An Analysis of the Association of Diet, Oral Health and Obesity in Canadian Adults

By

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ABSTRACT

Dental professionals are in a unique position to promote healthy eating among their patients, which benefit an individual's oral health. Dietary recommendations that support oral health are similar to recommendations to achieve healthy weights, thus dietary guidance by dental professionals could also impact an individual's weight status. To date, this topic has received little attention in Canada. This research examined the association between diet, oral health and obesity in Canadian adults ages 20-79 using data from the Canadian Health Measures Survey (CHMS) Cycle 1 (2007-2009). The quantitative analysis, which used logistic regression and linear regression found that increased milk consumption was associated with positive oral health ($p=0.04$) and healthy weights ($p=0.02$). On the other hand, increased soft drink consumption was associated with having fewer than the recommended number of teeth (< 21 teeth) ($p=0.04$) and a reduced Modified Oral Health Score ($p=0$) but not associated with increased obesity. A number of sociodemographic factors were associated with better oral health and lower chances of obesity: university education, increasing age and province of residence for example, were positive for both. The results from this study suggest the value of using dental settings to promote healthy food intakes, which may benefit oral health and weight status; highlight the importance of addressing the oral health and weight status needs within certain sociodemographic groups; and suggest the need for further Canadian research.

DEDICATION

To my late father-in-law Mr. Virendra Sharma who always encouraged and supported me in all my endeavors. This thesis is my tribute to him.

To my family, my husband Gaurav and my daughter Vidushi who have supported me in every way during the tenure of this program.

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1. INTRODUCTION

1.1 Background

Dental caries is a public health issue with high prevalence rates (Lancet, 2017) affecting 3.58 billion people (World Health Organization [WHO], 2018). Throughout the world, dental healthcare professionals strive to improve the oral health of their patients with each dental visit. Dentists not only have the opportunity to evaluate and treat ongoing oral health issues, but also to assess any underlying factors that can harm their patient's oral and general health (Reissman, John, Schierz, Kriston, & Hinz, 2013). Dietary intake has been identified by the WHO as a common risk factor for issues in the mouth and body (Peterson, 2003) and eating a healthy diet is one of the seven recommendations they make to promote oral health and prevent oral disease (Peterson, 2009). There are instances when patients visit a dental clinic with a complaint stemming from symptoms in the mouth but find the problem has roots in the body, similar to the tip of an iceberg.

At the same time, there is a global increase in obesity, a significant cause of which is food intake. Obesity increases the risk of medical conditions such as type 2 diabetes and cardiovascular disease and is also associated with poorer oral health outcomes (Burket, Greenberg, & Ship, 2008). Historically, dental professionals have focused on oral health,

but as obesity becomes a more significant health problem and because diet is a shared risk factor, dental professionals have the opportunity to join a multi-sectoral approach to promote healthy weights by reinforcing the importance of healthy eating and advocating for societal change (Touger-Decker & Mobley, 2007).

The WHO defines oral health as "a state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial wellbeing" (WHO, 2003, p. 4). An advantage that dental professionals have compared with other healthcare professionals is their ability to recall a patient regularly (Julien, 2000). In Canada, approximately 80% of the population has a dentist and 86% of Canadians visit a dentist at least every two years. Although lack of private dental insurance continues to be a barrier, an increasing number of Canadians report visiting a dentist annually, from 60% in 2001 to 75% in 2012 (Health Canada, 2010). Data from the same Canadian Health Measures Survey (CHMS) that was used in this research found that 38.2% of the adult population had visited a dental professional in the last year and 75.3% had visited a dental professional more than a year ago (Health Canada, 2010).

Dental caries, which is a marker of oral health, is defined as a "biofilm-mediated, sugar-driven, multifactorial, dynamic disease that results in the phasic demineralization and remineralization of dental hard tissues" (American Dental Association [ADA], 2018). Various organizations such as the WHO, Canadian Dental Association, American Dental

Association and Health Canada have suggested dietary recommendations to support oral health (refer to Table 1.1) such as reducing the amount of sugar in the diet, and avoiding sugar sweetened soft drinks and fruit juices and instead eating cheese, yogurt, fruits and vegetables. Similar recommendations have been made by other organizations such as Health Canada and the Heart and Stroke Foundation of Canada to promote healthy weights. The overlap among recommendations indicates that food items that are beneficial to oral health may also have a beneficial effect on weight status.

Table 1.1: Dietary recommendations to support oral health and healthy weights

Dietary recommendations for good oral health	**Dietary recommendations for healthy weights**
World Oral Health Report (WHO, 2003, p. 20): Decrease consumption of sugary drinks, promote a healthy diet.	Healthy Behaviors- Promoting Physical Activity and Healthy Eating (Canadian Medical Association, 2015): Restriction of high-calorie, high sugar foods/beverages.
Nutrition (Canadian Dental Association, n.d.): "Avoid sugar- sweetened drinks, fruit juices with sugar, eat healthy snacks like yogurt, cheese, raw fruits and vegetables."	Obesity in Canada - (Standing Senate Committee on Social Affairs, 2016): Decrease consumption of sugary beverages, increase consumption of fruits and vegetables.
Mouth Healthy (American Dental Association, n.d.): "For good dental health, drink plenty of water, eat from the food groups, fruits, vegetables, dairy, protein and grains''	Position statement-(Heart and Stroke Foundation of Canada, 2015): Reduce consumption of products high in sugar, provide access to healthy food, raise public awareness towards healthy food.

Dental Hygiene and your Diet (Canadian Dental Hygienists Association, 2017): "Choose water over fruit juice and carbonated beverages, eat fruits and vegetables, avoid sugary snacks.''	Canada's Dietary Guidelines for Health Professionals and Policy Makers – (Canada's Food Guide, 2019, p. 9): ''Vegetables, fruit, whole grains, and protein foods should be consumed regularly. Water should be the beverage of choice.''

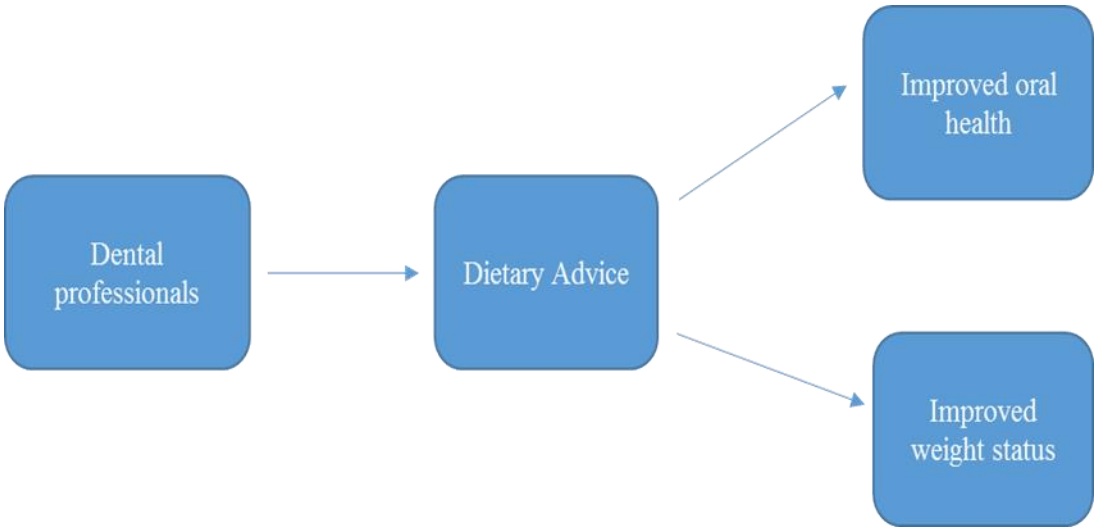
Conceivably, advice dentists provide to patients on food intake to promote oral health might also help combat obesity. A number of researchers have recommended that dental professionals provide dietary guidance or refer patients to a dietitian following dental screening (Moynihan, 2005; Li, Zou, & Ding, 2012; Moynihan, Makino, Petersen, & Ogawa, 2017). This recommendation is supported by existing literature from outside Canada that highlights associations among diet, oral health, and weight status (Pilotto, Celeste, Faerstien, & Slavutszky, 2013; Nakamura et al., 2016).

Currently, however, dental practitioners provide dietary advice rarely. A literature review from Australia that examined studies that focused on dietary advice by dental professionals (they mainly targeted children) confirmed this phenomenon (Franki, Hayes, & Taylor, 2014). Such advice could be beneficial, however. Another Australian study that developed an online module to educate dental professionals on counselling patients about their diets found that at a 6-months follow up after counselling occurred, patients reduced total sugar intake (food and beverages), frequency and exposure times significantly (Hayes, Cheng,

Musolino, & Rogers, 2017). Overall, more research is required to learn about the extent to which dietary advice occurs by practitioners is and acted upon by patients.

Dietary advice from dental professionals can focus on increasing the intake of protective foods while decreasing the intake of harmful foods. Regular vegetable, milk and cheese consumption and increased water intake are beneficial while consumption of sugar-containing foods, a high quantity of carbohydrates and sugar-sweetened beverages all contribute to poor oral health (Chaput, Gilbert, Caron, Nicolau & Tremblay, 2007; Touger-Decker & Mobley, 2013). These same foods have been implicated in maintaining healthy weights (Alinia et al., 2009; Lim et al., 2014), so potentially, the dietary advice provided to patients to improve oral health might also assist them with their weight status: one action by dental professionals – two beneficial outcomes (refer to Figure 1).

Figure 1: Potential benefits of dietary advice by dental professionals



1.2 Diet, oral health and weight problems

Existing literature indicates that poor diet, dental caries, (a marker of oral health) and obesity are major issues among Canadian adults (Bélanger-Ducharme & Tremblay, 2005). Poor diet in Canada is a leading contributor to early mortality and increased risk of chronic diseases such as cardiovascular disease (Nshimyumukiza, Lieffers, Ekwaru, Ohinmaa, & Veugelers, 2018). A study that assessed eating patterns found that the diet of many Canadian adults did not follow Eating Well with Canada's Food Guide (CFG)

(Jessri, Nishi, & L'Abbe, 2015). Intakes varied by demographic characteristics. For example, higher levels of education and income were associated with adequate consumption of fruits, vegetables and milk while lower levels were associated with inadequate consumption (Tarasuk, Fitzpatrick, & Ward, 2010).

Many Canadians experience problems with their oral health. According to a report by Health Canada, 57% of the adult population ages (20-79) had one or more untreated decayed tooth and 96% of Canadian adults have a history of dental disease (Health Canada, 2010).

Obesity is a serious issue. Obesity rates have increased multi-fold around the world in the past few decades and Canada is no exception. In Canada, obesity increased 300%; in 1985 rates were 6.1% and in 2011 were 18.3%; and are projected to increase steadily at a rate of 4-5% every year (Twells et al., 2014). In 2016 and 2017, the adult obesity rate was 27% (Statistics Canada, 2018).

To our knowledge, no research exists that examines the association of diet, oral health and obesity among Canadian adults (20-79) using CHMS data. This study adds Canadian evidence to the question whether dietary practices that influence oral health could also impact weight status. The remainder of this chapter introduces the research questions and hypotheses along with the key aspects of this study.

The impetus for this research is the potential role of dental professionals in providing dietary advice that could impact oral health and obesity. Therefore, the analysis is

unidirectional - that is analyzing the influence of diet on oral health and diet on obesity. It should be noted that other associations not explored in this study may exist among these three variables. For example, lack of teeth decreases fruit and vegetable intake (Nowjack-Raymer & Shieham, 2007) and increased obesity is associated with poor oral health (Nascimento et al., 2016).

1.3 Research question

The purpose of this research is to analyze the association among diet, oral health and obesity among Canadian adults to address the following research question:

1. Is there an association among diet and oral health and diet and obesity when demographic factors (education, income, sex, age, immigrant status and province of residence) are considered?

1.4 Hypotheses

The following hypotheses stem from the research questions and will examine if dietary intakes are associated with the number of teeth present, the modified oral health score, Body Mass Index (BMI) values controlling for education, income, sex, age categories, immigrant status and province of residence.

H^1-The dietary factors associated with better oral health outcomes and dietary factors are associated with healthy weights, which were divided into different sections:

H^{1a}-Dietary factors are associated with oral health outcomes, controlled for sociodemographic variables.

H^{1b} -Dietary factors are associated with weight status, controlled for sociodemographic variables.

H^{1c}-Associations exist between oral health and sociodemographic factors, and obesity and sociodemographic factors.

Depending on the results, the null hypothesis will be rejected or accepted. If the results confirm association, they will provide an evidence-based rationale to include dietary guidance in dental practice, which could help promote better oral health and healthy weights.

1.5 Key aspects of the study

This study focuses on analyzing associations between dietary intake and oral health and dietary intake and obesity. Additionally, the associations among poor oral health and obesity were explored relative to demographic variables: education, income, sex, age categories, immigrant status and province of residence.

1.5.1 Diet - aspects related to oral health and obesity

Previous studies that focused on dietary advice in dental practices identified food products with an anti-caries effect, which included cheese, milk, water, vegetables and fruits and sugar free drinks, and caries-promoting beverages such as soft drinks and fruit

juices (Moynihan, 2002; Palacios, Joshipura, & Willett, 2009; Somborac, 2010). Fibrous foods such as fruits and vegetables and dairy products such as cheese are beneficial for teeth and surrounding structures (Moynihan, 2000; Kasket & Deapaola, 2002; Touger-Decker & Mobley, 2013). Sugar-containing food items and beverages are detrimental for oral health as they cause caries (Gustaffon, 1954; Moynihan, 2005; Huogel et al., 2009; Goodson et al., 2013), and acidic foods lead to dental erosion (Scardina & Messina, 2011). Nutritional deficiencies of folate can manifest as mucosal abnormalities in the mouth as oral ulcers (Scardina & Messina, 2011). Adequate levels of Vitamin D are associated with a decreased risk of tooth loss and periodontal disease (Zhan et al., 2014).

In the pre-historic era, diets contained relatively low levels of fermentable carbohydrates and caries incidence was minimal, however caries occurrence rates increased multifold when refined foods became a major part of people's daily diet (Humphrey et al., 2014). Likewise, when people adopted modern lifestyles, the incidence of dental caries increased with a concurrent increase in obesity and related diseases (Hujoel, 2009; Scardina & Messina, 2011) thereby indicating that dietary changes are an important factor in the increasing incidence of dental caries and poor oral health as well as obesity.

1.5.2 Sociodemographic factors-aspects related to diet, oral health and obesity

A number of sociodemographic factors play an important role in the health of an individual. For example, poor oral health is more prevalent in individuals with low

education levels (Brodeur et al., 2000; Paulander, Axelsson, & Lindhe, 2003) and low-income categories (Geyer, Schneller, & Micheelis, 2010). The same factors have also been linked with a higher likelihood of being obese (Black & Macinko, 2008; Lovejoy et al., 2009; Webbink, Martin, & Visscher, 2010; Salois, Tiffin, & Balcombe, 2012). Low-income individuals often experience economic and physical barriers to eating healthy food (Moeller & Quinonez, 2016). Adequate information about a healthy diet, high cost of fresh foods and the ease of access to semi-processed foods are key factors that influence what is eaten by a household (Lovelace & Rabiee-Khan, 2013).

Previous Canadian evidence indicates that factors such as sex, income, being an immigrant and province are associated with a higher risk of being obese (Hajizadeh & Campbell, 2014). In terms of sex effects, it has been previously seen that females have poorer oral health than males (Urzua et al., 2012). Increasing age is an important factor in the oral status of an individual (Steele et al., 2003) and increasing age is associated positively with obesity (Twells et al., 2014).

Another sociodemographic factor that influences oral health and weight status is being an immigrant, as the process of relocating to a different country can trigger various circumstances that lead to poorer oral health (Calvasina, Muntaner, & Quiñonez, 2015) and variations in weight status (McDonald & Kennedy, 2005). In Canada, oral health varies according to province with residents of Ontario and British Columbia having the best oral health and those living in Newfoundland and Labrador and Quebec having the

worst (Millar & Locker, 2005). British Columbia has the lowest rate of obesity while Newfoundland and Labrador have the highest (Twells et al., 2014).

1.6 Canadian Health Measure Survey (CHMS)

The data source for this study was the Canadian Health Measures Survey - Cycle 1 (CHMS) as it contains information on dietary intake, oral health and height and weight (to assess weight status). Data for the CHMS were collected through a clinical examination of the participants, including lab tests, in addition to a household questionnaire that was completed by the participants.

Information on dietary intake, oral health and demographic information were obtained via household surveys, height and weight data were measured by trained assistants, oral health was assessed by a dental examination, and nutrition biomarkers obtained from a blood sample. For this study, self-reported intakes of individual foods comprised the dietary data, oral health was assessed by the number of teeth and a modified oral health score and weight status was calculated using BMI. The dependent variables were oral health variables (Modified Oral Health Score and number of teeth present) and BMI categories. The independent variables were the dietary variables and biomarkers, and the sociodemographic variables were the control variables.

1.7 Thesis Overview

The remainder of this thesis consists of four chapters: chapter two reviews existing literature regarding the key aspects of this study; diet, oral health, obesity and sociodemographic factors, and chapter three describes the source of the data along with the methods and models used for this study. Chapter four presents the results, including descriptive results and regression outputs. Chapter five analyses and discusses the results and provides recommendations arising from this study.

2. LITERATURE REVIEW

This literature review encompasses studies about adults from around the world, with special attention to research from Canada. Phrases employed to find the literature included 'relationships/association between diet and oral health outcomes', 'relationships/association between diet and obesity' and studies that explored the 'relationship/association between diet, oral health and obesity'. These sources were primarily peer-reviewed articles, previous dissertations, government reports and publications from professional organizations. Literature searches included using the following sources:

PubMed: https://www.ncbi.nlm.nih.gov/pubmed?otool=icaunbrulib

University of New Brunswick Libraries: https://lib-unb-ca.proxy.hil.unb.ca/

Statistics Canada: https://www.statcan.gc.ca/eng/start

Journal of the Canadian Dental Association: http://www.jcda.ca/

The remainder of this chapter examines existing literature on how dietary factors assessed in the CHMS (milk, cheese, yogurt, fruits and vegetables, soft drinks, water, fruit juices, fruit flavored drinks, ice-cream/frozen yogurt) influence oral health (number of teeth and Modified Oral Health Score) and obesity (BMI). This chapter also examines

literature that reviews the relationship among these factors in relation to education, income, sex, age categories, immigrant status and province of residence.

2.1 Dietary factors and oral health

The following section describes the role of dietary factors in influencing oral health based on the underlying rationale that these are foods and beverages dental professionals might advise patients about. While some foods and beverages promote positive oral health, others are detrimental and increase an individual's predisposition to dental caries and gum problems.

2.1.1 Milk and dairy products and oral health

In 2015, milk consumption in Canada was 64 liters per person annually, cheese consumption was reported at 3.2 kilograms per year and yogurt consumption was reported at 10.9 liters per person (Statistics Canada, 2017). A study that analyzed beverage intakes of Canadians ages 19-65 using Canadian Community Health Survey (CCHS, cycle 2.2) data from 2004, found that women drank relatively low amounts of milk compared with other beverages and consumed fewer of the nutrients found in milk compared with men (Nikpartow, Danyliw, Whiting, Lim, & Vatanparast, 2012).

Another Canadian study found that consumption of cheese after a meal can be protective for dental health as cheese neutralizes plaque pH especially after a sugary meal (Silva et al., 1986). Unsweetened milk and yogurt are also beneficial for oral health

(Moynihan, 2000; Levine, 2001; Kashket & DePaola, 2002; Walther et al., 2008; Ravishanker et al., 2012; Dror et al., 2014).

In a comparative study of dental students in India (n=68), where half the participants had dental caries and the other half were caries-free, researchers found that the overall effect of unsweetened milk, cheese and yogurt was protective regardless of the individual's oral health status (Ravishankar et al., 2012). In the United States, Kashket et al., (2002) found that milk in its natural form, without any added sugar or flavorings, was protective and promoted remineralization (protective effect on teeth). Cheese also reversed the cavity-forming process. A study in the United Kingdom yielded similar results (Levine, 2001). Adegboye et al., (2012) observed an inverse association between milk and cheese and the occurrence of periodontitis in adults over the age of 65, and similar results were reported in a study conducted in Japan (Kurahashi, Kitagawa, & Matsukubo, 2017).

2.1.2 Fruits and vegetable intake and oral health

The WHO found that a low intake of fruits and vegetables is one of the five main contributors to the global burden of disease (WHO, 2003). According to a report by Health Canada, 56.7% of the population reported inadequate consumption of fruits and vegetables (Perez, 2002). A recent report by Health Canada found that in 2015, only 31.5% of Canadians 12 years old and older consumed fruits and vegetables five or more times per day and this level decreased to 28.6% in 2017 (Statistics Canada, 2019).

Supporting this evidence, a study that utilized data from CCHS cycle 2.2 that focused on consumption frequencies found that only 26% of the participants met the recommended intake frequencies in their age-sex categories (Black & Billette, 2013). A report that compared data from the nutrition components of CCHS in2007 and CCHS in 2015 found that fruit and vegetable intake was consistently low and decreased significantly from 5.0 times a day to 4.7 times per day (Colapinto, Graham, & Pierre, 2018). No Canadian data were found that reported on fruit and vegetable intake and oral health but in the Kyoto-Kameoka study (n=6,551) conducted in Japan, a higher frequency of fruit and vegetable consumption was associated with better oral health (Nanri et al., 2017).

2.1.3 Water consumption and oral health

In Canada, water is consumed more frequently than other beverages, however it was found that water consumption decreases as age increases. For young adults (19-30), the consumption range was 1.1 to 1.3 liters, however for adults ≥ 71 the consumption ranged between .77 liters to .79 liters (Garriguet, 2008). As a non-cariogenic beverage, water consumption and dental health go hand in hand and water fluoridation is also a very important factor preventing the development of caries. In Canada, water fluoridation varies widely; for example, cities such as Moncton, Waterloo, Calgary and Quebec do not have fluoridated water (National Collaborating Center for Environmental Health, 2014).

Fluoridated water is beneficial to oral health (Armfield, 2005; McLaren et al., 2016) and is one of the most cost-effective public health measures for controlling dental caries.

Adequate water consumption not only helps flush out food particles but when fluoridated, helps keep caries prevalence rates in control (Stoneman, Papadopoulos, & Wallar, 2014).

2.1.4 Soft drinks and oral health

Soft drink consumption has a negative impact on oral health. The high sugar content in soft drinks not only provides ideal conditions for caries development (Marshall & Cunningham, 2002), their acidic nature (pH < 3.5) causes degradation of dental enamel (dental erosion) (Larsen & Nyvad, 1999). Garriguet (2008) found that in Canada, daily soft drink consumption in the age group of 19-30 ranged from approximately 530-650 ml, from ages 31-70 ranged from 400-600 ml, and beyond age 70 decreased to 300-320 ml. A study that analyzed data from CCHS Cycle 2.2, which studied adults from the age of 19 to 65, found that soft drinks and fruit drinks contributed more than 50% of the total energy intake from beverages in Canadian adults ages 19-65 (Nikpartow, Danyliw, Whiting, Lim, & Vatanparast, 2012).

Li, Zou, & Ding (2012), conducted a meta-analysis that included a total of nine studies primarily from the UK and Asia. They found that the risk of dental erosion increased by 2.4 times with increased consumption of soft drinks. A similar result from Finland was obtained in a 4-year prospective study (n=939), that measured the effect of soft drinks on oral health among Finnish adults. People who drank more than 3 portions of sugar sweetened beverages per day (SSB's) had a 33 percent higher number of Decayed, Missing, Filled Teeth (DMFT) and people who consumed 1-2 portions of SSB'S daily had a 31 percent higher DMFT score than people who did not consume soft

drinks (Bernabé, Vehkalahti, Sheiham, Aromaa, & Suominen, 2014). Increased consumption of beverages with a high sugar content is a risk factor for dental caries; the WHO recommends restricting sugar intake to improve oral health as a part of overall health (Meyer & Lee, 2015).

2.2 Dietary factors and obesity

This section highlights how the same dietary factors that influence oral health may have a positive or negative influence on weight status.

2.2.1 Milk and dairy products and obesity

An increased consumption of dairy products particularly, milk, yogurt and cheese may contribute to healthy weights. Dairy products such as cheese may have a high fat content hence it is perceived that these food items may contribute to obesity. Studies, however, indicate that there is an inverse relationship between milk and cheese consumption and high BMI values (Walther et al., 2008; Lee et al., 2014; Tunick & Hekken, 2015). A study in France (n=13,017), found that during a 6-year period, milk and yogurt consumption were inversely associated with weight in women and men (Vergnaud et al., 2008).

2.2.2 Fruit and vegetable consumption and obesity

Fruit and vegetable consumption have an inverse relationship with obesity. Obese people tend to eat fewer fruits and vegetables compared to people with healthier weights

(Tjepkema, 2006). In a Canadian survey of adults ages (35-69) from the Atlantic provinces, fruit intake and obesity were inversely related (Yu et al., 2018). An observational study by Mozaffarian et al., (2011) with 120,877 participants in the United States assessed weight change and lifestyle factors measured at 4-year intervals. The results indicated that consumption of an adequate amount of fruits and vegetables was inversely related to weight gain over time.

An increase in fruit and vegetable consumption does not increase weight; rather it helps maintain weight. This conclusion was reached by Mytton et al., (2014) through a systematic review that included eight studies; five from North America, two from Europe and one from India. All the studies found that dietary advice made a positive difference in fruit and vegetable intake (Mytton et al., 2014) as increased intake of fruits and vegetables resulted in no weight increase. A review of sixteen international studies including one study from Canada that examined fruit consumption only, found that increased fruit intake is inversely associated with weight gain (Alinia et al., 2009).

2.2.3 Water intake and obesity

The positive effects of adequate water include hydration, maintenance of a chemical balance in the body, and a vital contribution to many functions at the cellular level. Inadequate water intake leads to alteration of these functions, which can have a severe negative impact on the body (Gibson, Gunn, & Maughan, 2012). In a Canadian study that included data from seven provinces, the mean daily intake of water was 1.2 liters per day, ranging from 0.03l to 9.0l (Roche, Jones, Majowicz, McEwen, & Pintar,

2012). Existing literature suggests that water may act as a catalyst in weight loss and hence have a positive impact in obese individuals. In a randomized control trial, (n=41) conducted in the US, Davy, Dennis, Dengo, Wilson, & Davy (2008), reported that participants who drank 500 ml of water before every meal consumed 13% fewer calories, hence contributing to weight loss. In another study, the results changed when age was considered. Walleghen et al., (2007) found that intake of water before a meal resulted in weight loss in participants who were 60-70 years old but had no significant effect among the participants who were in the 21-35 year age group.

2.2.4 Sugar sweetened beverages and obesity

The past few decades have witnessed an increased consumption of soft drinks compared with other beverages (Luger et al., 2017) in Canada (Nikpartow, Danyliw, Whiting, Lim, & Vatanparast, 2012) and other parts of the world (Armfield, Spencer, Roberts-Thomson, & Plastow, 2013). The high sugar content in these beverages is a known contributor to obesity and unhealthy weights (Schulze et al., 2004).

A recent Canadian study predicts that the total new cases of obesity due to SSB's from 2016-2041 will amount to 2,101,399 (Jones, Veerman, & Hammond, 2017). Canadian data from CCHS 2.2 indicate that men consume higher amount of soft drinks than women. The average age of men in a cluster of 'high soft drink consumption group' was 34.6; and their overall caloric intake was the highest of seven clusters of beverage consumers (Nikpartow, Danyliw, Whiting, Lim, & Vatanparast, 2012). The authors

concluded that Canada needs measures and public health messages that target the reduction of SSB's (Nikpartow, Danyliw, Whiting, Lim, & Vatanparast, 2012).

A study that utilized data from the Australian National Nutrition Survey found that young adults, ages 19 to 24 years, were the largest consumers of soft drinks. Their average weekly consumption was 2.3 liters (McLennan & Podger, 1999). Another study that surveyed young adults (n=35) found that family plays a significant role in soft drink consumption; unavailability of soft drinks in the house led to decreased consumption (Hattersley, Irwin, King, Silva, & Allman-Farinelli, 2009).

A US study that used data from NHANES (2005-2007), found that the odds of being obese increased by 1.5 times when soft drink consumption was more than 2 servings per day and by 1.3 times when consumption was more than 1 serving (Miller et al., 2013). A study conducted in Thailand (n=59,283), spanning over 4 years (2005-2009) revealed that individuals who consumed SSB's had an increase in mean weight by 1.8 kg for females and an increase in mean weight by 2.0 kg for males. Weight gain in participants who increased their consumption of SSB's was more common than individuals who did not increase their consumption (Lim et al., 2014).

2.3 Nutritional biomarkers

The most reliable measures of the nutritional status of an individual are nutritional biomarkers, as self-reported data show trends of over-reporting in fruit and vegetable intake and under reporting of sugar, protein and energy consumption (Kuhnle, 2012).

Dietary data in the CHMS is self-reported so to strengthen the analysis this study analyzed oral health and obesity relative to biomarkers for folate and vitamin D. Folate as a nutritional biomarker reflects fruit and vegetable consumption and red blood cell folate is used to estimate folate stores in the body (Brevik et al., 2005). Although a number of vegetables and fruits are good sources of natural folate, due to folate fortification in North America, fortified grains are now the largest reported component of dietary folate, not fruits and vegetables (Chan, Bailey & O'Connor, 2013). Vitamin D is a measure of bone health and is measured as 25-hydroxyvitamin D. Milk is the largest source of vitamin D in the diets of Canadians (Vatanparast, Calvo, Green, & Whiting, 2010). Optimal vitamin D levels are beneficial for skeletal health and are protective against gum disease - an indicator of oral health (Antonenko, Bryk, Brito, Pellegrini, & Zeni, 2015).

2.4 Sociodemographic factors and oral health

Education, income, sex, age categories, being an immigrant and province of residence and their relationship with oral health are explored in the following section.

2.4.1 Education level and oral health

A report that analyzed data from the CHMS found there were more people in Canada in the lowest education category who had not visited a dentist in the past two years when compared to individuals who had higher education levels. Also, the type of care sought by higher educated individuals was more preventative in nature (Health Canada, 2010). A study in Quebec found that as the level of education increased, the DMFT scores

improved. People who completed primary or secondary levels of education had more missing teeth (9.8 versus 5.8), more decayed surfaces (2.3 versus 1.3) and fewer filled surfaces (19.6 versus 30.0) than people who went to university (Brodeur et al., 2000). Tooth loss is linked consistently to low levels of education: the chances of an individual becoming edentulous (having no teeth) increase two-fold with a lower level of education (Felton, 2009). In Canada, according to the CHMS data, the percentage of people having fewer than 21 teeth were almost double (22.3%) when compared with more highly educated people (12%) (Health Canada, 2010).

A study in Sweden that surveyed adults over the age of 35 found that when the number of teeth and prevalence of dental caries were considered, there were more edentate individuals with lower education levels. The percentage of fillings and treated teeth were higher in those with more education (Paulander et al., 2003).

In a study conducted in Australia (n=7312), oral health indicators were correlated with individuals with different levels of education. Individuals who completed the 10^{th} grade were less likely to visit a dentist (72%) compared to individuals who completed university (82%). Almost one-fifth (17%) of the individuals who avoided foods due to dental problems had lower levels of education. Individuals whose occupation was in the trade certification category had the maximum number of individuals (17%) who had not visited a dentist in the past five years (Australian Research Centre for Population Oral Health, 2006).

The type of dental care sought was also related to the level of education. People with lower levels of education category (grade 10, trade certification) were twice as likely to visit a dentist because of a problem versus university graduates who visited a dentist for preventative care. An important factor is dental insurance as it was more likely for individuals with a higher level of education to have dental insurance (60%) compared to the 10th grade category (37%) (Australian Research Centre for Population Oral Health, 2006).

2.4.2 Income and oral health

Income influences diet, oral health and weight. As income levels decrease, the prevalence of dental disease increases as does the incidence of chronic diseases related to obesity. According to the Canadian Academy of Health Sciences Report on Access to Dental Care (2012), the group that reported the highest number of individuals experiencing dental pain and experiencing problems eating food were in the lowest income category (Federal Provincial Territorial Dental Working Group, 2012). A person's oral health is often related to economic factors such as their income and insurance status. A study (n=20,481) that utilized data from 11 metropolitan areas in Canada confirmed that an individual with a low socioeconomic status experiences more dental problems and poorer oral health compared to individuals with higher economic standing (Moeller & Quiñonez, 2016). A study in Canada that used CCHS (2007) data found that low income, low education, sex differences and marital status were inversely related to adequate fruit and vegetable consumption (Azagba & Sharaf, 2011). The

Canadian Dental Association (2017) recommends increased action to improve access to dental care by low income and other vulnerable groups in Canada.

The social gradient is well demonstrated in the aspect of oral health. A study in Germany (n=925) demonstrated that low levels of income were related to a higher prevalence of dental problems. People with lower incomes had 3.74 times higher odds of having a higher DMFT score than people with better incomes (Geyer, Schneller, & Michelis, 2010). A study that utilized data from Australia's National Survey of Adult Oral Health (NSAOH), confirmed the income and oral health relationship. People who rated their oral health as poor mostly belonged to the income category of less than 20,000 dollars per year (Mejia, Armfield, & Jamieson, 2014).

Low-income individuals are in a disadvantaged position compared to individuals for whom finances are not a barrier (Tsakos, Herrick, Sheiham, & Watt, 2010). This situation can be due to multiple factors such as limited knowledge regarding dental health, unhealthy diets, and not being able to access dental services because of lack of insurance (Moeller & Quiñonez, 2016).

2.4.3 Sex and oral health

According to Health Canada, 41.1% of females reported time lost from work due to oral health reasons compared with 37.2% of males (Health Canada, 2010). In a national study (n=4606) in Hungary, which surveyed adults from ages 19-75, women exhibited a higher prevalence rate of dental caries (Fejérdy, Hermann, Madléna, & Jáhn, 2008).

Similar results were reported by Urzua et al., (2012), surveying 1553 adults from the age groups 35-44 and 65-74 and utilizing the DMFT index. They found that in both age categories, rates of tooth loss and caries rates were higher among females. In a pilot study of 20 men and 20 women aged 19-21 in Poland, certain patterns emerged. Women were more susceptible to gum disease, however there were no significant sex differences regarding caries (Kantorowicz, Olszewska, Kolarzyk, & Chomyszyn, 2014).

2.4.4 Age and oral health

Declining oral health has been associated with age in the Canadian adult population (Locker et al., 1996). An important factor is the individual's lowered expectations as they feel poor oral health is a natural consequence of aging (Kotzer et al., 2012). A similar phenomenon was seen in a study conducted in Finland (n=5,987) where adults from the age of 35 to 80 were surveyed. Those in the higher age category and with fewer natural teeth reported more oral health issues. In Finland, there is no charge to patients for dental care until age 19 and after that it is subsidized. In a representative, national survey of Finnish adults 30 years and older, participants in the higher age category of over 75 years old reported poorer oral health as did those with fewer natural teeth (Lahti et al., 2008).

2.4.5 Immigrant status and oral health

Canadian immigrants have poorer oral health than non-immigrants. In a study of immigrants in Nova Scotia (n=45) that obtained data from self-reported and clinical components, 48.9% immigrants (< 5 years in Canada) reported visiting a dental

professional once a year and 62.2% of these individuals reported untreated decay and the need for at least one filling. Only 17.8% of this population reported having dental care coverage, an important aspect of access to a dental professional (Ghiabi, Matthews, & Brilliant, 2013). Another study that utilized data from the CCHS 2014 suggests that oral health among immigrants declines as the number of years in Canada increase. Lack of access to dental services and dependence on insurance plans were important determinants of immigrant oral health (Sano & Abada, 2019).

2.4.6 Province of residence and oral health

A study that used CCHS data found that annual dental visits (ages ≥ 15) were highest in Ontario (70%), followed by British Columbia (67%) which were higher than the national average of 63%. Provinces that ranked below the national average included New Brunswick, Quebec, Newfoundland and Labrador and the three territories. An important determinant of access to dental services is the disparity among the publicly funded programs across provinces (Wayne, 2004). In another study that used CCHS survey data (n=20,864), 19.3% of the people living in Ontario visited a dentist only in emergencies and 27.8% had not visited a dentist in the past year (Zangiabadi et al., 2017). When total tooth loss (edentulism) was taken into consideration, the overall rate in Canada is 6% (CDA, 2017). Based on earlier data, Quebec had the highest prevalence of edentulism (14%) followed by New Brunswick (12%). Alberta and British Columbia exhibited similar edentulism rates (7%) and the lowest edentulism rates were in Ontario (6%) (Millar & Locker, 2005).

2.5 Sociodemographic factors and obesity

Obesity has an important relationship with the sociodemographic characteristics of an individual. The following section describes in detail how these factors (education, income, sex, age, being an immigrant and province of residence) are related to obesity levels.

2.5.1 Education level and obesity

In a study in Quebec (n=10,014), an inverse relationship was observed between the highest level of education achieved (elementary school, high school, college and university) and obesity. Males who attended university were at a 37% lower risk of being obese; in females the obesity risk was reduced only for participants who had attended university and not the other education levels (Huot, Paradis, & Ledoux, 2004).

Another study that used data from five CCHS surveys found that education was inversely associated with obesity levels across all surveys (Hajizadeh, Campbell, & Sarma, 2014). A study in Saskatchewan found that people with education levels less than grade 12 had a higher tendency to be obese (Chen et al., 2015). In another study, researchers found that the chances of being overweight decreased by 2-3 percentage points with every additional year of schooling (Webbink, Martin, & Visscher, 2010).

In a study in Sweden that compared results from 1971 and 1995, the number of overweight adult males was higher in the households with low education when compared to households with high education (Rasmussen, Johansson, & Hansen, 1999). When data

from Great Britain (n=1182) and Portugal (n=540) were compared, lower levels of education and being male were predictors of being obese (Stewart-Knox, Bunting, Parr, Vas, & Gibney, 2012).

2.5.2 Income and obesity

In a study using CCHS cycle 2.1 data, low income was associated consistently with obesity (Godley & McLaren, 2010). Another study that used data from five CCHS surveys (2000-2010) found that the prevalence of obesity was concentrated among low-income people in Canada (Hajizadeh, Campbell, & Sarma, 2014).

The most common food-related factors influencing an increased prevalence of obesity in individuals or communities with low socioeconomic standing is lack of nutritious food, inability to afford healthier food choices (Azagba & Sharaf, 2011) and low geographic density of stores that sell fruits and vegetables (Black & Macinko, 2008). As income decreases, inexpensive and calorie dense food items are selected, which are mostly fatty in nature. This shift contributes to the development of obesity (Salois, Tiffin, & Balcombe, 2012). Members of low-income households are more likely to experience obesity as observed by Giskes, Avendano, & Brug (2011).

The clustering of obesity in certain geographical areas highlights an obesity - promoting environment, which is higher in areas that are mostly low-income (Giskes, Avendano, & Brug, 2011). A study that surveyed Canadian adults found that use of

weight control strategies was lower in the low-income categories (40-41%) when compared to higher income categories (48-49%) (Tu & Masse, 2012).

2.5.3 Sex and obesity

Obesity prevalence was more common in males than females in Canada across five CCHS surveys (Hajizadeh et al., 2014). Pouliou and Elliot (2009) also found that obesity rates were higher in males than females. Another study in Canada, however found that BMI decreases in women as income increases and BMI increases in men with an increase in income (Godley & McLaren, 2010).

In a study in Cape Town (n=1,099) more women than men were found to be obese (Peer, Lombard, Steyn, Gwebushe, & Levitt, 2014). Lovejoy et al., (2009) states that a possible underlying factor for the difference in obesity rates in men and women may be associated with their hormonal differences.

2.5.4 Age and obesity

In a study that utilized data from the 2004 CCHS-Nutrition survey, the age categories of 50-64 were associated with the highest rates of obesity prevalence (Shields & Tjepkema, 2006; Hajizadeh et al., 2013). In another study that utilized data from four CCHS surveys and other Canadian surveys, the highest prevalence rates of obesity were in the age categories 40-59 and $\geq$ 60 respectively (Twells et al., 2014).

In a study that surveyed adults in the United States, BMI exhibited a positive relationship with age (Yen, Chen, & Eastwood, 2009). Another study that surveyed U.S. adults found that health care expenditures related to increased weights increased after 55 years of age (Wee, Phillips, Legedza, & Davis, 2005).

2.5.5 Being an immigrant and obesity

The probability of an individual being obese decreases by 4-5% if they are not born in Canada (Hajizadeh et al., 2014). On their arrival in Canada, immigrants are usually not overweight or obese, but the tendency towards weight gain increases over time. Immigrants have been seen to exhibit obesity after 2-3 decades of stay in Canada (McDonald & Kennedy, 2005).

2.5.6 Province of residence and obesity

Obesity rates in Canada were higher in rural than urban areas and this was more pronounced in western Canada. However, when all provinces were considered, the Atlantic provinces had a higher prevalence rate of obesity (Hajizadeh, Campbell, & Sarma, 2014). Residing in Quebec or British Columbia has been associated with a lower obesity rate, while the pattern of a higher prevalence rate associated with residing in the Atlantic provinces has continued (Hajizadeh et al., 2014). A general trend exists of lower rates in the west and higher rates in the east (Twells et al., 2014).

2.6 Previous studies utilizing CHMS data

Previously, CHMS cycle 1 data have been utilized in many studies and reports. The oral health component of the data has been used for reports (Health Canada, 2010; Canadian Academy of Health Sciences, 2014) and to examine associations among oral health and other factors such as health conditions (Zuk, Quiñonez, Lebenbaum & Rosella, 2017), sociodemographic characteristics (Thompson, Cooney, Lawrence, Ravaghi, & Quiñonez, 2014; Elani, Harper, Allison, Bedos, & Kaufman, 2012 ; Ravaghi, Quiñonez, & Allison, 2013) and dental treatment needs (Ramraj, Azarpazhooh, Dempster, Ravaghi, & Quiñonez, 2012; Ravaghi, Quiñonez, & Allison, 2013). None of the studies however, utilized this data set to understand the associations between diet and oral health and diet and obesity.

2.7 Summary of studies and evidence

All the studies included in this review were peer-reviewed. While some of the studies relied on longitudinal methods (Calvasina, Muntaner, & Quiñonez, 2015; Bernabe et al., 2014; Vergnaud et al., 2008; Mozaffarian et al., 2011 ; Lim et al., 2014) most used cross-sectional methods (Dror et al., 2012; Adegboye et al., 2012; Azagba & Sharaf, 2011; Nanri et al., 2017; Nikpartow et al., 2012; Lee et al., 2014; Roche et al., 2012; Miller et al., 2013; Moeller & Quininez, 2016;). Many of the studies that included dietary variables were reviews (Moynihan, 2000; Kashket & Depeola, 2002; Walther et al., 2008; Dror et al., 2012 ; Tunick & Hekken, 2015; Levine, 2001; Armfield, 2005; McLaren et al., 2016;

Larsen & Nyvad, 1999; Ravishanker et al., 2012; Mytton et al., 2014) and meta-analyses (Li, Zou, &Ding, 2012; Tunick & Hekken, 2015) that compiled multiple experimental studies that explored associations among the dietary variables and oral health. There was other evidence such as pooled analysis utilizing Canadian cross-sectional data like Roche et al., (2012), health reports utilizing national survey data in Canada like Garriguet (2008), and briefs by Levine (2001) and Marshall & Cunningham (2002). Although some studies had a small sample size like Davy et al., (2008), it was included as it was a randomized controlled trial.

Extra effort was used to identify studies from Canada such as Azagba & Sharaf (2011), Kotzer et al., (2012), Nikpartow et al., (2012), which utilized information from national surveys such as the CCHS and CHMS. Others like Alinia et al., (2009); Adegboye et al., (2012); Nanri et al., (2012); Bernabe et al., (2014); and Lee et al., (2014) utilized data sets from other countries.

Considering the existing evidence and the types of studies, a few relied on longitudinal methods whereas others were primarily cross-sectional in nature, like the CHMS data used in this research. All of them indicated associations between diet and oral health and diet and weight status. Existing literature highlights the interactions of diet in relation to oral health and obesity; and the literature indicates that most dietary factors that are associated with positive oral health are positively associated with healthy weights, while the opposite is also true. Milk and dairy products, fruits and vegetables and water consumption are beneficial for oral health (Moynihan, 2000; Kashket &

DePaola, 2002; Sheiham, Steele, Marcenes, & Lowe, 2001; Armfield, 2005) and also support healthy weights (Walther et al., 2008; Davy et al., 2008; Mytton et al., 2014; Lee et al., 2014).

On the other hand, dietary factors such as soft drinks and SSB's are not only detrimental to oral health (Bernabé, Vehkalahti, Sheiham, Aromaa, & Suominen, 2014) but are also associated with weight gain (Garriguet, 2008; McLennan & Podger, 1999; Armfield et al., 2013; Nikpartow et al., 2012; Lim et al., 2014) . Additionally, existing literature indicates that a clustering of poor oral health and obesity exists in low socio-economic groups and is associated with low education levels and varies by geographic distribution in Canada. This research is an effort to add to the existing literature by analyzing the interactions among diet and oral health and diet and obesity and in turn, add to the rationale for dental professionals to provide dietary advice.

3. METHODS

This chapter describes the data source that was used to investigate the research question: is dietary intake associated with oral health outcomes and with obesity? The following question was explored in this study.

Is there an association among diet and oral health and diet and obesity when demographic factors (education, income, sex, age, immigrant status and province of residence) are considered? This chapter also describes the variables, methods and analysis for this study.

3.1 Data Source: Canadian Health Measures Survey

The CHMS began in 2007 with the aim of gathering vital information related to the health of the Canadian population and included direct physical measurements. The CHMS aims to create and develop a biobank with samples and create baseline data on major health issues such as cardiovascular disease, hypertension, obesity, exposure to environmental contaminants and exposure to infectious agents (Statistics Canada, 2015). The CHMS is a cross-sectional data set containing a self-reported component and a clinical assessment. Participants completed a household interview followed by a clinical examination. The data for CHMS cycle 1 were collected between 19th March 2007 and 25th February 2009 (Statistics Canada, 2014).

This study was a quantitative analysis of secondary data using CHMS Cycle 1 master data file (2007-2009). The data were accessed through the Research Data Centre at the University of New Brunswick. Although the CHMS is conducted every two years, only the Cycle 1 master data file contains detailed information regarding food and beverage intake, oral health and BMI values making this dataset the best fit for this study. Another survey, the CCHS contains more detailed dietary data however, the CCHS contained insufficient information to analyze oral health and contains no clinical component.

3.1.1 Ethics

In this dataset, to maintain confidentiality, all the following principles were followed in accordance with the guidelines put forward by Statistics Canada. Firstly, information that can disclose the identity of an individual is not a part of the data set and only the requested data set can be accessed. Secondly, the researcher must undergo an extensive screening process from the RCMP and obtain a reliability status before accessing the data (Tri council Policy Statement, 2014).

Thirdly, the data are physically protected and can be accessed only through the computers provided by the Research Data Centre ensuring all principles (no use of personal devices, no note taking) are followed during the entire span of the research conducted at the center. Finally, any analytical output, including results, are first screened and vetted by the RDC analyst before release, ensuring that all principles of

confidentiality and privacy are maintained. These stringent requirements offset the requirement for a Research Ethics Board (REB) review for this research.

3.1.2 Household and clinical components

The CHMS household component contained an in-depth questionnaire that contained 722 questions and was structured to obtain background information for the clinical component. The questions were based on themes, which were health status, nutrition and food, medication use, health behaviors, environmental factors and socio-economic information (Tremblay, Wolfson, & Connor, 2007). The clinical component was conducted at a Mobile Examination Centre and included an oral health examination, fitness testing, health screening, anthropometry and blood collection (including nutrition biomarkers) conducted by trained medical professionals (Bryan, St-Denis, & Wojtas, 2007; Statistics Canada, 2014).

3.1.3 Sampling strategy in CHMS

The sampling method in CHMS was multistage in nature, and the age of the population measured in Cycle 1 was from 6 – 79 years. A total of 257 collection sites were created, and this sample represented 96.3% of the Canadian population. People residing in institutions, living on reserves, Indigenous settlements, and full-time members of the Canadian forces were excluded. To ensure validity, a sample size of 5000 participants was selected with at least 500 males and 500 females in each age group category which were 6-11, 12-19, 20-39, 40-59 and 60-79 (Statistics Canada, 2011).

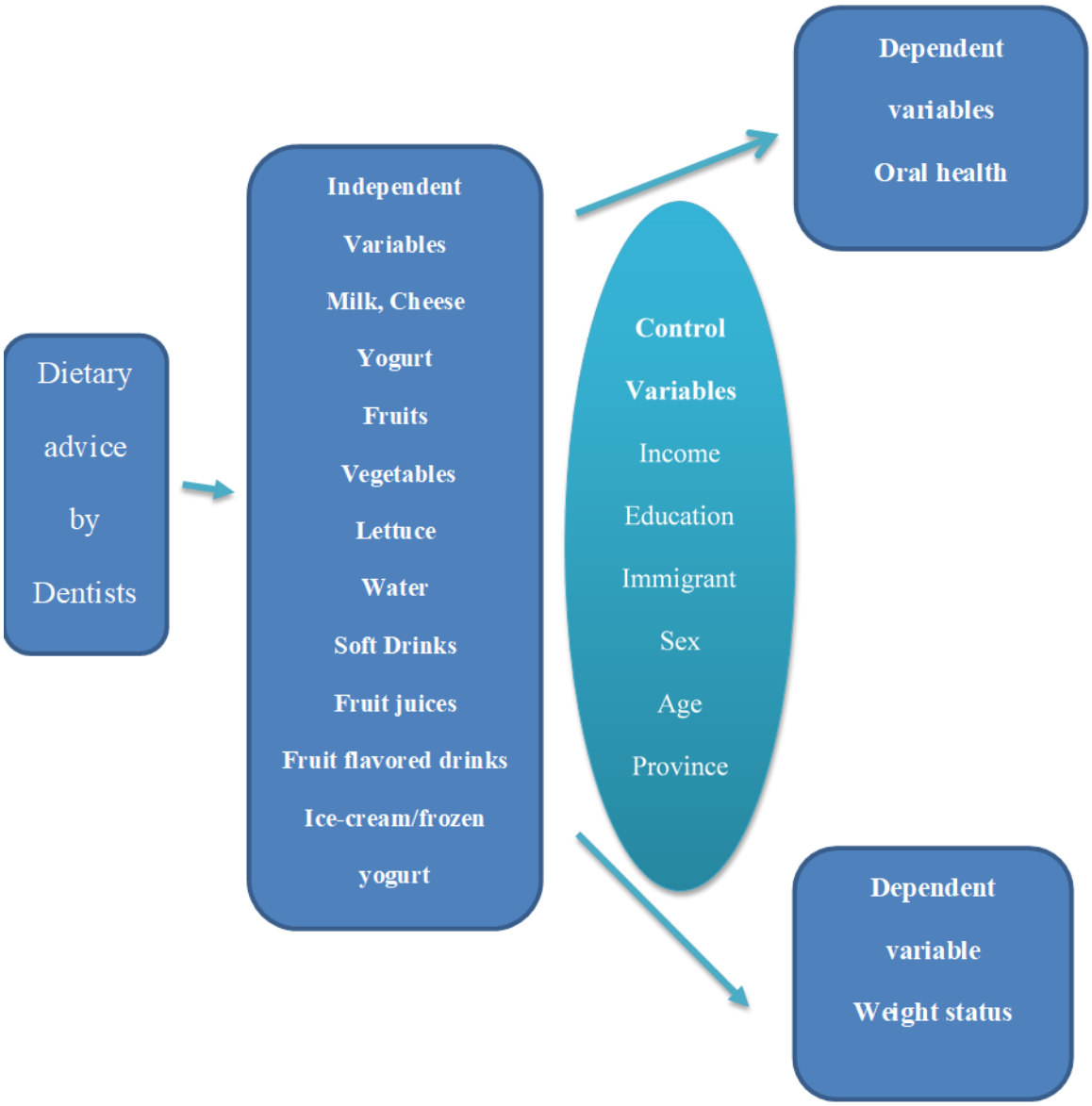
3.1.4 Exclusion criteria

CHMS established exclusion criteria as follows. Exclusion criteria for the oral health component were respondents who were suffering from hemophilia and respondents who answered yes to questions about oral health restrictions. These included medical conditions that required special protocols before dental treatment and respondents with a variety of medical conditions. The exclusion criteria for BMI were pregnancy, inability to sit or stand un-assisted, and any acute conditions that prevented an accurate measurement (Bryan, St-Denis, & Wojtas, 2007; Statistics Canada, 2011).

3.2 Components of this study

The sample for this study was adults 20 and over. Of the 2155 variables in the CHMS dataset, the variables selected for this study were dietary, oral health, height and weight, nutrition biomarkers and sociodemographic information. The dependent variables were oral health variables (MOHS and number of teeth) and weight status (measured as BMI). The independent variables were the dietary variables and nutrition biomarkers and the control variables were sociodemographic variables (See Figure 2) which were education, income, sex, age, being an immigrant and province of residence.

Figure 2: Conceptual model of the study



The dietary data in the CHMS warrant closer examination. In the CHMS, dietary intake was measured in frequencies (times per day) and did not ask for the serving size, therefore dietary indexes such as the Healthy Eating Index, which requires foods to be quantified to assess total caloric intake, could not be used. Moreover, because not all foods/nutrients used in the Healthy Eating Index are associated with oral health; such as saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, and sodium; such a score was not appropriate for this analysis (National Cancer Institute, 2018).

A study that compared the dietary component of CHMS and CCHS found that the CCHS dietary component contains more detailed food information. The CHMS dietary component contained fewer food items, for example, a number of milk products (buttermilk, drinkable yogurt, pudding/custard and kefir) were excluded. Results for certain food categories, such as cheese, were limited, as only cottage cheese was included in the CHMS (Hosseini, Whiting, & Vatanparast, 2019).

As indicated earlier, self-reported dietary data are error prone (Kuhnle, 2012), moreover a study that examined calibration of biomarker values with self-reported data found that participants in the overweight and obese category usually under-report energy consumption by 30-50% , leading to unreliable results (Prentice, Tinker, Huang, & Neuhouser, 2013). As biomarker information was available in this dataset, the relevant biomarkers were included to add data that were objective.

3.3 Analysis

3.3.1 Statistical software

Data analysis was conducted using Stata version 15. Stata is a statistical software that can easily manage simple or complex datasets (Statacorp, 2018), and is widely used in health research (Dembe, Partridge, & Geist, 2011). All computations can be saved in 'log' files and the commands and coding details of variables can be saved in 'do' files thereby creating a useful point of reference when required. The following steps were used to analyze the data.

3.3.2 Data clean up and management

New variables were created from existing CHMS variables where required and subsequent coding of variables were preliminary steps before any analytical procedures were conducted. The cases were weighted; weighting adjusts the results so that they reflect the actual population more closely (Iachan et al., 2016). Stata provides different options to weight the cases, and for this study importance weights (iw) were used. An advantage for using iw is that it minimizes the influence of outliers and one observation represents a certain number of people thereby minimizing bias (Statacorp, 2014).

3.4 Dietary variables

The dietary variables and nutrition biomarkers were grouped together in six categories (See Table 3.1) . The dietary variables were selected to represent foods and beverages that dental professionals might recommend or discourage their patients from consuming. The corresponding CHMS questions of these variables can be referred to in Appendix A-Table 1.

Table 3. 1 : Dietary variables

Variable category	CHMS Questions	Variable
1.Milk and Dairy		
	Eats cottage cheese	MDCD13Y
Dairy consumption	Eats yogurt	MDCD14Y
	Drinks milk	MDCD11Y
2.Fruit and Vegetable		
Fruits and Vegetables	Eats fruit	GFVD17Y
	Eats lettuce or green leafy salad	GFVD19Y
	Eats all other types of vegetables.	GFVD23Y
3.Water		
Water	Drinks water	WSDD21Y
4. Soft drinks		
Soft drinks	Drinks regular soft drinks	WSDD11Y
	Drinks fruit juices	WSDD14Y
	Drinks fruit flavored drinks	WSDD15Y
5.Sugar containing food items		

Sugar containing food items	Eats ice cream or frozen yogurt	MDCD15Y
6.Nutrition Biomarkers		
Blood tests	Vitamin D levels	LAB_VIT D
Lab tests	Folate levels	LABDRBCF

3.5 Oral health variables

The CHMS cycle 1 contains 77 variables related to oral health. In this study, oral health was measured using MOHS, adapted from the Oral Health Score (OHS) by the researcher. The original Oral Health Score (OHS) is used in the UK to educate individuals about their oral health status. The OHS has been used on 140,000 patients and is considered an easy-to-use index to represent the oral health status of an adult (Burke et al., 2003). The OHS has a self-reported component along with a clinical component and therefore it is relevant to the CHMS Cycle 1 data. The OHS originally had six parameters (Refer to Appendix A -Table 2), however, only four were used in this study as the data needed for the other two parameters do not have analogous variables in the CHMS (see Table 3.2).

The MOHS scoring included three questions from the household component of CHMS (OHM_Q23, OHM_Q22, OHM_Q12) and the rest of the scoring was adapted from the existing variables in the clinical component of CHMS. For example, tooth health was computed using a sum of (OHEDAC07+ OHEDAC08+OHEDAC09+OHEDAC10)

and gum health was computed using a sum of (OHEDGS12 + OHEDGS16+ OHEDGS24 +OHEDGS32+ OHEDGS36 +OHEDGS44). A detailed description of the categorization of the relevant oral health variables is available later in this document (Refer to Appendix A-Table 3.2 and Table 3.3).

Table 3. 2 : Original and modified version of the OHS

Parameters	**OHS scoring criteria**	**OHS**	**MOHS-For this study**
Comfort	Pain (0-pain,4-some pain,8-no pain)	8	8
Function	Problems (0-problems,4-minor problems, 8-no problems)	8	8
Appearance	Appearance (0-problems, 4-minor problems, 8-no problems)	8	8
Occlusion	0-Less than 10 teeth in each jaw unopposed,8-at least 10 teeth in each jaw opposed	8	Excluded
Soft Tissues	Treatment needs (0-needs treatment or referral, 4-needs observation, 8-healthy)	8	8
Tooth Health	Filling requirements (24-no fillings, caries free,18-sound fillings, caries free,12-less than 10% teeth need treatment,6-10-30% teeth need treatment 0-more than 30 % teeth need treatment)	24	24
Tooth Wear	Wear (0-much more wear than expected for age, 6-more wear than expected for age,12-normal wear for age)	12	Excluded

Gum Health	Periodontal disease (0-severe periodontal disease, 6-moderate periodontal disease,12-mild periodontal disease,18-gingivitis only,24-healthy)	24	24
Total Score		100	80

In the OHS, a score of 100 signifies ideal oral health and 30 represents poor oral health. For the MOHS, the equivalent values are 80 for ideal oral health and 24 for poor oral health.

3.6 Number of teeth present

The cut off for the variable 'number of teeth present' was set at 21 as this is the minimum number of teeth necessary for optimal oral function (Sheiham, Steele, Marcenes, Finch, & Walls, 1999; Ervin & Dye, 2013; Report on the Findings of the First Nations Oral Health Survey [FNOHS], 2012). The number, however, does not account for how the teeth were lost, the position of the missing teeth or whether individuals have pairs of teeth in opposing jaws to chew food (Sheiham et al., 1999).

In this study, the number of teeth present was a sum of the variables that represented sound teeth, decayed and filled teeth (OHEDAC01+ OHEDAC02 + OHEDAC07+OHEDAC08 + OHEDAC09 + OHEDAC10+OHEDAC12+ OHEDAC13 +OHEDAC14+ OHEDAC15+ OHEDAC16+ OHEDAC17) with the remainder out of 28

denoting missing teeth. In the CHMS data file, there were three categories of missing teeth - missing due to caries (OHEDAC05), missing due to trauma (OHEDAC04) and missing due to orthodontic treatment (OHEDAC03). In this study, missing teeth were not sub categorized as the number of present teeth were used as the parameter to measure oral health. Participants with no teeth (edentate) were included as a separate category (missing teeth) in the cross-tabs and were not included in the regression analysis as they were zero values.

3.7 Weight Variable

Weight categories based on BMI values were used as a dependent variable. As a screening tool, BMI can highlight health conditions associated with weight. BMI cut-offs are effective in categorizing a population sample when assessing weight related health issues (Twells, Knight, & Alaghehbandan, 2010). In this study, the categories were recommended weight and overweight (18.50-29.99) and obese ($\geq$ 30.00) as 30 is the usual BMI cut-off for obesity (refer to Table 3.3).

In the CHMS, BMI was measured during the clinical examination using the international WHO classification system. Although data on participants in the underweight category (BMI $\leq$ 18.50) were collected in the CHMS, they are excluded from this study because dental advice about dietary components to improve oral health are more applicable to someone who is obese (e.g. eat more vegetables and fruit) than someone who is underweight. Moreover, the type of dental problems that underweight

individuals may experience such as erosion (disintegration of enamel), which may indicate eating disorders (Milosevic, 1999) are beyond the scope of this study.

Table 3. 3 : Variables related to BMI

Variable Type	Description and category	Coding for the study
BMI categories	Recommended weight and overweight (BMI: 18.50-29.99)	0
	Obese (BMI≥ 30)	1

3.8 Sociodemographic Variables

The sociodemographic variables used for this study were education levels, income levels, sex, age categories, immigrant status and province of residence. The education variable was divided into four categories '1 – Less than secondary school', '2 – No post-sec education', '3 – Some post-sec education' and '4 – Post-sec degree/diploma'. The income level variable that was used divided total household income into four categories: 1- 'lowest income', 2- 'lower middle income', 3- 'upper middle income' and 4- 'highest income grouping'.

The sex variable was classified as male or female. With respect to age, initially 10-year intervals were used, however when minimum cell count criteria were not met in the category of '20-29' and '30-39' they were combined to make a new category : '20-39'.

The immigrant variable was divided into two categories based on the answer if it was 'yes=0' or 'no=1'. The provinces that were included in this study were those that were selected by the CHMS survey to represent 96.3% of the Canadian population (NB, QC, AB, BC & ON). All categorizations for this analysis except for age categories (which was modified, as indicated above) were the same as in the data files.

Table 3. 4 : Sociodemographic Variables

Variable	Description and category	Coding for the study
Education		
	Less than secondary school	1
	No post-Sec. education	2
	Some post-secondary education	3
	Post-secondary degree/diploma	4
Income		
	Lowest income (≤20,000 annually)	1
	Lower middle-income (20,001 to 39,999)	2
	Upper middle-income (40,000 to 79,999)	3
	Highest income (≥ 80,000)	4
Sex		
	Male	0
	Female	1
Age categories		
	20-39	1
	40-49	2
	50-59	3
	60-69	4
	70 and above	5
Immigrant		
	Yes	0
	No	1

Province		
	New Brunswick	1
	Quebec	2
	Ontario	3
	Alberta	4
	British Columbia	5

3.9 Descriptive statistics

Descriptive statistics provide a clearer understanding of the characteristics of the study population. Means, standard deviations, frequencies and percentages were calculated for all the variables (refer to table 4.7 and table 4.8). Individual crosstabs between dependent, independent and control variables are an important part of descriptive statistics and were carried out to understand the characteristics of the sample.

3.10 Minimum cell counts

In order to maintain confidentiality, unweighted counts in each cell should be a minimum of 10, therefore variables with categories having cell counts fewer than 10 were merged with the next one. This situation was encountered in fruit and vegetable consumption; hence they have fewer categories than the other dietary variables.

3.11 Interpreting dietary data

In the CHMS Cycle 1, dietary data were reported on a daily, weekly, monthly and yearly basis. Daily and weekly consumption were the units used for this study. A typical question was 'How often do you usually eat (food item)? (For example: twice a day, three times a week, once a month), however in the CHMS dataset, only yearly frequencies were available. For analytical purposes, yearly frequencies were divided by 365 to obtain daily frequencies, and weekly consumption was determined by dividing the yearly values by 52. The categories defined for each variable were '1=No intake', '2= Once weekly', 3=2-3 times weekly','4= 4-6 times weekly', '5=1-2 times daily' '6=More than 3 times daily' (Refer to Table 3.5).

The rationale for the categories was to simplify the analysis as yearly frequencies are harder to interpret. The cut off points were selected according to the distribution of the available data and care was taken that each category had the required sample size in accordance with RDC rules. For variables where the categories did not meet that criteria, the variables were grouped with the next category. There are dietary variables like fruits and vegetables where usually 5 or more servings per day are recommended, and the highest category in this study is 'more than 3 times daily' but more than one question addressed certain food groups. For example, three questions addressed consumption of fruits and vegetables so across all the three questions the cumulative highest categories exceeded the recommended number of servings. It is also important to remember,

however, that these are frequency values and are not actually quantifiable as number of servings.

Table 3. 5 : Dietary frequency categories

Consumption Freq.	Categories	Codes
YF=0	No intake	1
YF≥ 1 and ≤ 52	Once weekly	2
YF≥ 53 and ≤ 156	2- ≤3 times weekly	3
YF ≥ 157 and ≤364	>3- ≤6 times weekly	4
YF ≥ 365 and ≤730	1-2 times daily	5
YF≥731 till maximum	More than 3 times daily	6

3.12 Nutritional biomarker variables

The categories that were defined for folate were '1-deficient'and '2-adequate' (Refer to Table 3.6). The cut-offs are standardized reference ranges accepted by the WHO (WHO, 2008). The categorization of Vitamin D (Ross et al., 2011) has been estimated by the Institute of Medicine (refer to table 3.6) and was categorized as follows '1-deficient 'and '2-adequate' (Ross et al., 2011).

Table 3. 6: Nutritional biomarkers

Variable	Range	Categories	Codes
Folate	≤ 340 nmol/L	Deficient	1
	≥ 341 nmol/L	Adequate	2
Vitamin D	≤ 50 nmol/L	Deficient	1
	≥ 51 nmol/L	Adequate	2

3.13 Regression Analysis

The dependent variables 'adequate number of teeth', and BMI categories are binary variables that can assume values of 0 or 1. The regression method utilized for these variables was logistic regression and the results were expressed as odds ratios. The MOHS was treated as a continuous variable and linear regression was employed for this variable. The rationale to use this variable as a continuous variable was because the cell sizes in the cut-off of 24 or less (representing below the minimum score for adequate oral health) did not meet the minimum cell size criteria. Results for this model were expressed as coefficients.

3.14 Odds Ratios

Odds ratios are a method by which the probability of an event can be predicted and take into consideration the effects of other factors (logistic regression) (Bland & Altman, 2000). They are used to determine the likelihood of an increase in the outcome (dependent variable) when the exposure (independent variables) are increased unit wise. An odds ratio (OR) higher than 1 signifies that exposure is associated with increased likelihood and an OR less than 1 signifies decreased likelihood associated with the exposure (Szumilas, 2010). Confidence intervals (CI) determine the accuracy of the odds ratio; a large CI indicates low levels of accuracy and a small CI indicates higher accuracy. If the CI crosses 1, then the exposure and outcome are not related (Szumilas,

2010). The results in this study have been expressed in odds ratios and related confidence intervals.

3.15 Linear Regression

Linear regression is a statistical method employed to study the relationship between a dependent variable and independent variables. This method is based on the assumption that the dependent variable is continuous, whereas the independent variables can be dichotomous, categorical or continuous (Schneider, Hommel, & Blettner, 2010). In this study, linear regression was employed for model 1(b) which analyzed the association between MOHS (continuous) and the independent variables, which were categorical.

3.16 Regression models

Regression models that were utilized for this study are summarized below.

3.16.1 Analysis for research question 1a

Is there an association between diet and oral health (measured as number of teeth and modified oral health score)?

Table 3. 7 : Regression model 1(a) and model 1(b)

Model	Dependent Variables	Independent variables	Control variables
1(a)	Modified Oral Health Scores (Continuous variable)	Dietary variables (Milk and dairy, Fruit and Vegetables, Water, Soft drinks, Sugar related products)	Education Income Gender Immigrant Age categories Sex Province
1(b)	Total number of teeth present (Binary variable) 0=21-28 1=20 or less	Nutritional biomarkers (folate, vitamin D)	

3.16.2 Analysis for research question 2:

Is there an association between diet and obesity?

Table 3. 8 : Regression model 2

Model	Dependent variables	Independent variables	Control variables
2	BMI categories (a) Recommended weight and overweight (18.50-29.99) (b) Obese (≥30)	Dietary variables (Milk and Dairy, Fruit and Vegetables, Water, Soft drinks, sugar related products) Nutritional biomarkers (folate, vitamin D)	Education Income Sex Age categories Province Immigrant/non-immigrant

3.17 Summary

This study used the CHMS Cycle 1 as the data source and Stata was the software employed to conduct the analysis. Dietary variables were the independent variables for this study and the demographic variables were used as control variables. In addition to descriptive statistics, the methods used for this study were logistic regression (diet and number of teeth, diet and BMI categories) and linear regression (diet and MOHS). The

results were expressed as frequencies, cross tabs, odds ratios and coefficients. The following chapter describes the results in detail.

4. RESULTS

The objective of his study was to examine if associations exist among diet and oral health and diet and obesity. The chapter begins with the results of descriptive statistics, which include frequencies, percentages and crosstabs. The remainder of the chapter presents regression results expressed as odds ratios (number of teeth Model -1a and obesity - Model 2) and the results of the linear regression from the MOHS (Model 1b).

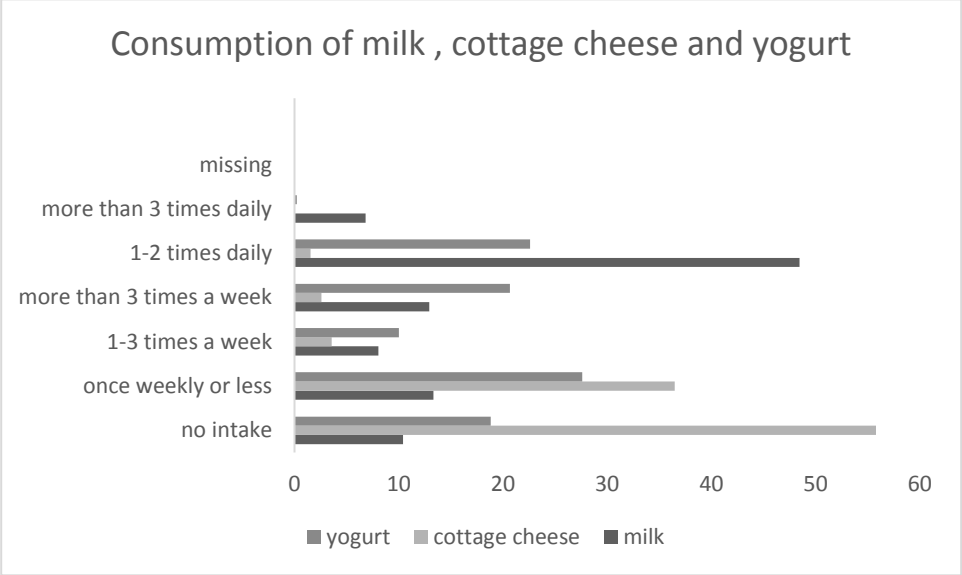
4.1 Descriptive statistics

The dietary intakes are presented below for the food categories (cheese, milk, yogurt, fruit, lettuce or green leafy salad, all other types of vegetables, water, soft drinks, fruit juices, fruit flavored drinks and ice-cream or frozen yogurt) and nutritional biomarkers (rbc folate and vitamin D). The means and frequencies for all the dietary variables as continuous variables can be referred to in Appendix B, table 1.

4.1.1 Consumption patterns of milk, cheese and yogurt

The consumption patterns of milk were that 48.5% reported consumption ‘1-2 times daily’ whereas yogurt consumption was evenly distributed among all categories. Cottage cheese consumption showed a limited consumption with the highest number of participants (55.8%) in the ‘no intake’ category and the lowest number of participants (1.5%) in the ‘1-2 times daily’ category.

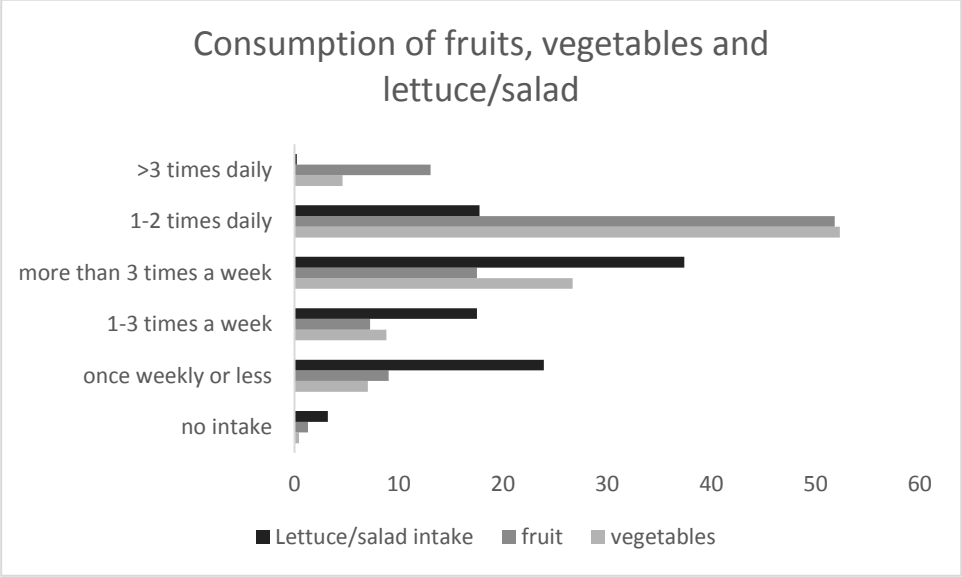
Table 4. 1: Consumption of milk, cottage cheese and yogurt



4.1.2 Consumption pattern of fruits, vegetables and lettuce

The consumption pattern for fruits (51.8%) and vegetables (52.3%) were highest in the '1-2 times daily' category. One-fourth (26.7%) of the participants reported vegetable intake 'more than 3 times a week', 17.5% participants reported fruit intake 17.5% in the same category. Lettuce/salad intake was highest (37.4%) in the 'more than 3 times a week' category followed by 'once weekly or less' (23.9%) .

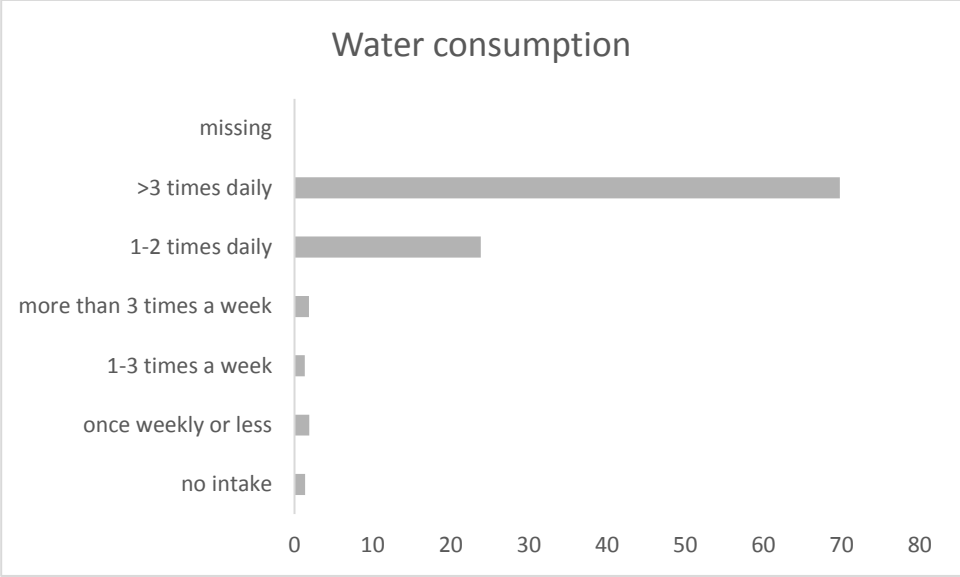
Table 4. 2: Consumption of fruits, vegetables and lettuce



4.1.3 Consumption patterns of water

More than two-thirds (69.8%) of the participants reported water intake of ‘more than 3 times daily’ and 23.8% of the participants reported water intake ‘1-2 times daily’. The CHMS data did not indicate if the water were fluoridated so no analysis regarding fluoridated water is possible.

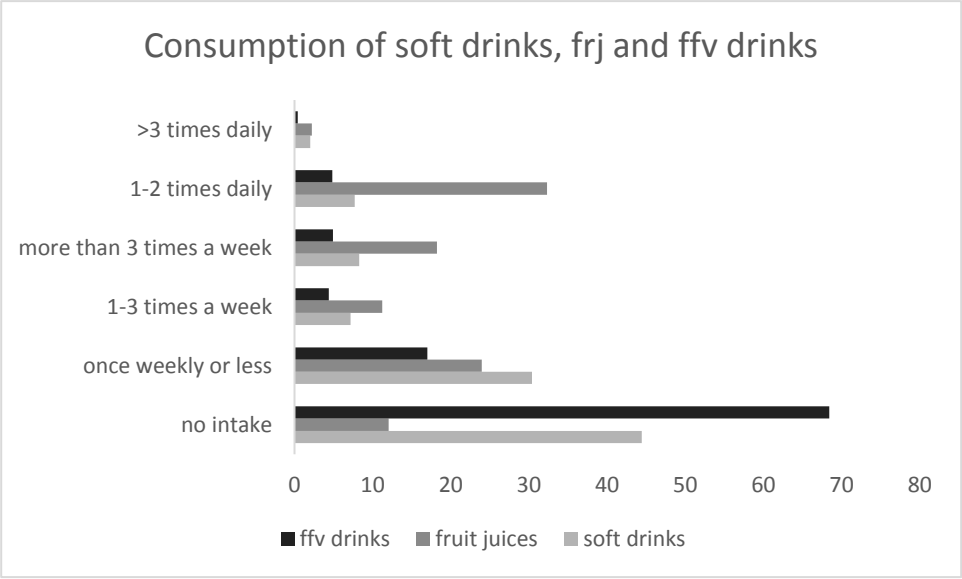
Table 4. 3: Water consumption



4.1.4 Consumption patterns of soft drinks, fruit juices and fruit flavored drinks

Almost half (44.4%) the participants reported ‘no intake’ and 2% of the participants reported soft drink intake ‘more than 3 times daily’. Almost one-third (30.4%) of the participants reported soft drink intake ‘once weekly or less’ and 24.0% of participants consumed fruit juices ‘once weekly or less’. The proportion of participants consuming fruit flavored drinks in this category was 17.0 %.

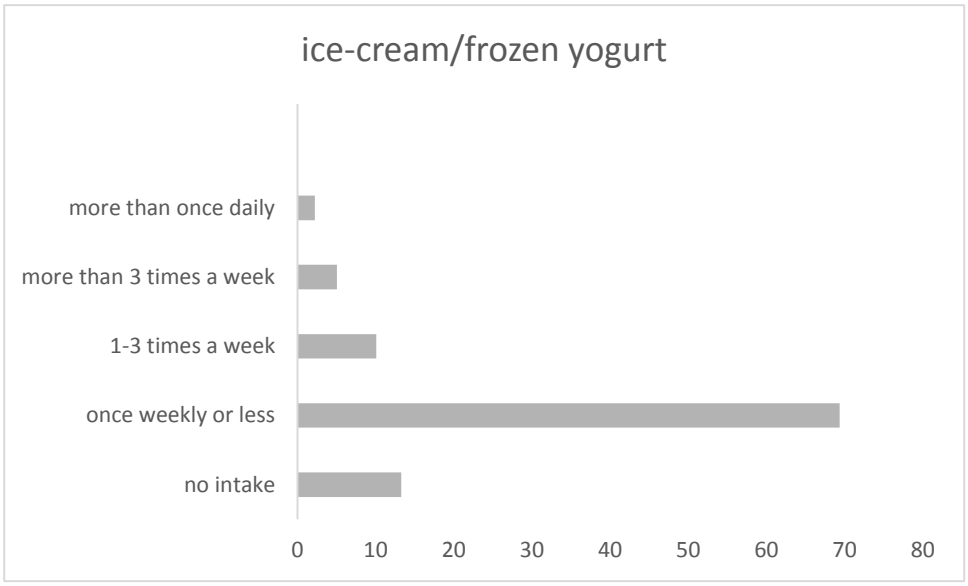
Table 4. 4 : Consumption of soft drinks, fruit juices (frj) and fruit flavored drinks (ffv).



4.1.5 Consumption pattern of ice-cream/frozen yogurt

Consumption patterns of ice-cream/frozen yogurt exhibited a spike (69.4%) in the ‘once weekly or less’ category.

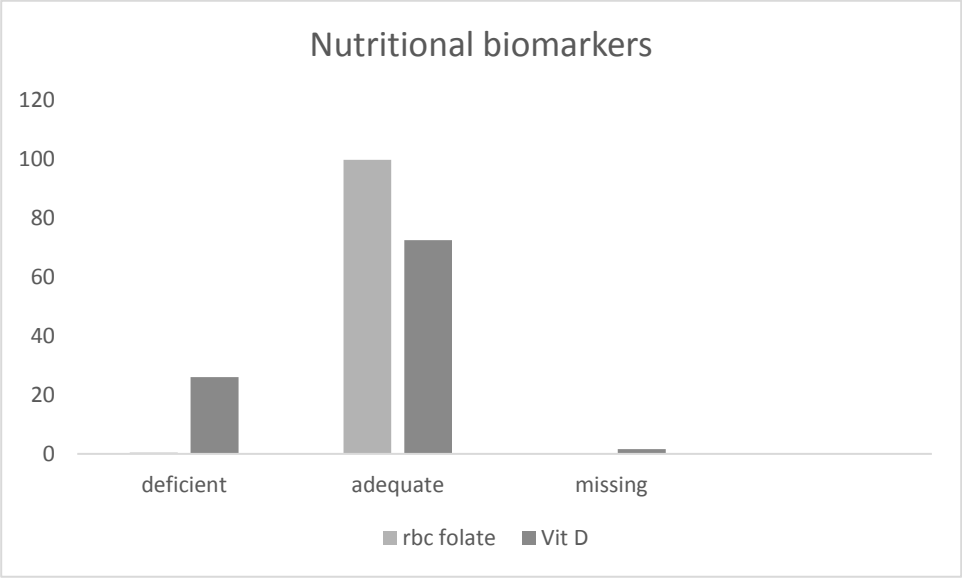
Table 4. 5 : Ice-cream/frozen yogurt consumption



4.1.6 Nutritional biomarkers

The blood tests for nutritional biomarkers revealed that the most (99.6%) of the sample had adequate levels of rbc folate. In the sample, 72.3% of the participants had adequate levels of vitamin D and approximately 26.1% had inadequate levels (Table 4.6).

Table 4. 6 : Distribution levels of biomarkers



4.2 Oral health and obesity distribution

Overall, three-fourths of the population (76.5%) had 21+ teeth, 16.8% had fewer than 21 teeth and 6.7% of the population had no teeth. In terms of the MOHS, the mean score was 68.31 with a standard deviation of 11.89. The overall result for BMI categories was that, 74.4% of the population were not obese and 25.5% were obese.

4.2.1 Oral health variables and sociodemographic characteristics

This section addresses the results of the crosstabs, analyzing dependent variables for oral health by the different sociodemographic characteristics identified for this study. The importance of sociodemographic factors when oral health is considered exhibits certain patterns also known as social determinants of oral health. Two oral health variables were analyzed, 'Number of teeth present' and 'Modified Oral Health Score'.

4.2.2 Number of teeth and sociodemographic characteristics

The sociodemographic characteristics that were tabulated against number of teeth were education, income, sex, age, immigrant and province. Participants with no teeth appeared as missing values. When number of teeth was considered with respect to the sociodemographic characteristics, the following results were seen.

Having a higher education (college/university) increased the likelihood of having 21+ teeth when compared to individuals with less than secondary school education (83% vs 49%). Participants belonging to the highest income levels were also more likely to have

21+ teeth when compared to the lowest income individuals (84% vs 67%). Slightly more males (77.4%) had more than 21+ teeth than females (75.7%).

The cross-tabulations revealed that the likelihood of having 21+ teeth decreased with increasing age, with the lowest likelihood in the age group 70-79 (32.2%) and the highest in the age group 20-39 (98%). There was little difference among immigrants (76.3% of immigrants and 76.6% of non-immigrants were likely to have 21+ teeth). Participants living in Alberta had the highest proportion of 21+ teeth (83.2%) and participants who lived in Quebec were least likely to have 21+ teeth (64.0%) (Refer to Table 4.7). Other cross tabs between dietary variables and number of teeth can be viewed in Appendix B table 3.1.

Table 4.7 : Socio demographic frequencies and percentages among participants from 20-79 according to number of teeth (weighted cross tabs):

	Number of present Teeth					
	21-28		**1 to 20**		**No teeth**	
	***n=23334302**					
Education						
< sec.sch	1380712	48.9	839204	29.7	605480	21.4
no post_sec	3100553	73.8	848458	20.2	253867	6
Some post_sec	1596783	82.6	210845	10.9	125934	6.5
College/univ	11581254	83	1860492	13.3	515372	3.7
Missing	199734	48.1	154504	37.2	61110	14.7
Total	17859036	76.5	3913503	16.8	1561763	6.7
Income						
lowest in	689428	68.9	172334	17.2	138796	13.9
lower mid	2111940	67.1	699304	22.2	334357	10.6
upper mid	5174550	72	1380550	19.2	633443	8.8
highest income	8902706	84	1349818	12.7	350966	3.3
Missing	980412	70.2	311497	22.3	104201	7.5
Total	17859036	76.5	3913503	16.8	1561763	6.7
Sex					.	
male	9006056	77.4	1887634	16.2	738144	6.4
female	8852980	75.7	2025869	17.3	823619	7
Age categories						
age 20-39	8523159	97.9	137778	1.6	45313	0.5
age 40-49	4709726	84.4	774653	13.9	94756	1.7
age 50-59	2723711	65.7	1071136	25.9	348021	8.4
age 60-69	1333833	42.3	1272316	40.4	545486	17.3
age 70-79	563300	32.2	657620	37.6	528187	30.2
Missing	5307	100	0		0	
Immigrant						
yes	4176687	76.3	1027272	18.8	268514	4.9
no	13680227	76.6	2886231	16.2	1293249	7.2
Missing	2122	100	0	0	0	0

Province						
NB	1161767	69.9	340938	20.5	159914	9.6
QC	3552825	64	1402831	25.3	595020	10.7
ON	7285206	80.5	1326079	14.7	443524	4.9
AB	3244931	83.2	453856	11.6	200240	5.1
BC	2614307	82.5	389799	12.3	163065	5.2
Total	1785906	76.5	3913503	16.8	1561763	6.7

*n=Weighted population count

4.3 Obesity and sociodemographic characteristics

Lower education levels were associated with a higher possibility of being obese (36.8%) for individuals who had less than post-secondary education compared to individuals who went to university (20.1%). Participants that belonged to the lowest income category comprised most of the obese population at 32.4% and the highest percentage of participants (76.0%) in the not obese category belonged to the highest income category. Being a female increased the likelihood of being obese (26.2%) slightly as compared to males (24.8%). The cross tabulation between BMI and age categories revealed that the likelihood of being obese was the highest for participants that belonged to the age category of 60-69 (34%). More non-immigrants were obese (27.2%) when compared to immigrants (20.1%) When province was considered, the likelihood of being obese increased for participants in New Brunswick (30.9%) followed by Alberta (30.7%). The province with the fewest number of participants who were obese were in British

Columbia (19.1%). Cross tabs between other independent variables and BMI categories can be referred to in Appendix B table 3.2.

Table 4. 8 : Socio demographic frequencies and percentages among participants from 20-79y according to BMI categories (cross tabs):

Variables	**BMI (18.50- 29.99)**		**BMI ≥30**	
Education				
< sec.school	1786386	63.2	1039010	36.8
no post_sec	2952368	70.3	1250510	29.8
Some pos	1425742	73.7	507820	26.3
College/u	10883627	78	3073491	22
Missing	331784	79.9	83564	20.1
Income				
lowest inc.	676084	67.6	324474	32.4
lower mid	2176622	69.2	968979	30.8
upper mid	5440898	75.7	1747645	24.3
highest inc.	8062982	76	2540508	24
Missing	1023321	73.3	372789	26.7
Sex				
male	8747407	75.2	2884427	24.8
female	8632500	73.8	3069968	26.2
Total	17379907	74.5	5954395	25.5
Age Categories				
age 20-39	6743356	77.5	1962894	22.6
age 40-49	4222918	75.7	1356217	24.3
age 50-59	3016445	72.8	1126423	27.2
age 60-69	2084250	66.1	1067385	33.9
age 70-79	1312938	75.1	436169	24.9
Missing	0	0	5307	100
Immigrant status				
yes	4372627	79.9	1099846	20.1
no	13005158	72.8	4854549	27.2
Missing	2122	100	0	0

Province				
NB	1148239	69.1	514380	30.9
QC	4185322	75.4	1365354	24.6
ON	6784103	74.9	2270706	25.1
AB	2699573	69.2	1199454	30.8
BC	2562670	80.9	604501	19.1

*n=Weighted population number

4.4 Regression results

The regression model 1a explores the association of number of teeth with the independent variables and control variables (r^2=0.33). Model 1b explains the relationship between the modified oral health score and the independent and control variables (r^2=0.22) and regression model 2 explores the association between obesity and the independent and control variables (r^2=0.07).

4.4.1 Model 1a (number of teeth)

The dependent variable in this model (number of teeth) was coded as a dichotomous variable (0= 21-28 teeth, 1= < 21 teeth) and the results are presented in terms of odds ratios. In this model, the negative results were indicated by less than 21 teeth for example, and 21-28 teeth were positive indicators. For example, consumption of milk 'more than 3 times per day' was associated with a decreased odds of having fewer than 21 teeth by 46%, which indicates that higher milk consumption is associated with having

the recommended number of teeth. The significant results are discussed below, and the non-significant results are in Appendix B (Table 1 and Table 2).

4.4.2 Dietary variables, nutrition biomarkers and number of teeth

There were some positive and some negative significant associations observed in model 1(a). The positive associations were that of milk, yogurt and cheese. The results indicated that consumption of milk 'more than 3 times per day' was associated with a higher odds of having fewer than 21 teeth by 46% indicating a positive relationship. Intake of yogurt 'more than 3 times a week' was associated with 33% higher chances of having 21 + teeth. Cottage cheese intake 'once weekly or less' was associated with an odds of 1.08 times of having less than 21 teeth.

Intake of soft drinks 'more than 3 times daily' was associated with 2.25 times higher odds of having less than 21 teeth compared to no intake. A higher intake of fruit juices 'more than 3 times daily' was associated with 2.75 times higher odds of having less than 21 teeth (i.e., this level of fruit juice was associated with fewer teeth). Surprisingly, fruit intake 'once weekly or less' was associated with 2.85 times higher odds of having less than 21 teeth, (i.e., fruit intake at this level associated with fewer teeth).

4.4.3 Sociodemographic variables

The odds of having fewer than 21+ teeth was 0.46 times less for individuals who had attended college/university when compared to the reference category of 'less than

secondary school'. The odds of having less than 21+ teeth was 0.43 times less for people with some post-secondary education. The results of this model showed that individuals were less likely to have 21+ teeth with increasing age. The odds of having fewer than 21 teeth were highest (97.02) times in the age group '70-79' whereas were the lowest '9.86' for the age group '20-39'.

In terms of province of residence, being from Ontario was associated with 0.55 less chances of having fewer than 21 teeth, similar to the odds for the residents of Alberta and British Columbia (0.54). Residents of Quebec had 1.71 higher odds of having fewer than 21 teeth.

4.5 Model 2 (obesity)

Model 2 explored the odds ratios between being in the 'obese' category measured as BMI $\geq$ 30 and being in the 'normal weight and overweight' category measured as BMI < 29.99 across all the independent variables.

4.5.1 Obesity and dietary factors

Milk intake 'more than 3 times a week' was associated with 0.57 times lesser odds of being obese and milk intake '1-2 times daily' was associated with 0.6 times lesser odds of being obese, indicating that a higher milk consumption was associated with lower rates of obesity. An adequate level Vitamin D was associated with 0.55 times lower odds of being obese. Again, surprisingly fruit intake was associated negatively with being obese.

Fruit intake ‘once weekly or less’ was associated with 3.57 times higher odds of being obese and fruit intake ‘more than 3 times a week’ was associated with 5.9 times higher odds of being obese. The intake categories ‘1-2 times daily’ was associated with 5.31 times higher odds of being obese and intake ‘more than 3 times daily’ was associated with 5.0 times higher odds of being obese.

4.5.2 Obesity and sociodemographic variables

The significant relationships between being obese and the sociodemographic variables were seen in the following categories. Individuals who had gone to college/university had 0.58 times lesser odds of being obese. Being in the age group of 60-69 increased the odds of being obese by 1.64 times. Not being an immigrant also increased the chances of being obese by 1.82 times. An individual from the province of British Columbia had 0.41 times lower odds of being obese than the reference category (New Brunswick).

Table 4.9: Odds ratio output for model 1(a) and model 2 (Significant results)

Variables	**Model 1 (a) (< 21 teeth)**			**Model 2 (BMI ≥ 30)**		
	odds ratio	**p-value**	**CI**	**odds ratio**	**p-value**	**CI**
Cottage cheese intake				NS		
No intake	1					
once weekly or less	1.08	0.545	(0.84-1.38)			
Yogurt intake						
No intake	1					
than 3 times a week	0.67	0.036	(0.45-0.97)	NS		
Milk intake						
No intake	1			1		
than 3 times a week	NS			0.57	0.02	(0.35-0.91)
1-2 times daily	NS			0.6	0.014	(0.40-0.90)
>3 times daily	0.54	0.04	(0.30-0.97)	NS		
Fruit intake						
No intake	1			1		
once weekly or less	2.85	0.044	(1.02-7.92)	3.57	0.044	(1.03-12.30)
1-3 times a week	NS			5.66	0.007	(1.60-19.98)
> than 3 times a week	NS			5.93	0.004	(1.76-19.96)
1-2 times daily	NS			5.31	0.006	(1.60-17.60)
> 3 times daily	NS			5.05	0.01	(1.47-17.28)
Soft drinks						
No intake	1			NS		
>3 times daily	2.25	0.045	(1.01-4.99)	NS		
Fruit juices						
No intake	1			1		
> than 3 times a week	NS			0.62	0.027	(0.40-0.94)
>3 times daily	2.75	0.024	(1.14-6.60)			
VIT D						
deficient				1		
adequate	NS			0.55	0	(0.41-0.71)

Table 4. 10 : Odds ratio output for model 1(a) and model 2 (Significant results)- Sociodemographic Variables

	Model 1 (a) (< 21 teeth)			**Model 2 (BMI ≥ 30)**		
Variables	**odds ratio**	**p-value**	**CI**	**Odds ratio**	**p-value**	**CI**
Age						
20-39	1					
40-49	9.86	0	(5.78-16.80)	NS		
50-59	28.57	0	(16.66-48.99)	NS		
60-69	65.1	0	(37.53-112.89)	NS		
70-79	97.02	0	(53.09-177.26)	NS		
Immigrant						
Yes	NS			1		
No	NS			1.82	0	(1.31-2.51)
Province						
NB	1			1		
QC	1.71	0.014	(1.11-2.63)	NS		
ON	0.55	0.005	(0.35-0.83)	NS		
AB	0.54	0.015	(0.32-0.88)	NS		
BC	0.54	0.017	(0.32-0.89)	0.41	0.001	(0.24-0.68)
Education						
< Sec. school	1			1		
Some post-sec	0.43	.002	(0.25-0.72)	NS		
College/uni	0.46	0	(0.32-0.65)	0.58	0.002	(0.41-0.81)

4.6 Model 1b (MOHS)

The MOHS is a composite score that was adapted from the Oral Health Score that was originally created to quantify the overall oral health of a patient (Burke et al., 2003). Model 1b (Table 4.11) explored the association between the MOHS and all the independent variables by means of linear regression. The results are discussed below.

4.6.1 MOHS and independent variables

The linear regression between MOHS and independent variables (Table 4.11) depicted significant associations between fruit consumption, vegetable consumption, soft drink consumption, fruit juice consumption, Vitamin D levels, education, income, province and age. Among dietary factors, a significant positive association was seen between vegetable consumption more than 3 times daily and an increase in the MOHS by 6.73 points when compared to the 'no intake' category. A positive association was observed with vitamin D levels as the MOHS increased by 1.75 points when compared to the 'deficient' category.

With regard to sociodemographic variables, higher education levels were associated with higher MOHS, university education was associated with an increased score of 5.20 points in comparison to 3.23 points for individuals with no post-secondary education. Higher levels of income were associated with higher MOHS scores. The highest income

category individuals had MOHS scores higher by 8.56 points whereas upper middle income individuals had MOHS scores 6.29 points higher than the reference category (lowest income <20,000).

The inverse associations were that of soft drink consumption where significant relationships were seen with consumption '1-2 times' daily resulting in a score that was 3.95 points lower than the 'no intake' category and soft drink consumption 'more than 3 times daily' resulting in a score that was 7.68 points lower than the 'no intake' category. With fruit juice consumption, consumption 'more than 3 times daily' resulted in a MOHS score lower by 4.68 points than the 'no intake' category.

Individuals from Quebec had the lowest MOHS (-4.70 points) followed by individuals from Alberta (-4.34 points). Individuals from Ontario had lower scores by 2.26 points and those from British Columbia had lower scores by 1.89 points. Increasing age was associated with lower scores and the lowest scores were associated with the age group of 70-79 when compared to the age category '20-39'.

An unexpected finding was that of lower MOHS associated with fruit consumption as significant associations emerged between consumption of fruits '1-2 times daily' and having a lower score by 4.11 points. Consumption '1-3 times a week' was associated with a lower score of 6.51 points and consumption 'once weekly or less' was associated with a negative score of 4.72 points when compared to the 'no intake' category.

Table 4. 11 : Linear regression output between MOHS, independent and sociodemographic variables

MOHS	Coef.	P>|t|	(95% Confidence	Interval)
Fruit				
once weekly or less	-4.72	0.03	(-8.91	-0.54)
1-3 times a week	-6.51	0.00	(-10.81	-2.20)
1-2 times daily	-4.11	0.04	(-8.08	-0.13)
Vegetables				
>3 times daily	6.73	0.01	(1.73	11.72)
Soft Drinks				
1-2 times daily	-3.95	0	(-5.96	-1.94)
>3 times daily	-7.68	0	(-11.65	-3.72)
Fruit Juices				
>3 times daily	-4.68	0.03	(-9.00	-0.37)
Vit_D				
adequate	1.75	0.0	(0.74	2.76)
Education				
no post_sec	3.23	0.00	(1.27	5.19)
Some post-sec	5.40	0	(3.22	7.58)
College/uni	5.20	0	(3.42	6.99)
Income				
lower middle inc	3.28	0.01	(0.72	5.84)
upper middle inc	6.29	0	(3.88	8.71)
highest income	8.56	0	(6.14	10.98)
Province				
QC	-4.70	0	(-6.18	-3.22)
ON	-2.26	0.00	(-3.67	-0.85)
AB	-4.34	0	(-6.03	-2.66)
BC	-1.89	0.02	(-3.50	-0.28)
Age				
age 40-49	-1.82	0.00	(-2.86	-0.79)
age 50-59	-4.39	0	(-5.75	-3.04)
age 60-69	-5.00	0	(-6.22	-3.78)
age 70-79	-5.85	0	(-7.50	-4.19)

The following chapter discusses the findings of this study and supporting evidence along with the limitations and possible applications of the results from this research.

5. DISCUSSION

The previous chapter summarized the results of this study, and this chapter discusses the results and possible reasons for the nature of results, identifies strengths and limitations and includes the implications arising from this study.

This study hypothesized that:

H^{1}-The dietary factors associated with better oral health outcomes and dietary factors are associated with healthy weights, which were divided into different sections:

H^{1a}-Dietary factors are associated with oral health outcomes, controlled for sociodemographic variables.

H^{1b} -Dietary factors are associated with weight status, controlled for sociodemographic variables.

H^{1c}-Associations exist between oral health and sociodemographic factors, and obesity and sociodemographic factors.

The following table (See Table 5.1) provides a snapshot of the results for all the models and the direction of associations that were observed in this study if at least one consumption category was significant (example, milk consumption three times a day).

Table 5. 1 : Summary of results

Variables	Model 1(a) (Diet and Number of teeth)	Model 1 (b) (Diet and MOHS)	Model 2 (Diet and BMI)	Direction of association
Dietary Variables				
Milk	Significant	NS	Significant	Positive
Cottage cheese	Significant	NS	NS	Positive
Yogurt	Significant	NS	NS	Positive
Vegetables	NS	Significant	NS	Positive
Fruit Juices	Significant	Significant	Significant	Negative
Soft Drinks	Significant	NS	Significant	Negative
Fruits	Significant	Significant	Significant	Negative
Vitamin D	NS	Significant	Significant	Positive
Sociodemographic variables				
Education	Significant	Significant	Significant	Positive
Income	NS	Significant	NS	Positive
Age	Significant	Significant	Significant	Negative
Province	Significant	Significant	Significant	NA
Immigrant	NS	NS	Significant	Positive

In model 1a, (diet and number of teeth) the variables that exhibited significant relationships were cottage cheese ‘once weekly or less’, yogurt intake ‘more than 3 times a week’, milk intake ‘more than 3 times daily’. Other significant relationships were observed for fruit intake ‘once weekly or less’, soft drink intake ‘more than 3 times daily’, fruit juice consumption ‘more than 3 times daily’ and adequate levels of Vitamin

D. Post-secondary education and college/university education were also statistically significant. The other variables (fruits, vegetables, water, sugar containing food items and folate levels) did not show any significant results.

In model 1b (diet and MOHS) the significant associations were observed in the vegetable consumption 'more than 3 times daily', fruit consumption, soft drinks, fruit juices and adequate levels of Vitamin D variables. Other significant relationships were observed in the education, income, age and province of residence variables. All the other variables (dairy, water, fruit flavored drinks, sugar containing food items and folate levels) did not exhibit any significant results.

Model 2 (diet and obesity) exhibited significant relationships for milk 'more than 3 times weekly' and '1-2 times daily' and adequate levels of Vitamin D. The sociodemographic variables that were statistically significant were college education, age (60-69), not being an immigrant, and living in British Columbia. A surprising finding was that fruit intake was associated with higher odds of lower MOHS scores and being obese.

5.1 Summary of findings

There were dietary factors that demonstrated positive associations and dietary factors that demonstrated negative associations. Dietary factors that exhibited an association with both oral health and weight status were milk intake (positive), fruit juice intake (negative), soft drinks (negative) and Vitamin D levels (positive). The findings in this research indicate that although some dietary associations exist, they were relatively

limited. The associations with sociodemographic factors such as education, age and province of residence were stronger. Based on these findings the null hypothesis can be rejected, although it needs to be considered that this is a single study and that more extensive research is required to investigate the extent of these associations. The following section discusses the results between the dependent and independent variables.

5.2 Diet and oral health

The intake of yogurt 'more than 3 times a week' decreased the chances of having fewer than 21 teeth by 33%. The protective effect of yogurt has been studied and a positive association was observed between increased yogurt consumption and better oral health (Ferrazzano et al., 2008). The percentage of the population in this study that reported yogurt consumption more than 3 times a day was 0.23%, and 22.62% of the population consumed yogurt 1-2 times daily. Intake of milk 'more than 3 times a day' decreased the odds of having fewer than 21 teeth by 46%. Increased milk consumption and better oral health outcomes have been reported previously by Vergnaud et al., (2008), Huojoel & Lingsrtöm, (2017) and Adegboye et al., (2012).

Consuming cottage cheese 1-3 times a week was significantly associated with 1.08 times higher odds of having less than 21 teeth. Studies centering around diet and oral health (Moynihan, 2000; Palmer, 2001), have emphasized the beneficial effects of cheese (not cottage cheese specifically) on oral health. In the CHMS, 1.53% of the population consumed cottage cheese '1-2 times a day', while 55.81% reported 'no cheese intake'.

Given the low intake of cottage cheese by CHMS participants, the relatively small odds ratio and the limited research on cottage cheese specifically, this result is difficult to interpret.

The odds of having fewer than 21 teeth increased by 2.25 times when soft drinks were consumed 'more than 3 times daily'. In another study, a similar result was seen when DMFT was used to measure oral health: as soft drink consumption increased, DMFT scores declined (Bernabe et al., 2014). Consumption of fruit juices 'more than 3 times daily' was associated with 2.7 times higher odds of having fewer than 21 teeth. Frequent consumption of fruit juices has been associated with a higher incidence of dental caries as their acidogenic nature repeatedly attacks the enamel structure and weakens it (Caswell, 2009).

In model 1 (b), (diet and MOHS) consumption of vegetables 'more than 3 times daily' was significantly associated with a higher MOHS of 6.73 points than the reference category (no intake). This result aligns with a previous study that found that increased vegetable intake is beneficial for oral health (Nowjack-Raymer & Shieham, 2007). Consumption of vegetables stimulates increased salivation in addition to providing adequate nutrition to the body. Increased salivation helps flush food particles thereby helping to prevent caries. Nutrients from fruits and vegetables help maintain the health of surrounding structures of the tooth: the gums and oral mucosa (Sheiham, Steele, Marcenes, & Lowe, 2001). Adequate vitamin D levels exhibited a significant relationship with a higher MOHS (1.75 points) indicating a positive relationship.

Consumption of soft drinks ‘more than 1-2 times daily’ (-3.95 points) and ‘more than 3 times daily’ (-7.68 points) exhibited significant associations with a decreased MOHS. Existing literature identifies the detrimental effects of excessive soft drink consumption on oral health (Larsen & Nyvad, 1999; Marshall & Cunningham, 2002) and their erosive potential, which is damaging to the tooth structure (Li, Zou, & Ding, 2012). The impacts of soft drinks and sugar-sweetened beverages is a global one and has almost become a lifestyle choice for many. In this situation, the role of dietary guidance is important and needs to be incorporated in routine healthcare settings. When fruit juice intake was considered, it was seen that consumption of fruit juice more than 3 times daily was associated with a lower MOHS (-4.7points). The new Canada’s Food Guide discourages fruit juice consumption due to its high sugar content and promotes water as the beverage of choice (CFG, 2019).

5.3 Diet and obesity

The odds of being obese were reduced by 43% when milk consumption was ‘more than 3 times a week’ and 40% when milk consumption was ‘1-2 times daily’ as compared to the reference category ‘no intake’. Previous studies have reported that increased milk consumption was associated with reduced risks of obesity (Aggarwal et al., 2013; Lee et al., 2014). Individuals who consumed fruit juices ‘more than 1-3 times a week’ had 0.6 times less chances of being obese. Adequate vitamin D levels were associated with 0.5 times less odds of being obese.

An unexpected finding in this model was the consistent association between increased fruit consumption and higher odds of being obese. The odds were higher by 3.5 times in the 'once weekly or less' category, 5.6 times in the '1-3 times a week' category, 5.9 times for individuals who consumed fruits 'more than 3 times a week', 5.3 times in the category '1-2 times daily' and 5.0 times in the category ' more than 3 times daily'. This finding aligns with a previous study conducted in Korea that studied the anti-obesity and pro-obesity effects of fruits. In this study, consumption of fruit is often interpreted as fruit in any form and commercially available forms of fruit including processed or canned versions that have a high sugar content and possible negative associations with healthy weights (Sharma, Chung, Kim, & Hong, 2016).

5.4 Sociodemographic variables

Education, age and province had significant associations across all models. In addition to these variables, income levels had significant associations in model 1(b) and being an immigrant had a positive association in model 2.

Education and income levels affects the diet of an individual as well as their oral health (Moeller & Quiñonez, 2016; Giskes et al., 2011; Felton, 2009; Huot et al., 2004). The other sociodemographic factors that influence oral health and obesity are gender (Urzua et al., 2012; Lovejoy et al., 2009; Tronieri et al., 2017), being an immigrant (Calvasina, Muntaner, & Quiñonez, 2015; McDonald, & Kennedy, 2005) and age.

5.4.1 Education

In model 1(a), (diet and number of teeth) it was seen that the odds of having fewer than 21 teeth were 0.43 times less for the categories 'some post-secondary education' and 'college/university'. In model 1(b), the MOHS scores of individuals who had 'some post-secondary education' were 5.4 points higher than the reference category (less than secondary school) category and for the 'college/university' category the score was 5.2 points higher. In model 2, going to college/university was associated with 0.58 times less odds of being obese.

5.4.2 Income

When income levels were considered, model 1(b) (diet and MOHS) exhibited significant associations. People in the highest income category had an increased MOHS score by 8.5 points, which was 6.2 points higher than the reference category (lowest income) and people in the lower middle-income category had a score 3.2 points higher than the reference category. Dental treatment is not included in the Canada Health Act. In 2010, a report found that publicly offered dental services vary from province to province reaching only 6 % of the Canadian population (Health Canada, 2010). With most of these programs targeted towards children under the age of 18, there is a stark inequity in terms of publicly funded dental care to low-income adults. The social gradient in oral health has been highlighted in earlier studies (Moynihan, 2005; Sabbah et al., 2007; Geyer et al., 2010) with lower incomes associated with poorer oral health.

5.4.3 Age

In model 1(a), (diet and number of teeth) being in the age category of '40-49' was associated with 9.8 times higher odds of having less than 21 teeth. These odds increased to 28.5 times in the '50-59' category, 65 in the '60-69' category and 97 in the '70-79' category. The correlation between age and the number of teeth has been previously reported (Lahti et al., 2008). Increasing age brings with itself limitations to travel and ability to do daily chores including visiting dental professionals; lowered personal expectations in relation to oral health can also act as an exacerbating factor (Kotzer et al., 2012). In model 2, (diet and obesity), increasing age was associated with a higher possibility of being obese in the '60-69' years age group, increasing the odds by 1.56 times. This finding is consistent with a previous study that found that there was an increase in BMI as participants advanced in age, specifically after 55 years (Wee et al., 2005).

In model 1(b) (diet and MOHS), increasing age was associated with lower scores. The age category '40-49' was associated with lower MOHS scores by 1.8 points, and in the category '50-59' the MOHS scores decreased by 4.4 points. The categories '60-69' were associated with decreased scores of 5.0 points and the age category '70-79'was associated with a decrease in 5.8 points. In earlier studies, age was a significant predictor for the oral health of the Canadian adult population (Locker et al., 1996).

5.4.4 Immigrant status

Being obese was significantly associated with not being an immigrant as a non-immigrant exhibited 1.82 times higher odds of being obese that their counterparts. This finding is consistent with existing literature (McDonald & Kennedy, 2005), which states that the probability of being obese is low for immigrants when compared to Canadians.

5.4.5 Province

The results from model 1(a) were that people who lived in Quebec had higher odds (1.71) of having fewer than the adequate number of teeth (21), while people from Ontario, Alberta and British Columbia had 50% chances of having fewer than 21 teeth. In earlier studies too, Quebec had the highest rate of edentulism (Millar & Locker, 1999). The average missing teeth per person in this province was 8.2 and they had a high DMFT score (19.2) (Brodeur et al., 2000).

In model 2, people living in British Columbia had 59% less chances of being obese. In model 1(b), living in British Columbia was associated with better oral health than other provinces. Living in Quebec was associated with a decreased MOHS score by 4.7 points, while in Alberta, the score decreased by 4.3 points. People who lived in Ontario had a decreased score by 2.2 points and for individuals in British Columbia the MOHS score was decreased by 1.8 points.

5.5 Unexpected findings

In model 1(a), fruit consumption 'once weekly or less' was associated with a 2.8 times higher chance of having fewer than 21 teeth. Current evidence indicates that fruit consumption is beneficial for oral health, particularly apples (Moynihan, 2000) however, other types of fruit may have different outcomes because of their acidogenic potential (Issa, Toumba, Preston, & Duggal, 2011).

In model 2, fruit consumption was directly associated with higher chances of being obese. Fruit intake 'once weekly or less' increased the odds of being obese by 3.57 times, whereas fruit consumption '1-3 times a week' was associated with a higher odds of 5.6 times. Fruit consumption 'more than 3 times a week' was associated with 5.9 times higher odds of being obese and fruit consumption of '1-2 times daily' and 'more than 3 times daily' were associated with a higher odds of 5.3 and 5 respectively.

In the CHMS survey the question that addressed fruit intake grouped all kinds of forms of fruit (fresh, frozen and canned), and this may be a possible reason for these unexpected findings. This finding was unusual as fruit consumption is often associated with weight loss (Alinia et al., 2009). For example, a study that surveyed Canadian individuals reported that fruit intake was associated with weight loss (Drapeau et al., 2004). However, a study that surveyed middle aged men and women in Australia found that obese women reported a higher intake of fruits and vegetables (Charlton et al., 2014). Although, this can be interpreted as a direct association, it can also be interpreted as a

reverse causal association, for example individuals who are overweight may try to eat more fruits in order to lose weight.

5.6 The rationale for this study

Given the findings from the study and the relatively weak association between diet and oral health and diet and weight status, it is useful to re-visit the reasons for conducting this study. The rationale was based on the biological understanding of the caries process and development of excess weight due to food intake, existing research evidence about the associations between diet and oral health and diet and obesity and current dental and weight recommendations.

First, biology supports this research. On a microscopic level, the etiology of caries (an indicator of oral health) is strongly related to the exposure of different dietary influences in the mouth. Some foods, such as cheese and milk have a beneficial effect (Silva et al., 1986; Levine, 2001; Kashket et al., 2002; Ravishankar et al., 2012), and others such as sweetened fruit juices and soft drinks damage the tooth structure (Li, Zou, & Ding, 2012; Bernabe et al., 2014). Likewise, an overconsumption of sugary drinks is associated with increased weight. Soft drinks contain large amounts of energy from sugars that are absorbed rapidly. One theory is that liquid calories do not carry the same satiety value as foods calories and make it easier for people to overconsume total calories (De Graaf, 2011).

Second, the associations explored in this study were based on existing research evidence, and it indicates that relationships exist among diet and oral health with dietary factors like cheese, unsweetened milk and yogurt, fruits and vegetables having a positive association (Silva et al., 1987; Moynihan, 2000; Levine, 2001; Ravishankar et al., 2012; Dror et al., 2014) and sweetened beverages (fruit juices and soft drinks) having a negative association (Li, Zou, & Ding, 2012; Benabe et al., 2014). Current evidence also indicates health-promoting associations between milk, cheese, fruit and vegetable consumption and weight status (Walther et al., 2008; Mozaffarian et al., 2011; Lee et al., 2014) and negative associations between sugar sweetened beverages and weight status (Schulze et al., 2004).

Third, a number of organizations recommend dietary practices to promote oral health, such as decreasing consumption of sugary drinks, regular consumption of fruits, vegetables and dairy products with no added sugars, which are similar to dietary recommendations for healthy weights (WHO, 2003; Canadian Medical Association, 2015; Health Canada, Canadian Dental Association, Canada's Food Guide, Standing Senate Committee on Social Affairs, 2016).

5.7 Strengths and Limitations

This study contained a number of strengths. First and foremost, CHMS Cycle 1 is the only national survey that has a clinical and self-reported component for oral health. The BMI component was measured clinically, minimizing the possibility for over reporting

heights and underreporting weights, which is a common phenomenon when self-reported (Villanueva, 2001). However, while the results of this study indicate some dietary relationships, namely positive association for milk and negative associations for fruit juices and soft drinks, more associations were expected. It is important to acknowledge that this is a single study. Nevertheless, it is useful to explore possible reasons for the results, including the survey design, nature of the questions on diet, the dietary results, and the potential complexity of the relationship between diet and oral health and diet and obesity.

First, the CHMS data set is cross-sectional, and the absence of longitudinal data is an important consideration, as dietary influences could be observed over subsequent periods (Hofer, Sliwinski, & Flaherty, 2002) and permit analysis for individuals, as well as the group.

Second, while the oral health component of the data set was robust, the dietary component was less comprehensive, and intakes were not quantifiable. The dietary component of the CHMS data set has a number of missing food components (Hosseini, Whiting, & Vatanparast, 2019) thereby limiting the inclusion of dietary components to assess sugar intake (available in CCHS data) known to affect both oral health and weight status. In the CHMS, dietary intake was measured in frequencies (times per day) and did not ask for the serving size, thereby excluding the use of dietary indexes like the Healthy Eating Index. Self-reported dietary information relies on the participant's memory and there is limited flexibility to identify food/food groups (WHO, 1996) which may result in

not all dietary information being captured. Concern about the dietary component of CHMS resulted in a study by Hosseini, Whiting, & Vatanparast, (2019) that compared CHMS results with CCHS results (also self-reported). Researchers concluded that although the quality of the CHMS data were sufficient to assess consumption of fruit and vegetable and milk and alternates food groups, the data for other food groups were inadequate. Moreover, the CHMS did not assess intake of a number of key foods, for example, only data for cottage cheese were collected, no other types of cheese (Hosseini, Whiting, & Vatanparast, 2019).

Third, the dietary results themselves, which were frequently skewed in one direction or another, may have influenced the results. For example, a major proportion of the population reported relatively low frequencies of consumption of fruits, vegetables, cheese and milk. This observation has been reported earlier specifically for the Canadian population (Garriguet, 2005).

Lastly, the results from this study may indicate that the relationships between diet and oral and health diet and obesity may be more complex than envisioned in the design of this study. Within the Canadian adult population, other factors may affect the relationships, suggesting further inquiry. For example, in extreme situations where dental disease has progressed into tooth loss, and leads to edentulism (total tooth loss), the effects on the body such as weight gain may be more rapid and obvious, however weight changes with teeth remaining in the mouth may be slower and more difficult to measure.

A study by Lee et al., (2014), confirmed that weight gain of more than 5% in one year was observed following edentulism (Lee et al., 2014).

5.8 Dietary advice by dentists?

The results of this study confirms the potential utility of dietary advice in dental practice, however, the impact may be smaller than originally anticipated. The results from the demographic analysis indicates that the prevalence of poor oral health and obesity may be clustered in certain demographic categories in the adult Canadian population. This result highlights the need for policies and programs that will address the specific requirements of these groups for example, access to dental care, and reinforcing the importance of healthy eating and the need for access to healthy food. This approach has the potential of improving oral and general health at a population level (Dyer & Robinson, 2005), and has been recommended by organizations such as the WHO, Heart and Stroke Foundation and the Canada Food Guide (Peterson, 2003; Heart and Stroke Foundation, Canada Food Guide, 2019).

Dental professionals are the most regularly visited healthcare provider and therefore providing messages to clients regarding diet and advocating for access to healthy food for all, such as restriction of sugar and sugar sweetened beverages, and increasing consumption of hard cheese may help patients maintain oral health while reinforcing healthy weights (Shieham & Watt, 2000; Faine & Oberg, 1995; Moynihan, 2002). Poor oral health indicates that the mouth and body are being exposed to food groups that are

more damaging than beneficial (Hujoel, 2009). In such a situation, using oral health parameters as a screening tool and referral to professionals such as dietitians to obtain guidance may be a cost-effective preventive strategy.

Recognizing that poor diet as a common risk factor for poor oral health and obesity (WHO, 2004), and advocating for nutrition advice in dental settings is a contributory step towards collaboration among health care providers working towards a common goal – healthier individuals (Chaput et al., 2007; Palmer, 2001; Raindi, Thornley, & Thornley, 2015). A report from the Canadian Dental Association indicated that dentists in Nova Scotia already conduct public education campaigns annually to create public awareness of important issues such as reducing sugar consumption (CDA, 2017). Greater involvement by dental professionals will also signify de-compartmentalizing disciplines so that better results can be achieved (Shieham et al., 2011). This strategy is potentially both cost-effective and causes no harm. Advice by dental professionals (directly or indirectly) may be received as a credible message.

5.9 Recommended Next Steps

The findings of this study suggest further research is needed. This was a single study addressing these associations and further studies can investigate the complex nature of these relationships. Ideally, this research would be longitudinal so potential relationships could be examined as they evolve. A more robust dietary database would increase the number of foods available for analysis (such as consumption of hard cheese and an

expanded database of more sugar-containing foods) and would permit quantification of food intakes. Furthermore, dietary variables could be grouped together (for example, grouping lettuce with vegetables, or grouping all types of sweetened beverages) and can be incorporated in future research, which might strengthen the analysis. Also, it is possible to link CCHS data with CHMS data, however, this type of analysis was beyond the scope of this thesis.

The results from this study also highlighted the important connections between the number of teeth present in an individual's mouth and sociodemographic characteristics. This finding is not unusual. Edentulism has been used previously as a marker of oral health and number of teeth present has consistently exhibited an association with sociodemographic characteristics in a study where multiple countries were analyzed, including Canada (Elani et al., 2017). Nevertheless, these results are a reminder that less than the adequate number of teeth can be a warning signal indicating underlying problems (poor diet, systemic issues) and can be used as a screening tool while constructing a treatment plan for the patient.

5.10 Implications

This study is the only study to date that investigated the association between diet and oral health and diet and weight status in the Canadian adult population. More studies need to be conducted in this area in order to provide additional evidence about these

relationships. The results of this study indicated that dietary influences such as increased milk intake was beneficial both for good oral health and weight status and that fruit juice and soft drinks had a negative association with oral health and weight status. This overlap indicates that an opportunity exists for dental professionals to advocate for dietary choices that benefit oral health and help promote healthy weights. These associations have been reported in earlier studies and the role of diet in both oral and general health has been highlighted by the World Health Organisation (Peterson, 2003; Sabbah et al., 2007; Peterson, 2009).

Significant associations were observed in this study between sociodemographic factors and the number of teeth, which in turn can be used as a predictor while conducting future surveys. Individuals having fewer than the recommended number of teeth can be referred to dietitians for screening of their food habits and can be counselled accordingly.

Dietary advice can potentially help reduce the high costs of dental care (Moynihan, 2005). The impact of sociodemographic factors on oral health and healthy weights create the need for specific policies and programs for vulnerable populations. For example, the need to reduce income-based inequalities in oral health have been brought forward time and again in Canada (Duncan & Bonner, 2014).

These results are an opportunity for further discussion about roles for dental professionals to work collaboratively with other disciplines with a common goal to achieve better overall health for their patients by promoting messages centering around

dietary choices and other actions to address dietary and dental needs. Not only are such messages likely to be taken more seriously but these actions would align with the 'inclusion of oral health as a part of overall health' recommendation made by the World Health Organisation (Peterson, 2003).

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7. APPENDIX

Appendix A

Table 1: Questions from the CHMS survey and their corresponding variables

Variable	Related questions
MDC_B11	How often do you drink milk or enriched milk substitutes or use them on cereal?
MDC_B13	How often do you usually eat cottage cheese?
GFV_B17	How often do you usually eat fruit (fresh, frozen or canned)?
GFV_B19	How often do you usually eat lettuce or green leafy salad with or without any vegetables?
GFV_B23	How often do you usually eat all other types of vegetables excluding those already mentioned?
WSD_B11	How often do you usually drink regular soft drinks?
WSD_B12	How often do you usually drink: … fruit juices?
WSD_B21	How often do you usually drink: … water?

Table 2: Oral Health Score calculation

Criteria	Maximum score	Possible score
Comfort	8	0-pain 4-some pain 8-no pain
Function	8	0-problems 4-minor problems 8-no problems
Appearance	8	0-unhappy 4-some concern 8-happy
Occlusion	8	0-Less than 10 teeth in each jaw unopposed) 8-at least 10 teeth in each jaw opposed
Soft tissues	8	0-needs treatment or referral 4-needs observation 8-healthy
Tooth health	24	24-no restorations, caries free 18-sound restorations, caries free 12-less than 10% teeth need treatment 6-10-30% teeth need treatment 0-more than 30 % teeth need treatment
Tooth wear	12	0-much more wear than expected for age 6-more wear than expected for age 12-normal wear for age
Gum health	24	0-severe periodontal disease 6-moderate periodontal disease 12-mild periodontal disease 18-gingivitis only 24-healthy
	100	

(Busby et al., 2014)

Table 3: Details of coding of variables in the RDC

Table 3.1: Dietary variables

S.no	Variable name	CHMS coding	Recoding	Type
1.	Cheese	mdcd13y	chee_cat	Categorical
2.	Yogurt	mdcd14y	yogurt_cate	Categorical
3.	Milk	mdcd11y	mil_cate	Categorical
4.	Fruit	gfvd17y	fruit_cate1	Categorical
5.	Lettuce/salad	gfvd19y	let_cate	Categorical
6.	Vegetables	gfvd23y	vege_cate1	Categorical
7.	Water	wsdd21y	water_cate	Categorical
8.	Soft drinks	wsdd11y	sdr_cate	Categorical
9.	Fruit juices	wsdd14y	frj_cate	Categorical
10.	Ice-cream	mdcd15y	ice_cate	Categorical

Table 3.2: Oral Health variables-MOHS scoring

S.no	Variable name	CHMS coding	Recoding	Type
1.	Comfort	OHM_Q23	comfort1	Categorical
2.	Function	OHM_Q22	function1	Categorical
3.	Appearance	OHM_Q12	appearance1	Categorical
4.	Soft tissues	OHE_N14	softtissue1	Categorical
5.	Tooth health	(OHEDAC07+OHEDAC08+OHEDAC09+OHEDAC10)	th_total1	Categorical
6.	Tooth health categories		thf	Categorical
7.	Gum health	Ohedgs12	gumhealth_1	Categorical
		Ohedgs16	gumhealth_2	Categorical
		Ohedgs24	gumhealth_3	Categorical
		Ohedgs32	gumhealth_4	Categorical
		Ohedgs36	gumhealth_5	Categorical
		Ohedgs44	gumhealth_6	Categorical
8.	Gum health score (gumhealth_1 + gumhealth_2 + gumhealth_3 + gumhealth_4 +gumhealth_5 + gumhealth_6)		ghf_score	Categorical
9.	Gum health score categories		ghf	Categorical
10.	Oral Health score (comfort1+function1 +appearance1+ghf+thf+softtissue1)		ohsf	Continuous

Table 3.3: CHMS (Household) questions for MOHS scoring

OHM_Q23	the past 12 months, how often have you had any other persistent or ongoing pain anywhere in your mouth?
OHM_Q22	(In the past 12 months,) How often have you avoided eating particular foods because of problems with your mouth
OHM_Q12	How satisfied are you with the appearance of your teeth and/or dentures?

Table 3.4: Tooth health scoring and equivalent code in CHMS

Score awarded	Health grading	Equivalent code in CHMS
24	No previous restorations and no caries	0
18	Sound restorations and no caries	1
12	Some caries or falling restorations (up to 10% of teeth need treatment)	2
6	A moderate number of carious lesions or failing restorations (10-30% of teeth need treatment)	3
0	A significant number of carious lesions or falling restorations (more than 30% of teeth need treatment)	5

Table 4: Periodontal health scoring and equivalent code in CHMS

Score awarded	Health grading	Equivalent code in CHMS
24	Healthy periodontal tissues	0
18	Gingivitis only	1
12	Mild periodontal disease	2
6	Moderate periodontal disease	3
0	Severe periodontal disease	5

Appendix B: Released Cross tabs results

Table 1.1 : Means and standard deviations for Dietary Variables.

Variable	Total (times per year)	Mean	Std. Dev.
Cottage Cheese	23334302	20.31	57.108
Yogurt	23325012	151.00	172.996
Milk	23334302	351.90	362.152
Ice cream/ Frozen yog	23334302	44.20	67.710
Fruit	23334302	474.65	403.348
Lettuce	23334302	171.59	140.524
Vegetables	23316198	366.34	291.068
Soft drinks	23334302	94.58	252.365
Fruit juices	23334302	215.70	250.167
Flavoured Drinks	23334302	45.73	147.204
Water	23331695	1535.21	1045.841

Table 2: Crosstabs between individual variables

Table 2.1: Dietary variables and number of teeth

Cheese	**21-28**	**%**	**1 to 20**	**%**	**Missing teeth**	**%**
no intake	98,99,349	55.43	22,40,096	57.24	8,83,302	56.56
once week	66,82,890	37.42	13,03,339	33.3	5,28,418	33.83
1-3 times	5,21,298	2.92	2,43,297	6.22	70,981	4.54
more than	4,79,287	2.68	64,171	1.64	60,829	3.89
1-2 times	2,76,212	1.55	62,600	1.6	18,233	1.17
Total	1,78,59,036	100	39,13,503	100	15,61,763	100
Milk	21-28	%	1 to 20	%	.	%
no intake	16,66,986	9.33	5,91,908	15.12	1,70,440	10.91
once week	22,97,141	12.86	5,24,562	13.4	2,88,460	18.47
1-3 times	13,09,135	7.33	3,88,974	9.94	1,81,994	11.65
more than	23,32,055	13.06	5,19,378	13.27	1,64,067	10.51
1-2 times	89,66,238	50.21	17,07,626	43.63	6,33,986	40.59
>3 times	12,87,481	7.21	1,81,055	4.63	1,22,816	7.86
Total	1,78,59,036	100	39,13,503	100	15,61,763	100
Water	21-28	%	1 to 20	%	.	%
no intake	1,81,458	1.02	82,578	2.11	51,428	3.29
once week	2,74,445	1.54	1,08,071	2.76	56,080	3.59
1-3 times	1,93,862	1.09	92,092	2.35	21,909	1.4
more than	3,43,188	1.92	56,054	1.43	30,148	1.93
1-2 times	41,18,537	23.06	9,58,549	24.49	4,84,128	31
>3 times	1,27,47,546	71.38	26,13,552	66.78	9,18,070	58.78
.	0	0	2,607	0.07	0	0
Total	1,78,59,036	100	39,13,503	100	15,61,763	100
Soft Drinks	21-28	%	1 to 20	%	.	%
no intake	75,06,191	42.03	20,95,307	53.54	7,64,695	48.96
once week	56,97,492	31.9	10,51,413	26.87	3,44,704	22.07
1-3 times	13,66,022	7.65	1,79,946	4.6	1,29,292	8.28

more than	15,55,109	8.71	2,59,925	6.64	1,17,308	7.51
1-2 times	13,80,811	7.73	2,28,850	5.85	1,90,649	12.21
>3 times	3,53,411	1.98	98,062	2.51	15,115	0.97
Total	1,78,59,036	100	39,13,503	100	15,61,763	100
Fruit juice	21-28	%	1 to 20	%	.	%
no intake	18,25,232	10.22	6,64,404	16.98	3,18,262	20.38
once week	43,65,542	24.44	8,86,518	22.65	3,37,740	21.63
1-3 times	20,62,531	11.55	3,95,719	10.11	1,64,317	10.52
more than	34,82,758	19.5	6,12,188	15.64	1,61,342	10.33
1-2 times	57,76,412	32.34	12,30,881	31.45	5,31,190	34.01
>3 times	3,46,561	1.94	1,23,793	3.16	48,912	3.13
Total	1,78,59,036	100	39,13,503	100	15,61,763	100
ice cream	21-28	%	1 to 20	%	.	%
no intake	22,44,767	12.57	5,54,115	14.16	2,96,723	19
once week	1,28,28,285	71.83	24,90,237	63.63	8,72,561	55.87
1-3 times	15,81,256	8.85	5,52,104	14.11	2,18,357	13.98
more than	8,72,050	4.88	1,84,272	4.71	1,23,308	7.9
more than	3,32,678	1.86	1,32,775	3.39	50,814	3.25
Total	1,78,59,036	100	39,13,503	100	15,61,763	100
Vit-D	21-28	%	1 to 20	%	.	%
deficient	48,55,756	27.19	8,50,987	21.74	3,73,466	23.91
adequate	1,27,24,371	71.25	29,81,618	76.19	11,76,734	75.35
.	2,78,909	1.56	80,898	2.07	11,563	0.74
Total	1,78,59,036	100	39,13,503	100	15,61,763	100

Table 2.2: Dietary variables and BMI categories

cheese	less than 30		more than 30		Total	
no intake	99,32,883	57.15	30,89,864	51.89	1,30,22,747	55.81
once week	61,76,609	35.54	23,38,038	39.27	85,14,647	36.49
1-3 times	5,77,707	3.32	2,57,869	4.33	8,35,576	3.58
more than	4,18,531	2.41	1,85,756	3.12	6,04,287	2.59
1-2 times	2,74,177	1.58	82,868	1.39	3,57,045	1.53
Total	1,73,79,907	100	59,54,395	100	2,33,34,302	100
milk	less than 30		more than 30		Total	
no intake	16,44,537	9.46	7,84,797	13.18	24,29,334	10.41
once week	21,80,030	12.54	9,30,133	15.62	31,10,163	13.33
1-3 times	13,65,066	7.85	5,15,037	8.65	18,80,103	8.06
more than	23,32,497	13.42	6,83,003	11.47	30,15,500	12.92
1-2 times	86,72,556	49.9	26,35,294	44.26	1,13,07,850	48.46
>3 times	11,85,221	6.82	4,06,131	6.82	15,91,352	6.82
Total	1,73,79,907	100	59,54,395	100	2,33,34,302	100
soft -drink	less than 30		more than 30		Total	
no intake	76,38,411	43.95	27,27,782	45.81	1,03,66,193	44.42
once week	54,79,312	31.53	16,14,297	27.11	70,93,609	30.4
1-3 times	11,44,350	6.58	5,30,910	8.92	16,75,260	7.18
more than	15,09,881	8.69	4,22,461	7.09	19,32,342	8.28
1-2 times	12,99,012	7.47	5,01,298	8.42	18,00,310	7.72
>3 times	3,08,941	1.78	1,57,647	2.65	4,66,588	2
Total	1,73,79,907	100	59,54,395	100	2,33,34,302	100
Fruit juice	less than 30		more than 30		Total	
no intake	19,38,866	11.16	8,69,032	14.59	28,07,898	12.03
once week	41,06,401	23.63	14,83,399	24.91	55,89,800	23.96
1-3 times	18,72,469	10.77	7,50,098	12.6	26,22,567	11.24
>3 times weekly	33,19,632	19.1	9,36,656	15.73	42,56,288	18.24
1-2 times	57,54,030	33.11	17,84,453	29.97	75,38,483	32.31
>3 times	3,88,509	2.24	1,30,757	2.2	5,19,266	2.23
Total	1,73,79,907	100	59,54,395	100	2,33,34,302	100
ice-cream/frozen yog	less than 30		more than 30		Total	

no intake	22,50,495	12.95	8,45,110	14.19	30,95,605	13.27
once week	1,22,03,166	70.21	39,87,917	66.97	1,61,91,083	69.39
1-3 times	16,55,039	9.52	6,96,678	11.7	23,51,717	10.08
more than	8,45,337	4.86	3,34,293	5.61	11,79,630	5.06
more than	4,25,870	2.45	90,397	1.52	5,16,267	2.21
Total	1,73,79,907	100	59,54,395	100	2,33,34,302	100
vit d	less than 30		more than 30		Total	
deficient	41,86,410	24.09	18,93,799	31.81	60,80,209	26.06
adequate	1,29,552	74.55	39,26,851	65.95	1,68,82,723	72.35
.	2,37,625	1.37	1,33,745	2.25	3,71,370	1.59
Total	1,73,79,907	100	59,54,395	100	2,33,34,302	100

Table 3.1: Regression results – Model 1(a) and Model 2

Variables	Model 1 (a)		Model 2	
	odds ratio	p-value CI	Odds ratio	p-value CI
	Number of teeth		BMI>30	
Cheese intake				
No intake	1		1	
once weekly or less	1.08	0.545 (0.84-1.388)	1.28	0.058 (0.991-1.652)
1-3 times a week	1.84	0.04 (1.028-3.294)	1.73	0.072 (0.951-3.146)
More than 3 times a week	0.85	0.674 (0.397-1.816)	1.22	0.525 (0.653-2.302)
1-2 times daily	0.72	0.494 (0.281-1.842)	1.48	0.485 (0.492-4.451)
Yogurt intake				
No intake	1		1	
once weekly or less	0.73	0.077 (0.514-1.034)	1.00	0.966 (0.712-1.424)
1-3 times a week	0.79	0.293 (0.501-1.231)	1.22	0.383 (0.775-1.939)
More than 3 times a week	0.67	0.036 (0.458-0.973)	1.14	0.497 (0.78-1.665)
1-2 times daily	0.8	0.243 (0.55-1.163)	0.92	0.685 (0.62-1.368)
> 3 times daily	1.99	0.481 (0.293-13.526)	2.67	0.168 (0.66-10.809)
Milk intake				
No intake	1		1	
once weekly or less	1.13	0.586 (0.728-1.75)	0.89	0.627 (0.568-1.405)
1-3 times a week	1.64	0.052 (0.995-2.707)	0.78	0.404 (0.448-1.38)
than 3 times a week	0.99	0.97 (0.632-1.554)	0.57	0.02 (0.356-0.916)
1-2 times daily	0.85	0.373 (0.585-1.222)	0.60	0.014 (0.408-0.905)
>3 times daily	0.54	0.04	0.69	0.224

		(0.304-0.971)		(0.392-1.245)
Fruit intake				
No intake	1		1	
once weekly or less	2.85	0.044 (1.026-7.929)	3.57	0.044 (1.037-12.305)
1-3 times a week	1.65	0.352 (0.575-4.718)	5.66	0.007 1.606-19.983)
More than 3 times a week	2.09	0.147 (0.772-5.646)	5.93	**0.004** (1.762-19.965)
1-2 times daily	2.21	0.11 (0.836-5.833)	5.31	0.006 (1.605-17.607)
> 3 times daily	2.17	0.132 (0.792-5.938)	5.05	0.01 (1.475-17.286)
Lettuce/salad				
No intake			1.00	
once weekly or less	1.01	0.965 (0.542-1.895)	0.76	0.444 (0.378-1.529)
1-3 times a week	0.75	0.391 (0.392-1.441)	0.89	0.764 (0.434-1.844)
More than 3 times a week	0.88	0.692 (0.475-1.638)	0.96	0.915 (0.482-1.923)
1-2 times daily	0.78	0.446 (0.409-1.481)	0.97	0.946 (0.475-2)
> 3 times daily	2.79	0.518 (0.124-62.461)	3.24	0.245 (0.445-23.687)
Vegetables				
No intake	1		1.00	
once weekly or less	0.63	0.57 (0.124-3.149)	1.28	0.712 (0.341-4.823)
1-3 times a week	0.54	0.449 (0.106-2.695)	1.09	0.898 (0.287-4.141)
than 3 times a week	0.64	0.583 (0.131-3.126)	1.17	0.805 (0.328-4.197)
1-2 times daily	0.54	0.44 (0.111-2.596)	0.99	0.992 (0.279-3.532)
>3 times daily	0.35	0.217 (0.067-1.845)	0.65	0.56 (0.162-2.677)
Water				
No intake	1		1.00	

once weekly or less	0.66	0.534 (0.178-2.443)	1.57	0.518 (0.398-6.217)
1-3 times a week	1.4	0.65 (0.326-6.02)	1.80	0.441 (0.404-7.965)
than 3 times a week	0.57	0.339 (0.176-1.818)	1.51	0.52 (0.431-5.258)
1-2 times daily	0.37	0.05 (0.133-1)	2.08	0.178 (0.717-6.005)
>3 times daily	0.4	0.071 (0.145-1.082)	1.72	0.308 (0.605-4.902)
Soft drinks				
No intake	1		1.00	
once weekly or less	0.9	0.462 (0.69-1.183)	0.90	0.451 (0.673-1.192)
1-3 times a week	1.18	0.531 (0.698-2.003)	1.51	0.102 (0.921-2.481)
than 3 times a week	1.23	0.403 (0.756-2.003)	0.77	0.281 (0.476-1.24)
1-2 times daily	1.11	0.704 (0.639-1.94)	1.07	0.778 (0.684-1.66)
>3 times daily	2.25	0.045 (1.017-4.991)	1.04	0.932 (0.684-1.66)
Fruit juices				
No intake	1		1.00	
once weekly or less	0.86	0.444 (0.579-1.27)	0.89	0.548 (0.598-1.313)
1-3 times a week	0.89	0.628 (0.57-1.403)	0.97	0.885 (0.612-1.527)
than 3 times a week	0.73	0.144 (0.479-1.112)	0.62	0.027 (0.407-0.948)
1-2 times daily	0.8	0.245 (0.558-1.16)	0.74	0.115 (0.509-1.076)
>3 times daily	2.75	0.024 (1.144-6.609)	0.90	0.819 (0.381-2.142)
Fruit fl. Drinks				
No intake	1		1.00	

once weekly or less	0.96	0.842 (0.663-1.398)	1.14	0.452 (0.806-1.62)
1-3 times a week	0.96	0.911 (0.477-1.934)	1.12	0.702 (0.624-2.011)
than 3 times a week	1.64	0.109 (0.894-3.02)	0.56	0.062 (0.306-1.028)
1-2 times daily	1.08	0.829 (0.53-2.204)	0.91	0.775 (0.491-1.697)
>3 times daily	0.35	0.331 (0.04-2.931)	0.86	0.814 (0.25-2.969)
ice cream/fr. Yogurt				
No intake	1		1.00	
once weekly or less	1.03	0.877 (0.725-1.455)	0.99	0.975 (0.691-1.428)
1-3 times a week	1.39	0.184 (0.855-2.251)	1.16	0.566 (0.704-1.897)
than 3 times a week	0.89	0.688 (0.507-1.564)	1.07	0.811 (0.628-1.811)
more than once daily	2.04	0.063 (0.961-4.333)	0.65	0.305 (0.284-1.481)
rbc folate				
deficient	1.00		1.00	
adequate	1.36	0.647 (0.368-5)	1.02	0.973 (0.265-3.955)
Vit D				
deficient	1.00		1.00	
adequate	0.88	0.372 (0.675-1.158)	0.55	**0** (0.418-0.713)
Age				
20-39	1		1	
40-49	9.86	**0** (5.782-16.803)	1.11	0.514 (0.805-1.54)
50-59	28.57	**0** (16.663-48.991)	1.22	0.283 (0.805-1.54)
60-69	65.1	(37.537-112.893)	1.64	0.005

				(1.158-2.315)
70-79	97.02	**0** (53.098-177.262)	0.99	0.973 (0.624-1.574)
Gender				
Male	1		1.00	
female	1.15	0.27 (0.898-1.469)	1.05	0.712 (0.801-1.382)
Immigrant				
Yes	1		1.00	
no	0.92	0.567 (0.689-1.225)	1.82	**0** (1.319-2.513)
Province				
nb	1		1.00	
que	1.71	0.014 (1.114-2.635)	0.68	0.09 (0.44-1.061)
ont	0.55	**0.005** (0.359-0.837)	0.68	0.086 (0.443-1.055)
alta	0.54	0.015 (0.327-0.886)	0.90	0.674 (0.559-1.456)
bc	0.54	0.017 (0.326-0.895)	0.41	**0.001** (0.24-0.683)
Education				
< Sec. school	1		1.00	
no post_sec	0.75	0.159 (0.503-1.119)	0.77	0.198 (0.51-1.149)
Some post-sec	0.43	**0.002** (0.254-0.729)	0.74	0.24 (0.448-1.221)
College/uni	0.46	**0** (0.323-0.654)	0.58	**0.002** (0.411-0.814)
Income levels				
lowest income	1		1.00	
lower middle inc	1.5	0.165 (0.845-2.673)	0.97	0.912 (0.593-1.592)
upper middle inc	1.18	0.56 (0.682-2.038)	0.67	0.099 (0.42-1.077)
highest income	0.74	0.283 (0.422-1.286)	0.66	0.086 (0.412-1.06)

Table 3.2: Linear regression output for Model 1 (b)

MOHS	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
edu_cat						
no post_sec	2.29	1.42	1.61	0.11	-0.49	5.06
Some post-sec	5.97	1.47	4.06	0.00	3.09	8.85
College/uni	5.57	1.24	4.49	0.00	3.14	8.00
incddia4						
lower middle inc	2.80	1.77	1.59	0.11	-0.66	6.27
upper middle inc	5.20	1.69	3.08	0.00	1.88	8.51
highest income	7.28	1.65	4.42	0.00	4.05	10.51
dhh_sex						
female	0.89	0.63	1.42	0.15	-0.34	2.12
sdcfimm						
no	0.33	0.76	0.44	0.66	-1.16	1.83
dhh_prn						
que	-4.38	0.97	-4.50	0.00	-6.30	-2.47
ont	-2.57	0.94	-2.73	0.01	-4.41	-0.72
alta	-4.13	1.08	-3.81	0.00	-6.25	-2.00
bc	-2.17	1.05	-2.07	0.04	-4.23	-0.11
age_cate						
age 40-49	-1.95	0.70	-2.80	0.01	-3.32	-0.59
age 50-59	-3.72	0.84	-4.45	0.00	-5.36	-2.08
age 60-69	-5.05	0.84	-6.01	0.00	-6.70	-3.41
age 70-79	-5.23	1.08	-4.85	0.00	-7.34	-3.12
chee_intake						
once weekly or less	1.00	0.58	1.74	0.08	-0.13	2.13

1-3 times a week	0.09	1.72	0.05	0.96	-3.27	3.46
more than 3 times a week	2.39	1.58	1.52	0.13	-0.70	5.49
1-2 times daily	-0.31	2.11	-0.15	0.88	-4.46	3.83
yogurt_intake						
once weekly or less	0.76	0.90	0.84	0.40	-1.01	2.52
1-3 times a week	0.36	1.13	0.32	0.75	-1.86	2.58
more than 3 times a week	0.77	1.00	0.77	0.44	-1.19	2.74
1-2 times daily	1.03	0.96	1.07	0.29	-0.86	2.91
more than 3 times daily	-6.03	3.34	-1.80	0.07	-12.57	0.52
mil_intake						
once weekly or less	-0.28	1.13	-0.25	0.80	-2.49	1.93
1-3 times a week	-0.81	1.38	-0.59	0.55	-3.51	1.88
more than 3 times a week	0.32	1.19	0.27	0.79	-2.02	2.66
1-2 times daily	0.40	0.96	0.42	0.68	-1.48	2.28
>3 times weekly	1.13	1.26	0.90	0.37	-1.33	3.60
fruit_intake						
once weekly or less	-7.34	2.37	-3.10	0.00	-11.98	-2.70
1-3 times a week	-8.47	2.35	-3.60	0.00	-13.08	-3.86
more than 3 times a week	-5.44	2.24	-2.42	0.02	-9.83	-1.04
1-2 times daily	-7.39	2.18	-3.39	0.00	-11.66	-3.11
> 3 times daily	-5.12	2.23	-2.30	0.02	-9.49	-0.75
let_intake						
once weekly or less	0.12	1.57	0.08	0.94	-2.97	3.21
1-3 times a week	2.77	1.56	1.78	0.08	-0.29	5.82
more than 3 times a week	2.28	1.50	1.52	0.13	-0.67	5.23
more than once daily	2.36	1.56	1.52	0.13	-0.69	5.41
.> 3 times daily	5.99	2.38	2.52	0.01	1.33	10.65
vege_intake						
once weekly or less	2.11	3.94	0.53	0.59	-5.62	9.84

1-3 times a week	0.69	4.01	0.17	0.86	-7.17	8.54
more than 3 times a week	1.62	3.84	0.42	0.67	-5.91	9.14
1-2 times daily	1.52	3.81	0.40	0.69	-5.95	8.99
>3 times daily	3.86	3.88	0.99	0.32	-3.75	11.47
water_intake						
once weekly or less	-1.07	4.78	-0.22	0.82	-10.43	8.30
1-3 times a week	5.98	4.90	1.22	0.22	-3.64	15.59
more than 3 times a week	0.96	4.52	0.21	0.83	-7.91	9.82
1-2 times daily	5.19	4.28	1.21	0.23	-3.20	13.59
>3 times daily	4.85	4.28	1.13	0.26	-3.54	13.24
sdr_intake						
once weekly or less	-1.11	0.63	-1.78	0.08	-2.34	0.12
1-3 times a week	0.23	1.19	0.19	0.85	-2.11	2.57
more than 3 times a week	-1.90	1.28	-1.48	0.14	-4.42	0.62
1-2 times daily	-3.62	1.28	-2.82	0.01	-6.13	-1.11
>3 times daily	-10.62	2.45	-4.33	0.00	-15.42	-5.81
frj_intake						
once weekly or less	0.41	0.95	0.43	0.67	-1.46	2.27
1-3 times a week	-1.10	1.19	-0.92	0.36	-3.42	1.23
more than 3 times a week	0.40	1.02	0.39	0.70	-1.61	2.41
1-2 times daily	0.35	0.93	0.37	0.71	-1.47	2.16
>3 times daily	-5.10	3.03	-1.68	0.09	-11.05	0.85
ffv_intake						
once weekly or less	-0.30	0.78	-0.39	0.70	-1.84	1.23
1-3 times a week	-2.33	1.54	-1.51	0.13	-5.35	0.69
more than 3 times a week	1.15	1.54	0.75	0.45	-1.86	4.16
1-2 times daily	-1.19	1.66	-0.72	0.47	-4.45	2.07
>3 times daily	-3.45	3.70	-0.93	0.35	-10.71	3.81

ice_intake						
once weekly or less	1.29	0.86	1.51	0.13	-0.39	2.98
1-3 times a week	-0.93	1.31	-0.71	0.48	-3.51	1.65
more than 3 times a week	0.93	1.32	0.71	0.48	-1.65	3.51
more than once daily	2.54	2.05	1.24	0.22	-1.48	6.57
rbcf						
adequate	-1.08	2.50	-0.43	0.67	-5.98	3.81
vit_d						
adequate	1.46	0.73	2.00	0.05	0.03	2.88
_cons	60.47	6.35	9.52	0.00	48.02	72.92

8. CURRICULUM VITAE

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