency questionnaires are related to the development and validation of these tools[45].

Other methods of dietary assessment include 24-hour dietary recall and food record methods. The 24-hour dietary recall method involves an interview about prior dietary intake from the previous day by a trained dietary interviewer[45]. The food record method consists of a detailed diary of all foods consumed in the previous one or more days. Both of the methods are based on actual intake, are open-ended allowing for incorporation of a wide variety of foods and unlimited specificity with regards to the type of foods, source of foods, as well as preparation[45]. These methods are particularly useful in culturally diverse studies[45]. These methods are unlikely to be representative of an individual's usual dietary intake because data is only available on a single day or a few days of intake [45]. To assess usual dietary intake using these methods would require multiple collections and would be very time consuming and expensive[45].

It is important to consider the study design when choosing an appropriate dietary assessment tool. In a cross-sectional study design you are looking at the relationship between an exposure and outcome at a certain point in time. For this reason, 24-hour recall methods are appropriate because it allows for the

assessment of average daily food and nutrient intake[47]. FFQ's have also been used in these studies to provide data on usual dietary intake[47]. In a cohort study you are interested in dietary intake at baseline and its relationship with the outcome at a later point in time. Therefore, a measure of usual dietary intake for example using a FFQ is needed[47]. However, dietary intake may change over time, for studies with long follow-up periods it is important to assess dietary intake at multiple points in time[47]. Multiple dietary recalls, diet records, diet histories and FFQ methods have all been used in cohort studies[47].

Another important aspect to consider is the population being studied. For example, there are different considerations that need to be addressed for elderly populations, ethnic populations and children. Children's diets are often more difficult to assess due to variability from day to day and potential for rapid change in dietary habits[47]. Obtaining diet quality information from children is often difficult mainly because children at younger ages have lower literacy, difficulties estimating portion sizes and limited cognitive abilities[48]. Cognitive abilities that are essential to accurately report food intake include a developed concept of time, good memory, good attention span and a broad knowledge of food names[48,49].

Evidence suggests that children under the age of 8 are unable to accurately recall foods, portion size and can't conceptualize frequency of food consumption[48]. For this reason, in young children the parent or guardian is often asked to report on the child's dietary habits[47]. In addition, children are generally not involved in food preparation methods and often require the help of a parent/guardian to report on dietary intake[50]. A consensus recall method is

another method of reporting dietary intake and is often more effective because it combines the 24 hour recall responses from both the child and the parent or guardian[51]. Therefore, including the parents/guardians in reporting diet quality often provides a more thorough assessment. However, methods of 24-hour recall, food record and FFQ have all been used in younger populations[47].

### 1.4.0 Diet Quality Index-International (DQI-I)

In the past the issue of malnutrition, in terms of low energy intake, was a serious public health concern. However, in recent years there has been a shift and in many circumstances excess caloric intake has replaced this issue of malnutrition[52]. The DQI-I is an instrument frequently used to measure overall diet quality. It focuses on four aspects of a high quality diet: variety, adequacy, moderation and balance[52]. These four aspects of the diet make up the individual component score of the DQI-I. Most dietary guidelines state that the consumption of a variety of foods in conjunction with an adequate intake of key foods and nutrients is most important in a healthy diet[52].

Each of these four components receives individual scores and also contributes to the overall diet quality score. The variety score is determined based on the consumption of at least one serving from each food group per day[52]. In addition, variety within protein sources is also important for a healthy diet and is determined by receiving a score when protein intake is derived from 3 or more different sources per day[52]. The adequacy score is determined based on the percent that an individual consumes of the recommended amount of specific nutrients[52]. The moderation score is determined based on the excess consumption

of fat, saturated fat, cholesterol and sodium[52]. This component also examines the consumption of 'empty calorie foods'. This means that it assesses the consumption of foods that provide energy but with minimal nutrient value[52]. The Balance score is determined based on the proportion of energy sources and fatty acid composition[52].

### 1.5.0 Link between Mental Health and Nutrition

There is a suggested link between nutrition and mental health, particularly in relation to specific nutrients such as fatty acids and B vitamins. Previous research has explored the association of nutrients including Vitamin B6,[53] Folate,[53] Vitamin B12,[54] and omega-3 fatty acids with mental health.[55,56] The literature suggests that lower levels of these nutrients are associated with mental health problems.

There are several mechanisms that may mediate the relationship between these nutrients and mental health. Lower levels of vitamins B6, B12 and Folate may affect mental health through their involvement in methylation reactions for the production of serotonin and other monoamine neurotransmitters[57]. Omega-3 fatty acids are key components in the structure of central nervous system membranes and are involved in serotonin transport[58]. This may explain their relationship with mental health disorders. With respect to omega-3 fatty acids there is also research examining the ratio of omega-6 / omega-3 fatty acids and its relationship with mental health disorders. An imbalance between omega-3 fatty acids and omega-6 fatty acids has been linked to an increase in depression[59]. This may be due to the drastic changes in Western diets in more recent years with

greater consumption of omega-6 fatty acids in comparison to omega-3 fatty acids[59].

Looking only at specific nutrients to explain the relationship between diet and mental health may be misleading. Examining specific nutrients does not explain the whole picture. A nutrient analysis of an individual's diet focusing on intakes of specific nutrients ignores the synergistic effects between nutrients consumed[52,60]. From a public health perspective, it is more appropriate to examine the overall diet because people do not consume isolated nutrients[52]. There is emerging research in the area of examining overall diet and mental health. Studies have been done in Spain[61], the United Kingdom[62] and Australia[63] that have linked depression and dietary patterns in older populations.

Studies performed in Spain examined the relationship between adherence to the Mediterranean diet with self-reported depression and mental health. The Mediterranean diet is often considered a healthy diet because of its relationship with better quality of life and health status[64,65]. The typical Mediterranean diet consists of a high consumption of plant foods, moderate consumption of alcohol, and low consumption of meat[66]. Research suggests that adherence to the Mediterranean diet may prevent depressive symptoms[61] and improve perceived mental health status[66].

One study performed in the United Kingdom investigated two different dietary patterns and its relationship with self-reported depression five years later using the Center for Epidemiology Studies Depression scale in a middle-aged population[62]. The two different dietary patterns in this study were whole food

versus processed food. The whole food diet consisted primarily of a high consumption of fruits, vegetables and fish[62]. The processed food diet consisted primarily of a high consumption of processed meat, sweetened desserts, fried food, refined grains and high fat dairy[62]. This study found that participants with a high intake of whole food were less likely to report depression five years later[62]. In addition, the odds of depression five years later were higher for those consuming a diet high in processed foods[62].

There is also research supporting the association between dietary patterns and depression in Australia. A recent study examined the cross-sectional association between dietary pattern and depression in Australian woman[63]. The authors found that woman who consumed an unhealthy 'Western diet' had a greater likelihood of psychological symptoms and disorders[63]. A 'Western' diet was comprised of processed and 'unhealthy foods' such as sugar, hamburgers, chips, and processed meat[63].

There is limited research regarding mental health and nutrition in children and young adolescents. It is evident that nutrition plays a major role in proper brain and cognitive development[67]. Therefore, it is of interest to examine the relationship between dietary patterns in children and the development of mental health disorders. A recent study performed in Australia among adolescents approximately 14 years of age assessed whether a Western dietary pattern was associated with poor mental health and behavioural problems[68]. Indicators of poor mental health were assessed using the Child Behaviour Checklist (CBCL) for Ages 4-18. The authors found that adolescents' consuming a Western diet,

which consisted of take-out food, red meat and confectionary, demonstrated higher CBCL scores, indicating poor mental health[68]. However, they saw no relationship with an overall healthy dietary pattern, which was determined by the consumption of vegetables, fruits, whole grains, legumes and fish[68]. A second study conducted in Australian schools aiming to support the previous research, also found that diet was associated with the mental health of the students[69]. Lower consumption of foods promoted by the Dietary Guidelines for Children and Adolescents in Australia paired with a greater consumption of unhealthy and processed foods, was associated with greater odds of self-reported symptomatic depression in adolescents[69].

### 1.6.0 Gaps in Research

There is a limited amount of research in the area of nutrition and mental health, particularly in children. The majority of existing research has focused on the relationship between specific nutrients and mental health disorders. Only a few studies have started to examine the relationship between diet quality and mental health disorders. The Diet Quality Index-International[52] allows for the investigation of not only the overall diet but also examines specific aspects of the diet that may need improvement[52]. Previous research is limited in that it has been unable to identify what aspects of the diet are involved in the development of mental health problems. This thesis will elaborate on the limited amount of research in the area of diet quality and mental health in children.

### 1.7.0 Public Health Implications

The relationship between diet and mental health has important public health implications because an individual's diet is modifiable. One's diet is something that can be altered for the better, however is it evident that unhealthy foods are more available to children and that this determines their food choices. Changes in children's dietary patterns in recent years demonstrate an increase in consumption of foods high in fat and sugar[32]. There is a greater consumption of fast foods, pre-prepared meals, soft drinks and candy among children[32]. The rising prevalence of obesity among children and adolescents may be partially explained by poor dietary habits. It is likely that these changes in children's lifestyle will have implications for health behaviors and health in adulthood, which may include both physical health and mental health. The increase in childhood obesity is troublesome because it tends to follow individuals into adulthood and is associated with many physical[70,71] and mental[72,73] health problems.

It is important to consider the potential for dietary interventions at the individual and population level to affect mental health. This thesis aims to provide additional evidence to support the importance of promoting a healthy lifestyle, particularly among children in Canada. The inclusion of improved mental health as an additional benefit for the promotion of a healthy diet in childhood will provide further evidence to support the imperativeness of nutrition policy and programs, particularly, in Canadian schools.

### 1.8.0 Research Objectives

The objective of this thesis is to investigate whether a relationship exists between diet quality and mental health disorders in children by:

- Examining the relationship between diet quality and feeling worried, sad or unhappy among grade 5 students across Alberta.
- Examining whether the development of an internalizing disorder among grade 5 students in Nova Scotia is related to their diet quality.

#### 1.8.1 Research Questions

**Part 1:** Are feelings of worry, sadness or unhappiness more prevalent among grade 5 students with poor diet quality, relative to grade 5 students with better diet quality, in schools across Alberta?

**Part 2:** Is the rate of diagnosis of internalizing disorder greater among grade 5 students with poor diet quality, relative to grade 5 students with better diet quality, in schools across Nova Scotia within three years of follow up?

### 1.9.0 Structure of this Thesis

The structure of this thesis is as follows. The first study of this thesis involved a provincial cross sectional survey of the 2008 and 2010 Raising Healthy Eating and Active Living Kids in Alberta study. The second study used province wide cross sectional survey data of the Children's Lifestyle and School Performance Study (CLASS) in 2003 from Nova Scotia, Canada linked with administrative data from 2003 until 2006. The first study provided an examination of the cross-

sectional association between diet quality and self-reported feelings of worry, sadness or unhappiness as part of a standardized health related quality of life survey. In the second study we used a longitudinal study design to examine directionality of the relationship between diet quality and mental health disorders. A clinical diagnosis of internalizing disorder was used to examine the relationship between diet and more severe cases of mental health disorders.

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## Chapter 2: The Relationship Between Diet Quality and Feeling Worried, Sad or Unhappy in Children

### 2.1.0 Introduction

Mood disorders are a serious public health concern because of their high prevalence, increased risk for suicide, economic burden and reduced quality of life[1]. These disorders affect individuals of all ages. Many children and young adolescents suffer from mood disorders, particularly depression and anxiety. In a study performed in the United States authors identified the lifetime prevalence of any anxiety or major depressive disorder in adolescents aged 13-18 years old to be 31.9% and 11.7%, respectively[2]. It is evident that depression and anxiety disorders contribute largely to the burden of mental health disorders in adolescents[3].

Poor nutrition of children is a huge public health concern due to its contribution to increasing rates of obesity and subsequent chronic diseases[4-6]. The availability of unhealthy foods tends to influence children's dietary choices and habits. In recent years, there has been a greater consumption of fast foods, pre-prepared meals, soft drinks and candy among children[7]. Children also prefer larger portions of unhealthy foods and smaller portions of vegetables[8]. Based on the Canadian results from the WHO Health Behaviour in School-Aged Children Survey (HBSC), less than 50% of youth reported consuming fruits and vegetables

more than once a day[9]. These changes in dietary habits may be an important factor contributing to the rising trend of mental health disorders.

There is research suggesting a link between nutrition and mental health. However, most of the previous literature has focused on adult populations[10-12]. Adequate nutrition in childhood is important for proper brain functioning and cognitive development[13]. Two separate studies performed in Australia have examined the association between diet quality and mental health of children. They found that children consuming diets comprised of unhealthy and processed foods were more likely to have poor mental health[14,15].

In the present study the cross sectional relationship between diet quality and mental health in children was examined. In this study mental health is represented by feelings of worry, sadness or unhappiness. From a public health perspective, it is important to examine this relationship in children to prevent future disability from mental health problems and at the same time provide further evidence to support the importance of nutrition policy and programs in Canadian schools.

## 2.2.0 Methods

### 2.2.1 Study Design

This study used data from the Raising Health Eating and Active Living Kids in Alberta study (REAL Kids) examining diet quality, physical activity and wellness of grade 5 students across Alberta, Canada.

### 2.2.2 Study Population

The REAL Kids Alberta study is a cross-sectional, province wide survey of Grade 5 students (age 10-11 years) and their parents from the Canadian province of Alberta. The REAL Kids Alberta study is an evaluation project developed by P.J. Veugelers as partial contract by Alberta Health and Wellness. The REAL Kids project consists of two surveys, one administered in 2008 and another in 2010. This study combined the data from both the 2008 and 2010 data collection. Parents were asked to complete a consent form and a survey on socioeconomic background. A team of two trained evaluation assistants visited each school to administer the two questionnaires to the Grade 5 students and measure height and weight of those that participated in the study. All elementary schools across Alberta were targeted with the exception of private schools (4.7% of Alberta children attend), francophone schools (0.6%), on-reserve federal schools (2.0%) charter schools (1.7%), and colony schools (0.8%)[16]. Schools were stratified into three categories. (1) Metropolitan area: which included elementary schools in Edmonton and Calgary (2) City: which included other municipalities with greater than 40,000 residents and (3) Rural: which included other municipalities with less than 40, 000 residents. An equal number of elementary schools were randomly selected to participate from each of these strata ensuring a balanced number of participants in each area.

### 2.2.3 Exposure of Interest: Overall Diet Quality

Nutrient intake and dietary habits were examined using the Harvard Food Frequency questionnaire for children and youth (YAQ)[17]. This questionnaire is used to assess usual dietary intake over the previous twelve months. It is a self-administered tool designed for children and adolescents aged 9 to 18 years, and has been shown to be a valid measure of nutritional information among this age group.[17]

On the basis of students' responses to the YAQ and the Canadian Nutrient Files[18] we calculated nutrient intake, numbers of daily servings of vegetables and fruits and daily energy intake. On the basis of these quantities we calculated the Diet Quality Index-International (DQI-I), an index that has been proven effective at identifying diet quality by incorporating many different dietary components.[19,20] The DQI-I ranges from 0 to 100, with higher scores indicating a higher diet quality, and constitutes four component scores: 1) Variety; 2) Adequacy; 3) Moderation; and 4) Balance.[19] DQI-Variety assesses whether foods consumed come from diverse sources within and between food groups.[19] DQI-Adequacy allows for the evaluation of undernutrition by assessing the intake of foods that are required to ensure a healthy diet.[19] Conversely, DQI-moderation assesses overnutrition by evaluating intakes of foods that need restriction due to their association with chronic diseases.[19] Lastly, DQI-balance examines the proportion of intakes from different energy sources.[19]

In addition to assessing the importance of diet quality and its four components for feelings of worry, sadness or unhappiness we explored the

association of food items and nutrients that other studies had implicated or suggested in the causation of mental health disorders. These included vegetable and fruit consumption, Vitamin B6,[21] folic acid,[21] Vitamin B12,[22] and Omega-3 fatty acids.[23,24] With respect to omega 3 fatty acids, we evaluated both the absolute amount of omega-3 fatty acids as well as the ratio of omega-6 / omega-3 fatty acids. A high ratio ratio of omega-6/omega-3 fatty acids has been shown to increase the risk of depressive symptoms in an adult population[25]. Calorie intakes of less than 500 and more than 5000 are considered outliers and were excluded as per recommendations for the analysis of food frequency data.[26]

### 2.2.4 Outcome of Interest: Depressive/Anxious Feelings

Indicators of childhood mental health were obtained based on one question from a Health Related Quality of Life (HRQOL) questionnaire, the EQ-5D-Y a modified version of the adult EQ-5D instrument[27,28] that is for children and youth. The EQ-5D is a self-report questionnaire comprised of 5 dimensions to quantify HRQOL. These 5 domains include: mobility, self care, usual activities, pain/discomfort and anxiety/depression to determine health status[29].

Depression is characterized by feelings of sadness, emotional and social withdrawal[30]. Feelings characteristic of depression and anxiety were captured in the depression/anxiety domain in the EQ-5D-Y that asks the student to describe their health today as "feeling worried, sad or unhappy" as part of a standardized HRQOL survey. The response to this question is comprised of three levels: "no problems," "some problems" and "extreme problems" [29]. Although this is not a diagnostic tool, this question has been used and proven to be effective at

identifying adults with depression and anxiety[31]. In addition, the use of a single question was shown to be an adequate tool for classifying the majority of adults with depressive symptoms who were identified as having depressive symptoms by a full questionnaire[32]. A study among children identified that a two question screening tool was effective for identifying children with depressive symptoms[33]. This suggests that the use of a short questionnaire may be considered an adequate method for assessing mental health. For the purpose of this study, responses to this question were dichotomized into two groups: no problems and some/extreme problems.

2.2.5 Covariates

All analyses were adjusted for energy intake, gender, household income, parental education, weight status (normal weight, overweight, and obese), physical activity level and area of residence (metropolitan/city/rural area). The parental survey provided information on socio-demographic characteristics including household income and parental education. Weight status was defined using international cut-off points established for children and youth by the International Obesity Task Force[34]. Student height was measured to the nearest 0.1cm after students had removed their shoes, and body weight was measured to the nearest 0.1kg on calibrated digital scales to determine weight status. Physical activity level was determined from the student survey and parental survey, based on a series of questions taken from the Physical Activity Questionnaire for Children (PAQ-C). The PAQ-C is a valid and reliable tool for assessing physical activity level[35]. These questions formed a composite score from 1-6, 1 being

least active. Total energy intake (kcal/day) was controlled for in each analysis to ensure that the relationship between diet quality and the presence of feelings of sadness or worry was independent of the child's total energy intake[36].

### 2.2.6 Total Participants

In 2008, 141 randomly selected schools across Alberta participated in the REAL Kids Alberta study. The grade 5 students attending these randomly selected elementary schools voluntarily participated in data collection and parental consent was required for students to be eligible to participate. From the 141 schools, 5321 grade 5 students received a parental survey and parental consent form. Of the 3704 grade 5 students who received parental consent to participate, 3421 students completed the surveys. This resulted in a response rate of 64%.

In 2010 these randomly selected schools were revisited, only 7 of the 141 schools originally visited did not participate in 2010 (95% return rate). In 2010, 5597 grade 5 students received a parental survey and parental consent form. Of the 3687 grade 5 students who received parental consent to participate, 3398 students completed the surveys. This resulted in a response rate of 61%. Therefore a total of 6,819 students participated in the survey in 2008 and 2010 combined.

Children were excluded from the analysis if they were missing information on gender (9.3%), depressive/anxious feelings (0.1%) or had an energy intake of less than 500 and more than 5,000 kilocalories per day (3.8%). A total of 6528 students were included in the analysis, 3288 from 2008 and 3240

from 2010. These results may be generalized to represent most grade 5 students in Alberta.

### 2.2.7 Statistical Analysis

Multilevel regression models were used to examine the effects of diet quality and dietary indicators on feelings of worry, sadness or unhappiness. Diet quality was assessed using the DQI-I, which ranges from 0 to 100. We considered diet quality variables as continuous variables because the relationship between DQI-I and feelings of worry, sadness and unhappiness was linear therefore we were able to treat DQI-I as a continuous variable (Figure 2.1). Odds ratios were adjusted to represent a 10% change in diet quality score in order to simplify interpretation of the results. Due to the nature of the outcome ordinal logistic regression was considered as a method for analysis. However, the proportional odds assumption was violated and this method could not be used. An alternative option would be a multinomial logistic regression however with only 3% of the sample reporting extreme feelings of sadness and worry the group was too small to examine this relationship. Therefore, the responses were dichotomized into two groups: no problems and some/extreme problems.

The relationship was examined using a multilevel logistic regression model with students nested in schools. Population weights were calculated to yield provincial population estimates. Unadjusted and adjusted odds ratios (OR) are reported. Regression models were adjusted for energy intake, year of data collection, gender, household income, parental education, weight status, physical

activity level and geographic area. Missing values for these variables were considered as separate covariate categories in the regression models, but results are not presented. Stata/SE 11 (Stata Corp., College Station, TX, USA) was used for the statistical analysis.

### 2.3.0 Results

A total of 32% of students reported moderate feelings of worry sadness or unhappiness and 3% of students reported extreme feelings of worry sadness or unhappiness. A higher proportion of girls reported moderate and extreme feelings of worry sadness or unhappiness than boys (Table 2.1). A greater proportion of students with moderate and extreme feelings of worry sadness or unhappiness were in lower socioeconomic groups, least physically active and had higher body weight status (Table 2.1).

Table 2.2 presents ORs (adjusted for energy intake, adjusted for energy intake and socio-demographic characteristics, and fully adjusted, respectively) for the association of diet quality and its components with a child feeling worried, sad or unhappy. Overall diet quality was significantly associated with children feeling worried, sad or unhappy. For a 10% increase in overall diet quality score the odds of feeling worried, sad or unhappy decreased by 10%. Since the DQI-I is a 100-point scale it can be assumed that a greater change in overall diet quality would result in a greater decrease in the odds of feeling worried, sad or unhappy. The dietary components that were significantly associated with lower odds of feeling worried, sad or unhappy were variety and adequacy. Students with greater variety and more adequate diets had significantly lower odds of these feelings. For a 10%

increase in diet quality adequacy score the odds of feeling worried, sad or unhappy decreased by 11%. Greater dietary balance was significantly associated with increased odds of feeling worried, sad or unhappy.

None of the food items and nutrients including folate, Vitamin B12, percent energy from fat and omega-3 fatty acids showed a statistically significant association with lower odds of feeling worried, sad or unhappy (Table 2.3). The ratio of omega-6 to omega-3 fatty acids did reveal a statistically significant association. An increase in the ratio of omega 6:omega 3 fatty acids was significantly associated with greater odds of worry, sadness, or unhappiness. Fruit and vegetable consumption and Vitamin B6 also revealed a statistically significant association. Students with greater fruit and vegetable consumption had significantly lower odds of feeling worried, sad or unhappy. In addition, for a 10% increase in Vitamin B6 consumption the odds of feeling worried, sad or unhappy decreased by 11% (Table 2.3).

Stratifying the results by gender (Tables 2.4-2.7), overall diet quality was significantly associated with lower odds of feeling worried, sad or unhappy in girls and not boys. As well, dietary components adequacy and moderation demonstrated a stronger relationship with lower odds of these feelings in girls than boys. In both boys and girls, greater dietary balance was associated with increased odds of feeling worried, sad or unhappy. None of the food items and nutrients including folate, Vitamin B12, percent energy from fat and omega-3 fatty acids showed a statistically significant association with lower odds of feeling worried, sad or unhappy in either gender. In girls, greater fruit and vegetable

consumption as well as Vitamin B6 was associated with significantly lower odds of feeling worried, sad or unhappy. In boys, a higher ratio of omega-6 to omega-3 fatty acids was associated with significantly higher odds of reporting feeling worried, sad or unhappy.

### 2.4.0 Discussion

The present study is one of only a few studies investigating the relationship between diet and mental health in children. These findings support previous studies that have suggested a relationship between poor diet quality and mental health problems in children[14,15]. Students with a better overall diet quality had lower odds of feeling worried, sad or unhappy. A 10 % increase in fruit and vegetable consumption was also significantly associated with lower odds of feeling worried, sad or unhappy. Higher intake of fruits and vegetables are often considered part of a healthy diet. Diets comprised of lower intakes of fruits and vegetables are typically lower in essential nutrients and have been shown to increase the risk for many diseases[37-39]. In a study from Nova Scotia, children did not meet recommendations for fruit and vegetable intake and had diets high in unhealthy foods like fat, salt, and sugar[40]. Another study found that children with higher intake of foods from fast food restaurants also consumed less fruits[38]. Greater fruit and vegetable consumption is often an indicator of better overall diet, which may be contributing to this trend.

Dietary components, variety and adequacy, showed a statistically significant association with decreased feelings of worry, sadness or unhappiness. Dietary variety is described as the consumption of foods from diverse sources

within and between food groups[19]. This suggests that it is important to expose children to a variety of foods in order to meet the recommended number of servings from each food group. Dietary adequacy evaluates under nutrition by assessing intakes of foods that are required for a healthy diet[19]. This suggests the importance of ensuring that children are receiving the essential nutrients provided by food required for a healthy diet. By exposing children to a variety of foods and at the same time ensuring they have an adequate diet they are more likely to consume sufficient amounts of the essential nutrients to ensure a healthy development and, as shown in this study, thereby lower their odds of feeling worried, sad or unhappy. Greater dietary balance, which examines the proportion of intakes from different energy sources,[19] was significantly associated with increased odds of feeling worried, sad or unhappy, which is the opposite direction than what was expected. The Balance score is determined based on the proportion of energy sources and fatty acid composition[19]. However, fatty acids were not assessed for several foods in the Canadian Nutrient Files, which may explain these results[41]. Dietary moderation showed no meaningful association with these feelings.

Previous literature has suggested a relationship between low levels of B vitamins with higher rates of depression or depressive symptoms[21 ,42-45]. However, these findings have been inconsistent[42 ,46 ,47]. The present study found that vitamin B6 was significantly associated with lower odds of feeling worried, sad or unhappy. This supports the results from a previous study among adolescents[21]. It is suggested that this relationship may be mediated through

increased levels of homocysteine or a reduction in the amount of monoamines in the brain due to lack of B6 in the diet[22,43]. Vitamin B6 is found in many foods such as meats, whole grains, bananas and nuts[48]. Therefore this study suggests it is important to ensure that children are receiving adequate amounts of these foods high in Vitamin B6 in their diet.

When examining the relationship separately in boys and girls the results differed. There appears to be a stronger relationship between better overall diet quality and lower odds of feeling worried, sad or unhappy in girls than boys. In addition an adequate diet and one lower in foods that need restriction due to their association with chronic disease appear to play a more important role with lower odds of feeling worried, sad or unhappy in girls than in boys. In both boys and girls, greater dietary balance was associated with increased odds of feeling worried, sad or unhappy, which is the opposite direction than what was expected. Greater fruit and vegetable intake and vitamin B6 intake was significantly associated with lower odds of feeling worried, sad or unhappy in girls only. In boys, an increase in the ratio of omega-6 to omega-3 fatty acids was associated with significantly higher odds of reporting feeling worried, sad or unhappy. A previous study among adults showed that the ratio of omega-6 to omega-3 fatty acids was higher among those with depression[25]. Omega-6 fatty acids are found predominantly in polyunsaturated vegetable oils and a high omega-6 to omega-3 fatty acid ratio is characteristic of a diet high in processed foods[48]. Therefore, in boys it appears that a diet high in processed foods may be associated with poor mental health.

It is unclear whether girls and boys report diet quality differently. It is suggested that both female adolescents and adults under report their diet on self-report questionnaires[49-52]. Girls are often more aware of body image and dieting which may be contributing to them reporting their diet differently[49]. Previous literature has reported differences in the relationship between specific nutrients and mental health based on gender[24 ,53]. This could be based on physiological differences or it may be due to differences in reporting diet quality. However, the results from this study suggest that diet may have more influence on the mental health of girls than boys.

The rising prevalence of obesity among children and adolescents may be partially explained by poor dietary habits[5]. Changes in children's dietary patterns demonstrate an increase in consumption of foods high in fat and sugar[7]. Previous research has noted a relationship between body weight status and lower self-esteem among children[54]. However, this relationship may be mediated through diet quality. Research suggests that lower self esteem may be an early predictor for mental health disorders[55]. From a prevention perspective, population-based interventions aimed at reducing obesity are important to prevent future disability from obesity and chronic disease. The inclusion of improved mental health as an additional benefit for the promotion of a healthy diet in childhood provides further evidence to support the imperativeness of nutrition policy and programs.

Information regarding a child feeling worried, sad or unhappy was part of a youth version of a widely used Health Related Quality of Life (HRQOL) measure, the EQ-5D-Y[56]. HRQOL has become an important area of research. It

is a multi-dimensional concept incorporating physical, mental, emotional, social and behavioural components of well-being and function[57]. HRQOL allow researchers to demonstrate the impact of health on quality of life[58]. It takes into account how an individual's health affects their daily living, functioning and health care use[58]. HRQOL can be used to identify individuals with relatively poor perceived health or those at risk for health problems and help guide prevention and intervention strategies[59].

The EUROQOL group is a group of multi-disciplinary researchers that developed this standardized self-report instrument to describe and evaluate HRQOL[28]. The EQ-5D is primarily used as a HRQOL measure in clinical and economic evaluation of health care and in population health surveys[59]. The instrument is comprised of 5 dimensions to quantify HRQOL. These dimensions were selected by the EUROQOL group after careful discussion and examining the literature[28]. This instrument requires the respondent to provide information about their health in two stages[60].

First they describe their health based on these 5 domains on that specific day. The responses to each of these domains are comprised of three levels: "no problems," "some problems," and "extreme difficulties". The responses to these five dimensions enable them to classify the individual into one of 243 different EQ-5D health states[60]. Secondly, they must rate their health status on a visual analogue scale (VAS) ranging from 'worst imaginable health' to 'best imaginable health'[60]. These two components allows for the individual's health status to be expressed in three ways. These include reporting only the score on the VAS, as a

profile based on the responses to the five domains or as a single weighted health state index score[60]. This study used the responses to the anxiety/depression domain since the outcome of interest was mental health not the overall health related quality of life.

There are several limitations to this study that should be noted. The cross-sectional study design does not rule out the potential for reverse causality. It may be that feeling worried, sad or unhappy result in children eating less healthy diets or there may be a common cause not accounted for in the analysis. There is also the potential for recall bias in the assessment of diet quality. Diet quality was assessed using self-administered questionnaires, although validated and suitable for this age group, self-report is prone to error particularly in this age group[61]. FFQs are typically used in large population based studies to assess a comprehensive estimate of an individual's usual diet[62]. FFQs assess how often an individual consumes foods from a variety of categories (e.g. pizza). However, they often do not know specific characteristics about that food (e.g. the type of pizza or how the pizza was prepared) which would be obtained from a 24-hour recall or dietary record[63]. Therefore, it can be difficult to accurately assess nutrient intakes using this method[63]. FFQs are often used to rank individuals rather than estimate absolute intakes therefore estimates of absolute nutrient intake must be interpreted with caution[62].

Lastly, the outcome for this study, feeling worried, sad or unhappy, was assessed using one question from a health related quality of life questionnaire. This question has proven to be an adequate tool for identifying individuals with

depression and anxiety[31]. However, the EQ-5D-Y measures HRQOL and is not considered a diagnostic tool. Other studies using short questionnaires of one or two questions have also proven to be effective at identifying depression[64-66]. Therefore, it is possible that the response feeling worried, sad or unhappy may be an early predictor for mental health problems. Future studies may benefit from using a more sophisticated questionnaire in the assessment of depression and anxiety. Despite these potential limitations, this study had several methodological strengths: It is a population-based study with a relatively high response rate, it had a large sample size and allowed for adjustment of socio-demographic factors in the analysis.

In conclusion, the present findings suggest that overall diet quality and vitamin B6 intake may play an important role in feelings of worry, sadness or unhappiness. It also suggests that diet may have a greater effect on mental health in girls than boys. This has important public health implications due to the modifiable nature of individual diet. Prospective studies with stronger assessment of mental health are needed to expand on the present findings.

**Figure 2.1** Lowess plot of DQI-I score and feeling worry, sadness or unhappy

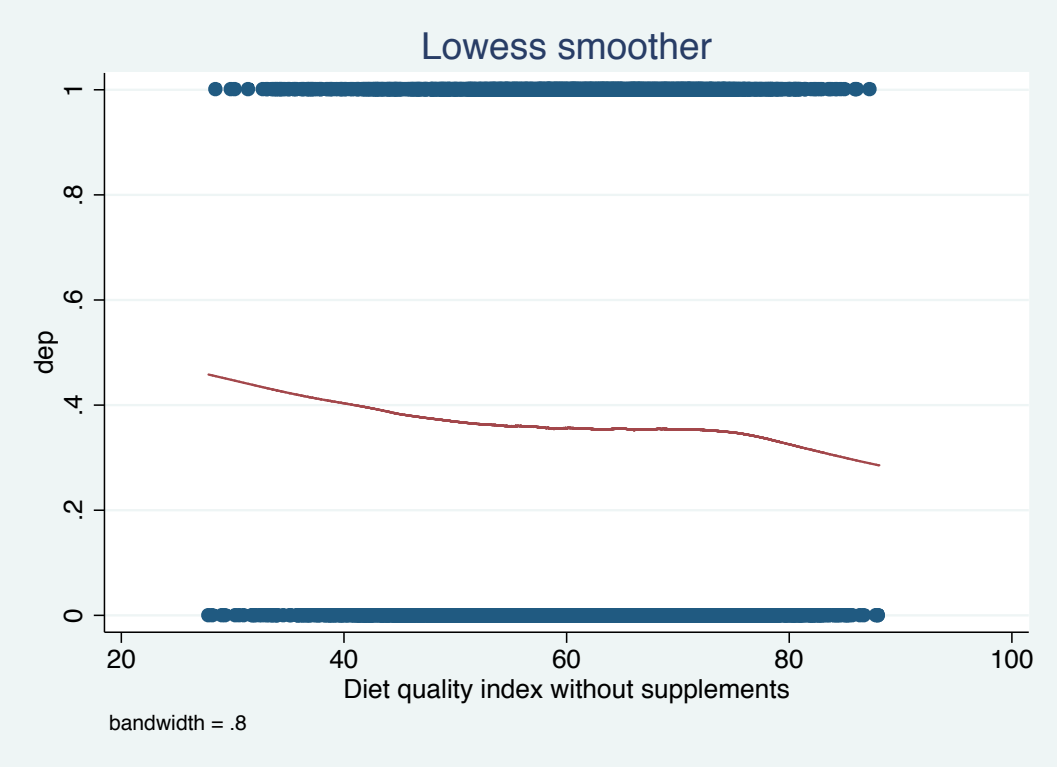

**Table 2.1** Sociodemographic and health characteristics of participants in the REAL Kids study

| | % of total population | % Reporting feeling worried, sad or unhappy | | |
|---|---|---|---|---|
| | | None | Some/Moderate | Extreme |
| Gender | | | | |
| Female | 51% | 58% | 38% | 4% |
| Male | 49% | 71% | 27% | 2% |
| Year of Data Collection | | | | |
| 2008 | 50% | 62% | 35% | 3% |
| 2010 | 50% | 66% | 30% | 4% |
| Household Income ($) | | | | |
| <50,000 | 16% | 62% | 34% | 4% |
| 50,001- 75,000 | 12% | 63% | 33% | 4% |
| 75,001- 100,00 | 14% | 66% | 31% | 3% |
| >100,001 | 25% | 66% | 31% | 3% |
| Missing | 33% | | | |
| Parental Education | | | | |
| Secondary school or less | 24% | 62% | 34% | 4% |
| College | 37% | 64% | 32% | 3% |
| University | 33% | 66% | 31% | 2% |
| Missing | 5% | | | |
| Residence | | | | |
| Metropolitan area | 47% | 64% | 33% | 3% |
| City | 39% | 65% | 32% | 4% |
| Rural-town | 14% | 64% | 32% | 3% |
| Physical Activity Level | | | | |
| Low level | 3% | 53% | 44% | 4% |
| Medium | 87% | 63% | 33% | 3% |
| High level | 10% | 76% | 22% | 2% |
| Body weight status | | | | |
| Normal weight | 72% | 65% | 32% | 3% |
| Overweight, not obese | 20% | 64% | 32% | 4% |
| Obese | 8% | 58% | 38% | 4% |

**Table 2.2** Odds ratios (OR) with 95% confidence intervals for the association between indicators of diet quality and moderate/severe feelings of worry, sadness or unhappiness.

| Dietary Indicators | Model 1[a] OR (95% CI) | Model 2[b] OR (95% CI) | Model 3[c] OR (95%CI) |
|---|---|---|---|
| DQI-I Overall | 0.92(0.86-0.98) | 0.89(0.84-0.96) | 0.90(0.85-0.97) |
| DQI-I Variety | 0.95(0.92-0.99) | 0.94(0.91-0.98) | 0.95(0.91-0.98) |
| DQI-I Adequacy | 0.90(0.84-0.96) | 0.87(0.82-0.93) | 0.89(0.83-0.95) |
| DQI-I Moderation | 0.96(0.92-1.01) | 0.95(0.91-1.00) | 0.96(0.91-1.00) |
| DQI-I Balance | 1.06(1.02-1.09) | 1.05(1.02-1.09) | 1.05(1.02-1.09) |

OR: odds rate ratio; CI: confidence interval
All analyses weighted to yield provincial population estimates
[a] Adjusted for energy intake
[b] Adjusted for energy intake, year of data collection, gender, household income, parental education and geographic area
[c] Adjusted for energy intake, year of data collection, gender, household income, parental education, geographic area body weight status and physical activity level

**Table 2.3** Odds ratios (OR) with 95% confidence intervals for the association between food items and nutrients and moderate/severe feelings of worry, sadness or unhappiness.

| Food Items/Nutrients | Model 1[a] OR (95% CI) | Model 2[b] OR (95% CI) | Model 3[c] OR (95%CI) |
|---|---|---|---|
| Fruit and Vegetable intake (servings/day) | 0.97(0.92-1.02) | 0.94(0.89-0.99) | 0.95(0.90-1.00)* |
| Vitamin B6(mg/day) | 0.89(0.81-0.98) | 0.87(0.79-0.97) | 0.89(0.80-0.98) |
| Vitamin B12 (mcg/day) | 0.96(0.90-1.02) | 0.97(0.91-1.03) | 0.97(0.91-1.03) |
| Folate (mcg/day) | 0.99(0.92-1.07) | 0.98(0.91-1.05) | 0.98(0.91-1.06) |
| Omega-3 Fatty Acids (g/day) | 1.04(0.97-1.12) | 1.02(0.95-1.10) | 1.01(0.94-1.09) |
| Omega-6:Omega-3 Fatty Acid ratio (g/day) | 1.12(1.02-1.24) | 1.16(1.05-1.29) | 1.16(1.04-1.28) |
| % Energy from fat (g/day) | 1.00(0.95-1.07) | 1.01(0.95-1.08) | 1.01(0.96-1.07) |

OR: odds rate ratio; CI: confidence interval
All analyses weighted to yield provincial population estimates
[a] Adjusted for energy intake
[b] Adjusted for energy intake, year of data collection, gender, household income, parental education and geographic area
[c] Adjusted for energy intake, year of data collection, gender, household income, parental education, geographic area body weight status and physical activity level
*pvalue<0.05

**Table 2.4** Odds ratios (OR) with 95% confidence intervals for the association between indicators of diet quality and moderate/severe feelings of worry, sadness or unhappiness in boys.

| Dietary Indicators | Model 1[a] OR (95% CI) | Model 2[b] OR (95% CI) | Model 3[c] OR (95%CI) |
|---|---|---|---|
| DQI-I Overall | 0.92(0.84-1.00) | 0.92(0.84-1.01) | 0.94(0.86-1.03) |
| DQI-I Variety | 0.92(0.87-0.98) | 0.93(0.88-0.98) | 0.93(0.88-0.99) |
| DQI-I Adequacy | 0.88(0.80-0.97) | 0.89(0.81-0.98) | 0.91(0.83-1.00) |
| DQI-I Moderation | 0.99(0.94-1.04) | 0.99(0.93-1.04) | 0.99(0.94-1.05) |
| DQI-I Balance | 1.06(1.01-1.11) | 1.06(1.00-1.11) | 1.06(1.01-1.11) |

OR: odds rate ratio; CI: confidence interval
All analyses weighted to yield provincial population estimates
[a] Adjusted for energy intake
[b] Adjusted for energy intake, year of data collection, gender, household income, parental education and geographic area
[c] Adjusted for energy intake, year of data collection, gender, household income, parental education, geographic area body weight status and physical activity level

**Table 2.5** Odds ratios (OR) with 95% confidence intervals for the association between indicators of diet quality and moderate/severe feelings of worry, sadness or unhappiness in girls.

| Dietary Indicators | Model 1[a] OR (95% CI) | Model 2[b] OR (95% CI) | Model 3[c] OR (95%CI) |
|---|---|---|---|
| DQI-I Overall | 0.88(0.79-0.97) | 0.88(0.80-0.97) | 0.89(0.80-0.98) |
| DQI-I Variety | 0.96(0.90-1.02) | 0.96(0.91-1.02) | 0.96(0.91-1.02) |
| DQI-I Adequacy | 0.86(0.78-0.94) | 0.86(0.79-0.94) | 0.87(0.80-0.95) |
| DQI-I Moderation | 0.93(0.87-0.99) | 0.93(0.87-0.99) | 0.93(0.87-0.99) |
| DQI-I Balance | 1.04(1.01-1.09) | 1.04(1.00-1.09) | 1.04(1.00-1.09) |

OR: odds rate ratio; CI: confidence interval
All analyses weighted to yield provincial population estimates
[a] Adjusted for energy intake
[b] Adjusted for energy intake, year of data collection, gender, household income, parental education and geographic area
[c] Adjusted for energy intake, year of data collection, gender, household income, parental education, geographic area body weight status and physical activity level

**Table 2.6** Odds ratios (OR) with 95% confidence intervals for the association between food items and nutrients and moderate/severe feelings of worry, sadness or unhappiness in boys.

| Food Items/Nutrients | Model 1[a] OR (95% CI) | Model 2[b] OR (95% CI) | Model 3[c] OR (95%CI) |
|---|---|---|---|
| Fruit and Vegetable intake (servings/day) | 1.00(0.92-1.08) | 1.00(0.92-1.08) | 1.01 (0.93-1.10) |
| Vitamin B6(mg/day) | 1.00(0.87-1.17) | 1.02(0.87-1.19) | 1.04(0.89-1.21) |
| Vitamin B12 (mcg/day) | 0.93(0.86-1.01) | 0.94(0.86-1.02) | 0.94(0.87-1.03) |
| Folate (mcg/day) | 0.95(0.86-1.06) | 0.97(0.87-1.09) | 0.97(0.87-1.08) |
| Omega-3 Fatty Acids (g/day) | 0.97(0.87-1.08) | 0.97(0.87-1.09) | 0.97(0.87-1.08) |
| Omega-6:Omega-3 Fatty Acid ratio (g/day) | 1.29(1.09-1.52) | 1.28(1.09-1.50) | 1.26(1.07-1.48) |
| % Energy from fat (g/day) | 0.98(0.91-1.06) | 0.98(0.91-1.06) | 0.98(0.90-1.06) |

OR: odds rate ratio; CI: confidence interval
All analyses weighted to yield provincial population estimates
[a] Adjusted for energy intake
[b] Adjusted for energy intake, year of data collection, gender, household income, parental education and geographic area
[c] Adjusted for energy intake, year of data collection, gender, household income, parental education, geographic area body weight status and physical activity level

**Table 2.7** Odds ratios (OR) with 95% confidence intervals for the association between food items and nutrients and moderate/severe feelings of worry, sadness or unhappiness in girls.

| Food Items/Nutrients | Model 1[a] OR (95% CI) | Model 2[b] OR (95% CI) | Model 3[c] OR (95%CI) |
|---|---|---|---|
| Fruit and Vegetable intake (servings/day) | 0.89(0.83-0.96) | 0.89(0.83-0.96) | 0.90(0.84-0.96) |
| Vitamin B6(mg/day) | 0.75(0.65-0.87) | 0.76(0.66-0.87) | 0.78(0.67-0.89) |
| Vitamin B12 (mcg/day) | 1.00(0.92-1.08) | 1.00(0.93-1.08) | 1.00(0.93-1.08) |
| Folate (mcg/day) | 1.00(0.91-1.10) | 1.00(0.90-1.10) | 1.00(0.91-1.10) |
| Omega-3 Fatty Acids (g/day) | 1.07(0.97-1.18) | 1.07(0.97-1.18) | 1.06(0.96-1.17) |
| Omega-6:Omega-3 Fatty Acid ratio (g/day) | 1.05(0.90-1.22) | 1.04(0.90-1.22) | 1.04(0.90-1.21) |
| % Energy from fat (g/day) | 1.04(0.96-1.14) | 1.04(0.96-1.14) | 1.04(0.95-1.13) |

OR: odds rate ratio; CI: confidence interval
All analyses weighted to yield provincial population estimates
[a] Adjusted for energy intake
[b] Adjusted for energy intake, year of data collection, gender, household income, parental education and geographic area
[c] Adjusted for energy intake, year of data collection, gender, household income, parental education, geographic area body weight status and physical activity level

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## Chapter 3: Diet Quality and Mental Health in Subsequent Years among Canadian Youth

### 3.1 Introduction

Recent research suggests a link between nutrition and mental health, particularly in relation to specific nutrients such as fatty acids[1,2] and B vitamins[3]. However, individuals do not consume isolated nutrients. Research focusing on intakes of specific nutrients ignores the synergistic effects among nutrients[4]. There is emerging research examining the overall diet and mental health[5,6]. Studies from the United Kingdom[5] and Spain[6] have linked depression to poor dietary patterns in older populations. A study comparing the effects of consuming a diet with a high intake of whole foods versus processed foods found that individuals consuming a diet high in processed foods had greater odds of depression at the end of the study[5]. In 2004, the Canadian Community Health Survey found that the majority of Canadian youth were not receiving adequate nutrition[7]. Of all children aged 4 to 8, 70% were not consuming the recommended number of servings of vegetables and fruits, and one third did not meet the recommendations for milk products[7]. The growing number of children with inadequate nutrition raises public health concerns for their mental health later in life if an association exists. In the present study we examine the relationship of diet quality of children with their mental health in subsequent years.

## 3.2 Experimental Methods

### 3.2.1 Study Design

This study used survey data on diet and socioeconomic background from fifth grade students participating in the Children's Lifestyle and School Performance study (CLASS) in the Canadian province of Nova Scotia. This information was linked with administrative health data to obtain information on physician-diagnosis of internalizing disorders.

### 3.2.2 Study Population

The CLASS study was a cross-sectional, province wide survey among grade 5 students (age 10-11 years) and their parents conducted in 2003. Approximately 97% of students in Nova Scotia attend public schools. Of all 291 public schools with grade five students, 282 participated by providing their grade five students study documentation to take home. This documentation included a consent form and survey on socioeconomic background for parents to complete. Parents were also asked to provide their child's Health Insurance Number to allow for linkage of the survey data with administrative health care databases. A team of two trained research assistants visited each school to administer a questionnaire on activities and a modified version of the Harvard Youth/Adolescent Food Frequency Questionnaire (YAQ)[8]. The YAQ was slightly modified to reflect Canadian dietary patterns[9]. More details on the survey are available elsewhere[10].

### 3.2.3 Administrative Health Data

In Canada, a publicly funded health care system provides Canadians with universal access to all medically necessary hospital and physician services[11]. The administrative health datasets encompass the Medical Services Insurance (MSI) database and the Canadian Institute for Health Information Discharge Abstract Database (CIHI DAD). Data were available from 1992 (when the child was born) until 2006. The MSI database is administered by Medavie Blue Cross for the province of Nova Scotia and contains administrative records for each insured health service rendered by a physician (including emergency room visits) and paid for by the Nova Scotia provincial healthcare system. The CIHI DAD contains a comprehensive administrative transcription of each admission to a Nova Scotia hospital facility. Both of these databases contain individual patient-level information including patient demography (age, gender, location, etc), attending physicians, diagnoses and procedures performed, service transfers while in hospital, specialty services received (e.g. physiotherapy, occupational therapy) and case complexity (e.g. resource intensity weight). A combination of deterministic and probabilistic matching was used to link the CLASS study data with the administrative health datasets. The administrative health datasets were linked with the CLASS study data through the health card numbers provided by the students' parents. Where no direct match was found, the birth date and civic address were used establish a probable match.

### 3.2.4 Exposure of Interest: Overall Diet Quality

Nutrient intake and dietary habits were examined using the YAQ[8]. This questionnaire is used to assess usual dietary intake over the previous twelve months. It is a self-administered tool designed for children and adolescents aged 9 to 18 years, and has been shown to be a valid measure of nutritional information among this age group[8].

On the basis of students' responses to the YAQ, the Canadian Nutrient Files[12] were used to calculate nutrient intake, numbers of daily serving of vegetables and fruits, number of servings of fish and daily energy intake. On the basis of these quantities the Diet Quality Index-International (DQI-I) was calculated, an index that has been proven effective at identifying diet quality by incorporating many different dietary components[13,14]. The DQI-I ranges from 0 to 100, with higher scores indicating a higher diet quality, and constitutes four component scores: 1) Variety; 2) Adequacy; 3) Moderation; and 4) Balance[13]. DQI-Variety assesses whether foods consumed come from diverse sources within and between food groups[13]. DQI-Adequacy allows for the evaluation of undernutrition by assessing the intake of foods that are required to ensure a healthy diet[13]. Conversely, DQI-moderation assesses overnutrition by evaluating intakes of foods that need restriction due to their association with chronic diseases[13]. Lastly, DQI-balance examines the proportion of intakes from different energy sources[13]. In addition to assessing the importance of diet quality and its four composites for mental health, we explored the association of food items and nutrients that other studies had implicated or suggested in the causation

of mental health disorders. These included vegetable and fruit consumption, fish consumption[1,15], Vitamin B6[3], folate[3], Vitamin B12[16], and omega-3 fatty acids[1,2]. With respect to the latter, we evaluated both the absolute amount of omega-3 fatty acids as well as the ratio of omega-6 / omega-3 fatty acids[1,2].

### 3.2.5 Outcome of Interest: Internalizing Disorder

The primary outcome of interest was the number of health care provider contacts where a primary diagnosis of an internalizing disorder was given between 2003 and 2006 for each child. Internalizing disorders include common symptoms of depression and anxiety such as low mood, inhibition, excessive worrying, physical complaints, trouble sleeping and shyness[17]. A child was considered to have an internalizing disorder if he or she received an ICD-9 or ICD-10 diagnosis of a depressive episode, recurrent or persistent mood disorder, neurotic or general anxiety disorder, an acute reaction to severe stress, or an emotional disorder with onset specific to childhood (see Table 3.1 for list of ICD-9/10 codes used).

### 3.2.6 Covariates

Analyses were adjusted for factors that could potentially confound the relationship between diet quality and internalizing disorders. These included: energy intake, gender, household income, parental marital status and education, body weight status, physical activity level and area of residence. The parental survey provided information on socio-demographic characteristics including household income (23.3% missing), parental education (7.1% missing), parental

marital status, and urban/rural residence. Urban and rural residence was classified based on the student's postal code (if the second character is a "0", it is considered "rural" all other postal codes are considered "urban")[18]. Body weight status was defined using international cut-off points established for children and youth by the International Obesity Task Force[19]. Student height was measured to the nearest 0.1cm after students had removed their shoes, and body weight was measured to the nearest 0.1kg on calibrated digital scales. Physical activity level was determined from the student survey, which included validated questions taken from the National Longitudinal Survey for Children and Youth[20]. These questions required the student to report how often they participated in organized sports and leisure time physical activities per week[20]. Total energy intake was adjusted for as per recommendations for the analyses of food frequency data[21].

### 3.2.7 Number of Participants

Of the 5517 grade 5 students who received parental consent to participate, 5,200 students completed the surveys. The average participation rate per school was 51.1%. Of the 5,200 students who participated, 4,380 had adequate information to be linked with the administrative health care databases. Among these, 3,953 students had complete information from the food frequency questionnaire and an energy intake of more than 500 and less 5,000 kilocalories per day. Calorie intakes of less than 500 and more than 5000 are considered outliers and were excluded as per recommendations for the analysis of food frequency data[22]. Children with a diagnosis of an internalizing disorder before the administration of the survey in 2003 (n=196) were excluded from the analysis,

leaving a final sample of 3757 students. The study's retention rate in 2006 could not be determined, as the database had no information on whether a child moved from the province or was otherwise lost to follow-up. However, 88% of the 3757 students had at least one health care provider contact in 2005 or 2006.

### 3.2.8 Statistical Analysis

The association between diet quality and the diagnosis of internalizing disorder was examined using multilevel regression models to accommodate the nested structure of the data whereby observations of students are nested within schools. The distribution of the number of healthcare provider contacts with a diagnosis of an internalizing disorder showed overdispersion (i.e. the variance of the data exceeded what might be expected under the Poisson distribution). Therefore negative binomial regression was used instead of Poisson regression. Regression results are reported as incidence rate ratios (IRR). IRR's for diet quality were adjusted for energy intake, gender, household income, parental marital status and education, body weight status, physical activity level and geographic area. Missing values for these variables were considered as separate covariate categories in the regression analyses, but their estimates are not presented. As participation rates for the CLASS study in residential areas with lower estimates of household income were slightly lower than the average, response weights were calculated to overcome potential non-response bias and to yield provincial population estimates for grade 5 students in Nova Scotia[10]. Stata/SE 11 (Stata Corp., College Station, TX, USA) was used for the statistical analysis.

### 3.3.0 Results

The incidence of a health care provider contact for internalizing disorder between 2003 and 2006 in our sample was 7.8% (95%CI 7.0-8.7). A higher proportion of girls (n=172) were diagnosed with internalizing disorders than boys (n=122) over the four years following the survey (Table 3.2). A greater proportion of students diagnosed with internalizing disorder were in lower socioeconomic groups and from single parent families. The proportion of students diagnosed with an internalizing disorder was lower among those children that were physically active and had normal body weights (Table 3.2).

Table 3.3 presents IRRs (adjusted for energy intake and fully adjusted, respectively) for the association of diet quality and its components with the number of healthcare provider contacts with a diagnostic code for internalizing disorder. Diet quality was not significantly associated with an internalizing disorder. Relative to children with little variety in their diets, those with greater variety in their diets had a statistically significant lower rate of receiving a diagnosis of internalizing disorder. Relative to children in the lowest tertile for diet variety, children in the highest tertile for variety had approximately half as many visits with a diagnosis of internalizing disorder. Relative to children in the lowest level for diet adequacy, those in the highest tertile for adequacy demonstrated a trend towards lower rates of being diagnosed with internalizing disorder, but these differences were not statistically significant. Dietary moderation and balance showed less meaningful associations with internalizing disorders.

None of the food items and nutrients including vegetable and fruit consumption, Vitamin B6, folate, Vitamin B12, omega-3 fatty acids, and the omega-6 / omega-3 fatty acids ratio showed a statistically significant association with internalizing disorder. However, fish consumption did reveal a statistically significant finding. Relative to the one third of children with the lowest fish consumption, the one third of children with the highest fish consumption had lower rates of being diagnosed with internalizing disorder (Fully adjusted IRR: 0.59 95% CI: 0.41,0.87).

### 3.4.0 Discussion

The present study is one of few studies investigating the relationship between diet quality and internalizing disorders in children and youth. Our findings seem to contradict findings from previous studies[5,6,23] and suggest that overall diet quality does not appear to play a major role in the risk of developing an internalizing disorder. These results may be different due to the differences in study design, previous prospective studies followed individuals over a longer duration[5,6]. Another possible explanation is the dietary assessment method. This study used a FFQ to assess usual dietary intake, which may not accurately identify diet quality[24].

Although overall diet quality did not show a significant relationship, dietary variety was associated with internalizing disorder in subsequent years. Dietary variety is described as the consumption of foods from diverse sources within and between food groups[13]. This suggests that it is important to expose children to a variety of foods in order to meet the recommended number of

servings from each food group. Having diversity in the diet has been shown to provide more of the important nutrients for a balanced diet among adults[25]. By exposing children to many different foods they are more likely to consume sufficient amounts of the essential nutrients to ensure a healthy development and, as shown in this study, thereby lower the risk of developing internalizing disorder. Dietary moderation, which refers to the lack of overnutrition and excess intakes of foods, has been associated with the development of chronic diseases[13]. This study, however, showed no statistically significant relationship between the dietary moderation and the development of an internalizing disorder. In other words, dietary diversity rather than excess consumption seems to determine the development of mental health.

Fish is the most widely available source of omega-3 fatty acids, an essential nutrient that has been shown to reduce the risk of depressive symptoms[1,2]. Omega-3 fatty acids are key components of synaptic neuronal membranes and play an important role in neurotransmitter function[26]. Changes to this membrane may impair neurotransmitter function, in particular, the functioning of serotonin and dopamine[26], which may explain the association between omega-3 fatty acids and depressive symptoms. Also an imbalance between omega-6 fatty acids and omega-3 fatty acids has been linked to an increase in depression[27]. In the present study, however, an association of omega-3 fatty acids and the omega-6 / omega-3 fatty acid ratio with internalizing disorders was not observed, but an association of fish consumption with internalizing disorders was observed. More fish consumption would imply more omega-3 intake, for which we did not observe an

association with mental health. Fish consumption is also referred to as an indicator of dietary variety, for which we did observe an association with mental health.

The continuing increase in childhood overweight rates is acknowledged as a major public health problem as it underlies the current rises in the incidence of type 2 diabetes and other chronic diseases with mounting healthcare costs[28]. Many jurisdictions of Western countries are therefore preparing for, or are already implementing population-based health promotion initiatives aimed to reduce the prevalence of overweight and consequent burden of chronic diseases. Previous literature has noted a relationship between body weight status and lower self-esteem among children[29]. Lower self-esteem may be an early predictor for poor mental health later in life[30]. Those population-based health promotion initiatives that also promote dietary variety, may therefore benefit self-esteem and reduce internalizing disorders. These initiatives also provide unique opportunities for further study of the importance of diet for mental health and to move evidence based on cross sectional associations to stronger evidence from intervention research.

The relatively short follow up period of four years should be noted as a limitation of the present study. The relatively short follow up period does not completely rule out the possibility of reverse causality: It is possible that poor mental health conditions had affected the child's dietary choices in a negative manner. Future studies would benefit from following children into early adulthood to assess the development of mental health problems over a longer

duration, as the conduct of randomized controlled trial's to study dietary variety is not uncomplicated. Another limitation is that the study only included those children who were diagnosed or treated for internalizing disorders. There are likely many children who did not seek treatment or had barriers to access to care but were suffering from symptoms of an internalizing disorder.

Finally, diet quality was assessed using self-administered food frequency questionnaires. Although the questionnaire was validated and suitable for this age group, self-report is prone to error particularly in this age group. FFQs are designed to assess usual dietary intake and eating habits over a period of time. FFQs are a useful tool in epidemiological studies because they are consistent, inexpensive and can be administered in large population with relative ease[22]. The disadvantages of using FFQs are generally related to the development and validation of these tools[22]. However, one of the main limitations of FFQs is that only information on the frequency and quantity of foods from a specified list is collected[24]. Characteristics of the foods, such as preparation methods and many other details of dietary intake are not often measured[24]. In addition, there may be errors in estimating frequency or usual serving size of foods consumed[24]. Therefore assessment of usual dietary intake is limited by this method, however this tool is widely used in epidemiological studies and has been shown to be a valid measure of nutritional information among this age group.[8].

Despite these potential limitations, this study is unique in it size and had several methodological strengths: It is a population-based study with a relatively high response rate, it involved a clean cohort by excluding students previously

diagnosed with internalizing disorder and allowed for adjustment of socio-demographic factors in the analysis. In addition, the use of administrative data provided valid and reliable information and minimized bias in the assessment of internalizing disorder.

In brief, the present findings suggest that variety in children's diet may reduce the risk of developing internalizing disorders. This has important implications for the prevention of mental illness due to the modifiable nature of individual diet. Intervention studies and studies with longer follow up are needed to expand on the present findings.

**Table 3.1** ICD 9/10 codes identifying diagnosis of internalizing disorder

| Disorder | ICD-9 code | ICD-10 code |
|---|---|---|
| Depressive episode, recurrent/persistent or unspecified mood disorder (excluding bipolar) | 296.2, 296.3, 296.9, 311 | F32, F33, F34, F38, F39 |
| Neurotic, general anxiety disorders, reaction to severe stress, emotional disorders with onset specific to childhood | 300, 308, 309, 313 | F40, F41, F42, F43, F48, F92, F93 |

**Table 3.2** Sociodemographic and health characteristics of participants in the CLASS study

| | % | Internalizing Disorder * % |
|---|---|---|
| Gender | | |
| Female | 52% | 8.7% |
| Male | 48% | 6.8% |
| Household Income(CDN$) | | |
| <20,000 | 11% | 11.0% |
| 20,001- 40,000 | 23% | 9.6% |
| 40,001- 60,000 | 27% | 7.3% |
| >60,000 | 39% | 6.2% |
| Parental Education | | |
| Secondary school or less | 31% | 7.5% |
| College | 38% | 7.9% |
| University | 31% | 8.0% |
| Parental Marital Status | | |
| Married or common law | 83% | 7.2% |
| Separated / divorced / widowed / single | 17% | 11.0% |
| Residence | | |
| Urban | 66% | 7.2% |
| Rural | 34% | 11.0% |
| Physical Activity Level | | |
| 2x/week or less | 23% | 10.7% |
| >2 to 4x/week | 17% | 8.1% |
| >4 to 7x/week | 34% | 7.1% |
| >7/week | 26% | 6.2% |
| Body weight status | | |
| Normal weight | 67% | 7.4% |
| Overweight, not obese | 23% | 7.7% |
| Obese | 10% | 10.8% |

* A participant was considered having internalizing disorder if she or he had one or more health care provider contacts with diagnosis of internalizing disorder

**Table 3.3** Incidence rate ratios with 95% confidence intervals for the association between indicators of diet quality and number of health care provider contacts for internalizing disorder.

| Dietary Indicators | IRR* | 95%CI | IRR† | 95% CI |
|---|---|---|---|---|
| DQI-I Overall | | | | |
| First tertile (lowest) | 1.00 | | 1.00 | |
| Second tertile | 0.94 | (0.60,1.48) | 0.99 | (0.69,1.44) |
| Third tertile (highest) | 0.97 | (0.65,1.46) | 1.09 | (0.73,1.63) |
| DQI-I Variety | | | | |
| First tertile (lowest) | 1.00 | | 1.00 | |
| Second tertile | 0.61 | (0.32,0.99) | 0.60 | (0.40,0.89) |
| Third tertile (highest) | 0.44 | (0.25,0.80) | 0.45 | (0.25,0.82) |
| DQI-I Adequacy | | | | |
| First tertile (lowest) | 1.00 | | 1.00 | |
| Second tertile | 0.84 | (0.53,1.34) | 0.89 | (0.59,1.35) |
| Third tertile (highest) | 0.59 | (0.31,1.10) | 0.64 | (0.34,1.20) |
| DQI-I Moderation | | | | |
| First tertile (lowest) | 1.00 | | 1.00 | |
| Second tertile | 0.88 | (0.53,1.44) | 0.94 | (0.62,1.41) |
| Third tertile (highest) | 1.02 | (0.59,1.76) | 1.07 | (0.66,1.73) |
| DQI-I Balance | | | | |
| <1 (poor) | 1.00 | | 1.00 | |
| > or equal to 1 (good) | 0.93 | (0.65,1.35) | 1.06 | (0.66,1.73) |

IRR, incidence rate ratio; CI confidence interval.
*Adjusted for energy intake
† Adjusted for energy intake, gender, household income, parental marital status and education, body weight status, physical activity level and geographic area
‡ Total sample included in analysis was 3757; 294 students classified as having an internalizing disorder

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# Chapter 4: General Discussion and Conclusions

## 4.1.0 Summary

In the present thesis we have examined both the cross-sectional and longitudinal relationship between diet quality and mental health of children. The two studies complement one another through the use of different outcomes (Chapter 2: self report mental health status, Chapter 3: clinical diagnosis of mental health disorder) and by using two different study designs. Most importantly the relationship was examined in two independent samples representative of two Canadian provinces. The cross sectional relationship was examined in Chapter 2 followed by using a longitudinal study design in Chapter 3. The second study (Chapter 3) adds to the current literature in this area due to the lack of longitudinal research. The longitudinal study design provides additional information regarding directionality of the relationship between diet and mental health. This thesis provides evidence to support the need for more longitudinal research of this relationship. In addition it supports the implementation of intervention strategies and policy making targeted at improving nutrition and mental health of Canadian children.

## 4.1.1 Principal Findings of this Thesis

The results of this thesis consist of two separate studies one performed in the Canadian province of Alberta and the other Nova, Scotia. The first study revealed

a cross-sectional relationship between diet quality and self reported feelings of worry, sadness or unhappiness among grade 5 students. Better overall diet quality along with the greater variety and adequacy component scores revealed statistically significant associations with lower odds of feeling worried, sad or unhappy. In addition, after examining several other food items and nutrients, greater fruit and vegetable intake and increased vitamin B6 intake both had statistically significant associations with lower odds of feeling worried, sad or unhappy. When examining the relationship in boys and girls separately, the results between the genders differed. The relationship between greater overall diet quality and adequacy with lower odds of feeling worried, sad or unhappy remained in girls but not boys. As well, when examining other food items and nutrients, the results of fruit and vegetable intake and increased vitamin B6 intake remained in girls and not boys. This suggests that diet may have a greater influence on the mental health of girls or perhaps girls are better able to report dietary intake.

In the second study, which investigated the longitudinal relationship between diet quality and a clinical diagnosis of internalizing disorder, better overall diet quality was not significantly associated with a lower rate of being diagnosed with internalizing disorder. Therefore, these results were not fully consistent with the Alberta study. However, results did show a significant association between greater variety score and a lower rate of being diagnosed with internalizing disorder, which is consistent with the Alberta study.

In summary, these findings suggest that diet does play a role in mental health of children. It suggests that diet quality rather than specific nutrients may be implicated in the development of mental health disorders.

### 4.2.0 Embedding in Existing Literature

Other studies have examined the relationship between diet quality and mental health disorders in adults[1-4], with fewer studies examining this relationship in children[5,6]. Therefore, these two studies are important for several reasons. These studies expand on the limited amount of research between diet and mental health in children. The second study involves a longitudinal study design providing some directionality of the relationship. As well, the DQI-I allows for the identification of specific aspects of the diet that may be involved in the relationship between diet and mental health disorders.

An interesting finding is the difference in the results of the two studies (Chapter 2 and 3). When examining a more clinical outcome of mental health status, there was no significant relationship with overall diet quality. However, when looking at self-report data there was. This suggests that there may be a difference in this relationship based on the severity of symptoms. As stated earlier, variety in the diet remained an important factor in both self-reported feelings of worry, sadness or unhappiness (Chapter 2) and the clinical diagnosis of an internalizing disorder (Chapter 3). Therefore, perhaps as symptoms become more severe variety in one's diet is more important than other aspects.

The results of the first study (Chapter 2) are supported by studies demonstrating a relationship between overall diet quality and mental health

disorders[1-6]. The second study (Chapter 3) seems to contradict this previous work, suggesting there may be a difference between the cross sectional and longitudinal relationship. Most of the previous literature has focused on the cross sectional relationship between diet and mental health[2 ,4-6]. The second study (Chapter 3) begins to investigate the longitudinal relationship between diet and mental health disorders over a short follow-up period. Therefore, the differences in results may be attributed to the study design. Cross-sectional studies examine the relationship at one particular point in time whereas longitudinal studies permit the relationship to be examined over a period of time. In this case, the relationship between diet and mental health was examined over a period of three years. In prospective studies the outcome has not occurred at the beginning of the study when the exposures are assessed therefore, they are assessing direction of the relationship. In Chapter 3, the development of an internalizing disorder is measured based on poor diet quality. In Chapter 2 we are assessing whether those with feelings of worry, sadness or unhappiness also have poor diet quality. This suggests that there may be a difference in the relationship between diet and mental health when examined over a longer period of time.

There were also differences in the results when looking at specific nutrients in the diet. Vitamin B6 (Chapter 2) and fish intake (Chapter 3) proved to play an important role in mental health. There is previous research supporting both of these relationships[7 ,8]. These results lead us to believe that once again, there may be a difference in the relationship between certain nutrients and mental

health based on the severity of mental health status or when looking at the cross-sectional relationship versus the longitudinal relationship.

### 4.3.0 General Implications

This thesis focused on childhood mental illness because its prevalence is increasing and it has been associated with many short and long term consequences[9-12]. There is a need for studies that investigate the relationship between diet and mental health disorders. This thesis provides evidence that will be important to policy makers and further our current understanding of the relationship between diet and mental health. The knowledge from this study could affect future nutrition policies and programs due to the modifiable nature of individual diet. The inclusion of improved mental health as an additional benefit for the promotion of a healthy diet provides further evidence to support the imperativeness of nutrition policy and programs. Future studies should focus on the longitudinal relationship between diet and mental health of Canadians over a longer period of time. These studies would provide further insight into the direction of the relationship as well as provide support for intervention studies to assess whether improving an individual's diet also improves their mental health. Further investigation of this relationship is needed to provide additional high quality data to influence policy and support intervention programs.

Mental health disorders result in substantial economic costs on society in addition to the personal costs [13,14]. The lack of information regarding the relationship between diet and mental health prevents the development of effective interventions and policies targeted to alleviate these issues. Investigating the

relationship between diet and mental health may provide sufficient evidence to influence policy and intervention strategies. Given its modifiable nature, diet is an ideal target for public health intervention. Large-scale dietary interventions have been shown to be successful in effecting change, with such programs as healthy school lunches, banning the use of unhealthy fats in restaurants, providing nutrition labels on restaurant menus and social marketing campaigns. These types of dietary interventions and policies have been proven effective at improving diet quality and nutritional knowledge across various populations[15-17]. Nutrition intervention strategies and policies in schools have been effective at significantly improving one's diet[18-20].

It is important to consider the potential for dietary interventions at the individual and population level to affect mental health. Although the evidence linking diet and mental illness is growing, the quality of that evidence prevents the development of effective interventions and policies targeted to alleviate these issues. This thesis supports the need for interventions by providing the highest quality data on diet and mental health to date in Canadian children. This thesis provides additional evidence to support the importance of promoting a healthy lifestyle, particularly among children in Canada. The inclusion of improved mental health as an additional benefit for the promotion of a healthy diet in childhood provides further evidence to support the imperativeness of nutrition policy and programs, particularly, in Canadian schools.

### 4.4.0 Covariates

All analyses were adjusted for a variety of factors that could potentially confound the relationship between diet quality and mental health. These include: energy intake, gender, household income, parental marital status and education, weight status (normal, overweight and obese), physical activity level and area of residence. The parental surveys from each study provided information on sociodemographic characteristics including household income, parental education, parental marital status (Chapter 3), and urban/rural residence. Age was not considered because all children participating were between 10 and 11 years of age. Weight status was defined using international cut-off points established for children and youth by the International Obese Task Force[21]. Physical activity level was determined from the student surveys. Total energy intake was controlled for in each analysis to ensure that the relationship between diet quality and mental health is independent of the child's total energy intake. This is based on recommendations for analysis of food frequency data[22].

Numerous studies have suggested a link between socioeconomic status and mental health disorders[12 ,23-25]. Socioeconomic status has also been shown to influence diet quality[26-28]. Evidence suggests that an increased income allows for the purchase of foods with higher nutritional value[29]. Therefore, children from families with lower socioeconomic status have less access to nutritious foods. Studies from the United States[30], Netherlands[31] and Scotland[32] have demonstrated an association between lower socioeconomic status and lower diet quality.

Weight status and physical activity level were considered confounders because they have also been associated with both diet quality and mental health disorders independently. There is a clear association between increased Body Mass Index (BMI) categories and poor diet quality. Studies have demonstrated an association between BMI with depression and anxiety[33-36]. It is not clear that BMI is on the causal pathway between diet and mental health. Improving an individuals diet may lower their BMI however it will not necessarily improve their mental health. It may be that overall diet quality is the mediating factor between BMI and mental health. The relationship between diet and mental health is being examined in these two studies therefore, we control for BMI to ensure that it does not distort the true association between diet and mental health.

There is research suggesting that children who engage in higher amounts of physical activity are less likely to develop depressive symptoms[36-38]. There are many possible explanations linking physical activity levels and reduced risk for depression and anxiety. These include physiological explanations for example, by increased amounts of endorphins in the body[39]. There are also psychosocial explanations, for example the fact that physical activity is often undertaken in a team environment provides social interaction and often social support which may improve self esteem[39]. In a study performed in Nova Scotia, higher amounts of physical activity was associated with lower risk of poor diet quality among grade 5 students[20]. This relationship between physical activity levels and diet quality is supported by studies in other populations as well[40-42].

Many children are exposed to traumatic events throughout their life. Divorce or death of a parent can be very traumatic for the child and often influences their mental health. This is supported by studies that suggest mental health disorders are more common among children who have experienced some form of family dysfunction[43]. In addition, children from single parent families whether that be separated, divorced or widowed are often at a greater risk for poor diet quality[20].

Interestingly, in preadolescence boys are more likely to experience feelings of depression or anxiety than girls[44,45]. This relationship shifts in early adolescence and suggests that girls are often at a greater risk for mental health disorders [46,47]. Gender also influences the exposure, diet quality. Boys are at a greater risk for poor diet quality than girls in a study performed among grade 5 students in Nova Scotia[20]. Therefore, in the Alberta study (Chapter 2), the relationship between diet and mental health was examined separately for boys and girls. There are also differences between families living in urban and rural communities that must be accounted for. The causal pathway between mental health and diet is complex and these factors influence both mental health and diet quality. Therefore, they are treated as confounding variables so that they do not distort the true association between diet and mental health.

There is the potential of residual confounding even after controlling for all of these variables. In these two studies, residual confounding may be caused by variables for which data was not collected or when a variable is not measured accurately[48]. It is possible that other variables not accounted for in the analysis

may distort the relationship between diet and mental health. Using secondary data limits the availability of collecting data on all potential confounders. In these two studies there may be variables for which data was not collected and thus, may result in residual confounding. For example, in the Alberta study (Chapter 2) we did not have information on parental marital status and were unable to control for this variable in the analysis. Other variables that may distort the relationship between diet and mental health but were not controlled for in the analysis are family structure, living conditions and parental history of mental illness. However, we did control for a variety of variables including a wide range of sociodemographic and lifestyle characteristics to limit the amount of potential residual confounding.

It is possible that the variables that we did control for were not measured accurately. For example, residual confounding may arise when a continuous variable is divided into a categorical variable[49]. Parental income and physical activity level were categorized rather than treated as a continuous variable. By categorizing variables information may be lost and results may differ based on the cut points chosen[50]. Residual confounding by uncontrolled or miss-measured variables is possible in these two studies. It is important to note that although residual confounding may be present it is unlikely that it fully explains these results.

There is also the possibility that the strength of the association between diet and mental illness differs according to the level of another variable this phenomenon is called effect modification[48]. Gender may modify the relationship

between diet and mental illness. When the analysis was stratified by gender the stratum-specific estimates differ from one another. Stratifying the results reduces the sample size and decreases the power, which may explain these results. Given the large sample size it is more appropriate to study the difference in the strength of the association by gender using stratification rather than working with interaction terms. This allows for the investigation of gender differences that may be lost when examining the entire sample.

### 4.5.0 Strengths and Limitations

#### 4.5.1 Overall

In the present thesis there are several limitations that should be noted. The cross sectional nature of the first study (Chapter 2) allows for the possibility of reverse causation. Since the design is cross sectional the temporal sequence may be unclear because the data is gathered on the exposure and the outcome at the same point in time. Therefore, it may be that poor mental health results in children eating less healthy foods. It is also possible due to the nature of the study design that there is a common cause between diet and mental health, which may explain these results. However, the longitudinal component of Chapter 3 suggests some directionality of the relationship. In both studies (Chapter 2 and 3) there is potential for information bias or more specifically, recall bias. Diet quality was assessed using self-administered questionnaires. Although the questionnaire was validated and suitable for this age group information may be subject to recall bias if those who subsequently are diagnosed with an internalizing disorder or are

identified as having depressive symptoms recall dietary intake differently from others. This is unlikely to concern the validity of the study because the YAQ is widely used and has proven to be effective at providing nutritional information that can serve as the basis for epidemiological research[51].

In both studies (Chapter 2 and 3), selection bias is a concern. To prevent this in the Alberta study (Chapter 2) schools were randomly selected to participate in the study. In 2008, 141 schools were randomly selected to participate in the study. In 2010 only 7 of the 141 schools were unable to participate (95% return rate). The response rate for both surveys is relatively high (61% and 64% for the REAL Kids study and an average of 51.1% per school for the CLASS study). However, it doesn't rule out the possibility that the students not participating in the study may be systematically different from those participating. It is essential to ensure that there are not systematic differences in characteristics between those participating in the study and those choosing not to participate. Some of the main ways in which selection bias may occur in the two studies presented in this thesis are through refusal to participate and non-response. Non-response was of particular concern in the Nova Scotia study (Chapter 3) as participation rates in residential areas with lower estimates of household income were slightly lower than the average. To overcome the issue of non-response bias response weights were calculated to yield provincial population estimates for grade 5 students in Nova Scotia[52].

There is evidence that suggests mental illness may affect participation in research[53]. The prevalence of mental health disorders appears to differ by age,

gender and ethnicity however, it may be explained by the fact that the likelihood of participation in research differs by these characteristics as well[54]. Therefore, the difference in prevalence may be explained by the underrepresentation of these groups. There is a wide range of barriers to participation in mental health research that have been identified ranging from practical reasons like transportation and language difficulties to more complex reasons like severity of illness, stigma surrounding mental health and fear of relapse[53]. These two studies required the students to receive consent from the parent or guardian in order to participate. Children or parents of children suffering from mental health problems may have been less inclined to participate in research. It is possible that the parent or guardian not providing parental consent for participation in the study may be affected by some of these barriers associated with participation in mental health research. However, the Alberta and Nova Scotia study (Chapter 2 and 3) were considered population based health surveys and not primarily mental health research. Therefore these barriers are likely not to concern the validity of the two studies.

In the first study (Chapter 2) there is an additional limitation. The outcome for this study is not as sophisticated as other studies assessing mental health using full mental health questionnaires. Mental health was assessed using one question from a health related quality of life questionnaire (EQ-5D). The EQ-5D depression/anxiety domain was proven to be effective at identifying adults with depression and anxiety[55]. More specifically, it appears to be more efficient at identifying individual with depression alone than anxiety alone[55]. The use of a

single question has proven to be an adequate tool for classifying most individuals with depressive symptoms who were identified as having depressive symptoms by a full questionnaire[56]. Therefore, this suggests that a single question may be used to identify individuals with depression. Other studies using short questionnaires of one or two questions have also been proven effective at identifying depression in an adult population[57-59]. However, the use of a single questionnaire to identify individuals with depression is somewhat inconsistent[60-62]. Using a more sophisticated questionnaire in the assessment of depression and anxiety may be more effective at identifying children with reduced mental health.

In the second study (Chapter 3) there are some additional limitations. One setback is the relatively short follow up period of three years. The prevalence of mood disorders tends to increase in late adolescence and early adulthood[63]. Future studies would benefit from following children into early adulthood to assess the development of mental health problems. In addition, the short follow up period does not completely rule out the possibility of reverse causality. It may be that mental health disorders result in children eating less healthy diets. Dietary habits tend to remain rather constant over time and eating patterns take years to evolve[64]. Therefore, the issue of a short follow up period likely is not a major concern with respect to diet.

Another limitation is that the study only includes those children who are treated or diagnosed with an internalizing disorder. Therefore, we are identifying children with fairly severe internalizing disorders. There are likely many children who did not seek treatment or had barriers to access to care but were suffering

from symptoms of internalizing disorder. This also raises the concern of selection bias. It may be that students whose parents sought treatment were systematically different from those who did not. Depression is more common among children of parents suffering from depression[65]. As well, these children are also more likely to seek treatment, perhaps because their parents received treatment[65]. There are a significant proportion of children suffering from mental health disorders that do not seek help or receive treatment[66]. It is also suggested that children from lower socioeconomic groups are less likely to seek treatment[66]. Using mental health screening surveys may identify untreated mental health disorders that would not be detected when using clinical data[12]. These factors associated with seeking treatment may also be associated with diet quality, which would introduce selection bias. For example, children from lower socioeconomic groups may have less access to nutritious foods[29].

In the face of these potential limitations, this thesis has several methodological strengths. A primary strongpoint is that these are population-based studies with high response rates representative of Grade 5 students in Nova Scotia and Alberta, Canada. In addition, both studies (Chapter 2 and 3) have large sample sizes. The second study (Chapter 3) used two population-based data sources, which ensures greater accuracy. The second study (Chapter 3) linked diet quality data with administrative data providing valid and reliable information and minimizing bias in the assessment of internalizing disorder.

### 4.5.2 Use of Administrative Data

Administrative datasets are widely used in epidemiological studies. There are many advantages to using these datasets. The data are often readily available for analysis, efficiently provide information on a large geographic region, presumed near complete information of patient's access to the health care system and they do not rely on self-reported information[67]. However, administrative data do have drawbacks as many studies have shown that using these datasets often leads to underestimating the burden of certain conditions[67]. Although the data are often readily available there are often many ethical considerations due to the confidential nature of the data that must be accounted for. This may make the data more difficult or time consuming to obtain. In addition, access to administrative data and the data itself may differ across provinces in Canada.

Administrative databases are not designed for research but rather for clinical and administrative purposes. Therefore, it is important when using administrative data in mental health research to ensure that the information accurately identifies and classify individuals with mental health disorders[68]. Using administrative data gives the researcher no control over what information is included in these databases or the quality of the data collection[69]. However, secondary analysis of administrative data is often more feasible to gain access to the required information in vulnerable populations for instance, individuals suffering from mental illness[68]. A study performed in Alberta Canada provided

evidence suggesting that administrative data is an effective tool for assessing prevalence of mental health disorders in a pediatric population[12].

Administrative data providing information regarding mental illness in society includes hospital discharge and physician billing data. In a study performed in Ontario, Canada examining the burden of adolescent injury, it was found that using physician-billing data in addition to hospital discharge data provided a more comprehensive dataset[70]. Therefore, in Chapter 3, all hospital and physician records were used when identifying children with internalizing disorders rather than simply hospital discharge information.

### 4.6.0 General Conclusions

These two studies have contributed to our understanding of the relationship between diet and mental health in Canadian children. In brief, the present findings suggest that overall diet may be implicated in the development of mental health disorders. It appears that the quality of an individual's diet, as opposed to intakes of specific nutrients, plays an important role in mental health. This has important implications for the prevention of mental illness due to the modifiable nature of individual diet. Intervention studies and studies with longer follow up periods are needed to expand on the present findings.

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