ASSOCIATION BETWEEN VEGETARIANISM AND CARDIOVASCULAR RISK FACTORS IN SOUTH ASIAN ADULTS AT RISK FOR TYPE 2 DIABETES

by

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Association between vegetarianism and cardiovascular risk factors in South Asian adults at risk for Type 2 diabetes

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Abstract

Background and Objective: South Asians develop cardiovascular risk factors and Type 2 diabetes earlier and at lower body mass index (BMI) compared to other ethnic populations in Canada. Diet is a modifiable risk factor. Adherence to a vegetarian diet has been associated with a favourable cardiometabolic profile including body weight, blood pressure, cholesterol, and glycemic control compared to an omnivorous diet. Despite having the greatest proportion of vegetarians in the world, South Asians have amongst the highest rates of diabetes in Canada. This study aims to examine vegetarian dietary intake, explore the relationship between vegetarianism and adiposity, and identify associations between sociodemographic characteristics and adiposity measures in South Asians living in Metro Vancouver.

Methods: Using the American Diabetes Association Diabetes Risk Test, 100 South Asian adults identified to be high risk for diabetes were recruited from 12 faith-based centres in Metro Vancouver. 96 participants completed a 163-item culturally tailored food frequency questionnaire and vegetarian status was determined. Waist circumference (WC) and BMI were measured to evaluate adiposity. Dietary intake including calories, macronutrient and micronutrient consumption were compared between vegetarians and omnivores. Associations between diet and sociodemographic characteristics with adiposity markers were examined.

Results: 50 participants identified as vegetarian and 46 as omnivore. Vegetarians more frequently consumed carbohydrates and foods with higher glycemic load and glycemic index. Omnivores reported higher intake of several micronutrients (niacin, vitamin B-12, potassium, and zinc), but both diet groups did not meet their nutrient requirements for niacin, potassium and vitamin D. 90.6% of all participants had overweight/obese BMI and a vegetarian diet was not associated with improved adiposity. Female sex and education were positively associated with BMI, while age was associated with higher WC.

Conclusion: In addition to the high prevalence of overweight and obesity, both vegetarians and omnivores had dietary intake that may be associated with increased diabetes risk. Factors such as age, socioeconomic status, and Westernization may account for the unhealthy dietary intake

observed in this study. Findings demonstrate that promoting healthy nutrition is a priority for this community, and interventions should be tailored to address culture-specific dietary habits in South Asian Canadians.

Lay Summary

Following a vegetarian diet can improve long term health and has been associated with reduced risk for diabetes and cardiovascular disease. Despite high rates of vegetarianism, South Asians are at greater risk for developing diabetes compared to other ethnic groups. As a highly diverse population, South Asian dietary intake needs to be examined comprehensively. 100 South Asians living in Metro Vancouver were recruited for this study. Dietary intake and body fat composition were then assessed in vegetarians and omnivores. Vegetarians more frequently consumed carbohydrates, while both vegetarians and omnivores had insufficient intake of several vitamins and minerals. The prevalence of overweight and obesity was high, and a vegetarian diet was not associated with improved body fat. Female sex, older age and higher educational achievement were associated with increased body fat. Promoting healthy nutrition is crucial, and findings from this study provide a basis for dietary interventions for South Asian Canadians.

Preface

The contents and data presented in this thesis are original and were collected from the study, Prevention Matters: Reducing the diabetes burden in the South Asian community, for which Dr. Tricia S. Tang is the Principal Investigator. This study has received ethics approval from the Fraser Health Research Ethics Board (FHREB 2013-030) and the University of British Columbia Clinical Research Ethics Board (H13-00189). The objectives, analyses, and interpretation of research findings presented in this thesis were conducted by me with supervision and guidance provided by my supervisor, Dr. Tricia S. Tang, and supervisory committee members, Dr. Rachel A. Murphy and Dr. Nadia A. Khan. All written content including tables and figures presented in this thesis are my original own work. Hong Qian at the Centre for Health Outcomes and Evaluation Sciences provided statistical consultation for the data presented in Tables 4.2 to 4.4, Table 4.8 and Table 4.11.

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List of Abbreviations

ADA	American Diabetes Association
AI	Adequate Intake
BMI	Body Mass Index
CCHS	Canadian Community Health Survey
CM	Centimetres
CSDLH	Canadian Study of Diet, Lifestyle and Health
DBP	Diastolic Blood Pressure
EAR	Estimated Average Requirement
EWCFG	Eating Well with Canada Food Guide
FBG	Fasting Blood Glucose
FFQ	Food Frequency Questionnaire
HDL-C	High Density Lipoprotein Cholesterol
HMLR	Hierarchical Multiple Linear Regression
ICS-DOAMS	India Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and Metabolic Syndrome
IDF-CWDMS	International Diabetes Federation Consensus Worldwide Definition of the Metabolic Syndrome
LDL-C	Low Density Lipoprotein Cholesterol
MG	Milligrams
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
SBP	Systolic Blood Pressure
SES	Socioeconomic Status

TC	Total Cholesterol
TG	Triglycerides
WC	Waist Circumference

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Chapter 1: Introduction

1.1 Glucose metabolism

The human body is a complex interconnected system of cells, tissues and organs; each of which require energy to complete metabolic processes and carry out physiological functions. While the body can generate energy from various carbohydrates, fats and amino acids, glucose (a simple monosaccharide) is a critically important energy source for the body.[1-3] Under normal conditions, blood glucose levels are tightly regulated through catabolic and anabolic hormones secreted by the alpha and beta cells of the pancreas.[4-5] When blood glucose levels are too low (e.g. periods of fasting) pancreatic alpha cells are stimulated to release glucagon. Glucagon is a catabolic hormone that increases blood glucose levels through the breakdown of glycogen into individual glucose molecules (i.e. glycogenolysis) as well as through the production of glucose from non-carbohydrate sources (i.e. gluconeogenesis).[4-5] Glucagon also stimulates lipolysis, a process by which fatty acids are broken down for energy production.[5] In contrast, when blood glucose levels are too high (e.g. after eating a meal) pancreatic beta cells are stimulated to release insulin. Insulin is an anabolic hormone that promotes the uptake, storage and polymerization of glucose into glycogen (i.e. glycogenesis), subsequently reducing blood glucose levels.[4-6] Insulin also stimulates triglyceride production (i.e. lipogenesis) and protein synthesis, reducing systemic fatty acid and amino acid levels, respectively.[5-6]

Poor glycemic control and persistently high blood glucose levels can lead to serious physiological complications. As a result of the body's attempt to reduce chronically elevated blood glucose levels, there is an increased demand on beta cells to produce and secrete insulin. Over time, this can lead to detrimental changes in beta cell structure and function.[7-11] Eventually, beta cells may not be able to produce enough insulin to effectively reduce blood glucose levels, resulting in hyperglycemia (i.e. high blood glucose) and glucose intolerance.[9-11] Other cells in the body (e.g. muscle cells, adipose cells) that require insulin for glucose uptake and energy production may also grow increasingly resistant to the effects of insulin.[6-8] It has been widely demonstrated that beta cell dysfunction, insulin resistance and glucose intolerance are synergistically linked with cardiometabolic risk, including the onset of prediabetes and Type 2 diabetes mellitus.[8-11]

1.2 Type 2 diabetes disease process and the metabolic syndrome

Type 2 diabetes, hereby referred to as diabetes, is a debilitating non-communicable disease. Characterized by the inability of the body to effectively use insulin, the onset and development of diabetes can lead to several microvascular and macrovascular complications.[12-14] Without treatment and management, chronically elevated blood glucose levels and subsequent hyperglycemia can lead to circulatory damage as well as structural and metabolic changes to blood vessels around the body.[12-16] Microvascular complications result from damage to small blood vessels, such as arterioles, capillaries and venules.[13] These small blood vessels carry nutrients to important bodily structures, including the retina, kidneys and peripheral nervous system.[13] Abnormalities in blood flow to each of these structures can result in retinopathy and visual impairment, nephropathy and renal failure, as well as neuropathy and damage to peripheral nerves that innervate the extremities (e.g. legs and feet).[12-14] In contrast to microvascular complications, macrovascular complications result from plaque build up (i.e. atherosclerosis) and damage within large blood vessels, such as arteries and veins.[14-15] Greater resistance to blood flow through larger blood vessels that feed organs such as the heart and brain can lead to increased risk for coronary artery disease, peripheral artery disease and stroke.[12-15]

Several cardiometabolic risk factors contribute and result from the onset and development of cardiovascular disease and diabetes related complications. Abdominal obesity, or excess visceral fat deposits around the waist, has been strongly associated with insulin resistance, cardiovascular disease and diabetes.[17-19] Increased blood pressure and hypertension are common predictors of cardiovascular disease and contribute to several diabetes related microvascular and macrovascular complications including retinopathy, stroke and nephropathy.[12-14, 20–21] Dyslipidemia and abnormalities in blood lipid levels, including high TG and low HDL-C, is also a significant risk factor for atherosclerosis and the development of cardiovascular disease.[22-23] Collectively, abdominal obesity, hypertension and dyslipidemia augment the effects of insulin resistance and glucose intolerance.[24-26] This cluster of cardiometabolic risk factors comprise the metabolic syndrome. While each risk factor can present individually, they are interdependent.[25-26] Overall, the metabolic syndrome increases individual risk for cardiovascular complications and diabetes related comorbidities.[24-26]

1.3 South Asians and diabetes

Diabetes has escalated into a global epidemic. According to 2019 statistics, 463 million people around the world are living with diabetes, a figure projected to increase to 700 million people by 2045.[27] With rising disease incidence and prevalence follows increased health care costs to manage this disease. In 2019, the International Diabetes Federation reported that diabetes accounted for 10% of global health expenditures. The prevalence of diabetes has more than doubled in North America since 2000 (21.4 million to 48 million), but in recent decades has begun to predominate in low and middle-income countries.[27] The sub-continent of South Asia, which includes Afghanistan, Bangladesh, Bhutan, the Maldives, Nepal, India, Pakistan and Sri Lanka, has experienced a significant increase in the rates of diabetes. Between 2000 (35 million cases) and 2019 (88 million cases) the prevalence of diabetes increased by 151.4%, and South Asia currently accounts for an estimated 19.0% of all diabetes cases worldwide.[27-28]

In Canada, diabetes is a public health concern. As of 2019, an estimated 11 million people live with prediabetes or diabetes, a figure that has doubled since 2000.[29] South Asians, or individuals with origins in sub-continent of South Asia, are the largest visible minority group in Canada, representing 5.6% of the Canadian population.[30] According to 2016 Census data, South Asian Canadians predominantly live in Ontario and BC. Within BC, South Asians represent 8.0% of the provincial population, with nearly 80% (i.e. 291,005) living in the Metro Vancouver area.[30-31]

It is well documented that South Asians experience earlier onset and greater risk for cardiovascular disease and diabetes compared to other ethnic groups.[19, 32-36] This increased cardiometabolic risk can be attributed to a combination of genetics and lifestyle factors. In what has been termed the "South Asian phenotype", South Asians have greater abdominal adiposity, insulin resistance, hyperglycemia and dyslipidemia relative to Caucasians with comparable body weight and BMI, possibly due to genetic factors. This phenomenon is also observed at normal body weight and BMI (20.0–24.9 kg/m^2) which is typically associated with a healthier metabolic profile.[35-41] This genetic susceptibility and increased cardiometabolic risk is an underpinning factor for early onset metabolic syndrome, diabetes and cardiovascular disease commonly experienced by South Asians.[19, 32–38] As such, red-defined guidelines for the diagnosis and classification of obesity, abdominal obesity, hypertension, dyslipidemia and dysglycemia have been established for South Asians through ICS-DOAMS.[42]

1.4 Lifestyle factors, sociodemographic characteristics, and diabetes

Physical activity is a significant modifiable lifestyle factor that contributes to diabetes risk and the development of microvascular and macrovascular complications. It has been widely demonstrated that physical activity, including both aerobic and resistance exercise, contribute to increased insulin sensitivity, better regulation of blood glucose levels, improvements in cardiometabolic measures such as weight and blood pressure, and reduced risk for cardiovascular disease.[43-44] However, inside and outside South Asia, studies have consistently reported that South Asians have greater levels of physical inactivity and sedentary time compared to other ethnic groups.[32, 45-46] These high levels of physical inactivity are most common amongst males, skilled workers and urban dwellers.[45-47]

Dietary intake is also widely recognized as an important risk factor for the prevention and management of diabetes.[48-51] More specifically, the type and quantity of macronutrients (e.g. carbohydrates, fats and proteins) and micronutrients (e.g. vitamins and minerals) consumed has crucial implications on total energy balance, blood glucose levels and the subsequent development of cardiometabolic risk factors.[49-51] Unfortunately for many South Asians living inside and outside South Asia, globalization, urbanization and dietary acculturation have led to shifts in dietary consumption, including increased intake of foods considered to be less healthy: processed foods, refined carbohydrates and saturated fats; and lower intake of foods considered to be healthier: fruits and vegetables, whole grains and plant-based proteins.[52-58] Ultimately, globalization, urbanization and dietary acculturation have contributed to a substantial increase in the rates of non-communicable diseases amongst South Asians.[52-58]

1.5 Healthy eating and vegetarian diets

The updated 2019 EWCFG provides dietary guidance designed to help individuals meet their macronutrient and micronutrient requirements for overall health, growth and development.[59] The dietary guidelines focus on promoting healthy dietary habits with an emphasis on consumption of fruits and vegetables, whole-grain carbohydrates and plant-based protein foods. At a given meal, the ‘ideal’ plate should consist of approximately 50% fruits and vegetables, 25% whole grains, and 25% protein-based foods. The 2019 EWCFG also emphasizes the need to reduce intake of refined and processed foods while making water the drink of choice.

Despite well-established guidance from the EWCFG, only 28.6% of Canadians 12 years and older were consuming fruits and vegetables five or more times per day according to the 2017 Canada Community Health Survey.[59] Higher intake of fruits and vegetables has been associated with reduced cardiometabolic risk including the development of obesity and diabetes.[61-63] Contrastingly, consumption of fried foods, starchy carbohydrates and sugar sweetened beverages have grown in prevalence amongst Western countries as these foods have become increasingly available and affordable. Previous studies have demonstrated the negative impacts these foods can have on cardiometabolic health. For example, starchy carbohydrates and fried foods have been associated with increased risk for diabetes and cardiovascular disease.[64-65] Moreover, sugar sweetened beverages have widely been considered to be a leading contributor to overweight and obesity and can potentially increase diabetes risk by up to 30%.[66-67] Ultimately, promoting the EWCFG guidelines is important to improving and maintaining the long-term health of Canadians.

Although Diabetes Canada encourages adherence to guidelines outlined by the EWCFG, they have also recommended that individuals living with diabetes practice portion control while consuming calorie-reduced diets, increasing individual intake of fiber and avoiding foods high in trans fatty acids.[68] It has also been suggested that individuals living with diabetes follow a Mediterranean diet or the Dietary Approaches to Stop Hypertension (DASH) diet.[69-70] Both of these diets are characterized by increased intake of fruits and vegetables, beans, legumes, nuts, whole-grains and fish, with reduced consumption of red meat, processed foods and sugar-sweetened beverages. However, there are important differences: the Mediterranean diet promotes consumption of extra virgin olive oil as well as moderate intake of dairy products, poultry and red wine; meanwhile, the DASH diet promotes intake of low-fat dairy products, poultry, lean animal-based proteins and the restriction of salt. Ultimately, following a healthy diet such as the Mediterranean diet or DASH diet can improve cardiometabolic measures and reduce overall risk for diabetes and cardiovascular disease.[69-71]

While decreased intake of red meat and convenience foods that are high in trans-fat or sugar can improve long-term health outcomes, studies have demonstrated that following a vegetarian diet significantly reduces cardiometabolic risk across countries and ethnic groups.[72-74] Individuals that follow a vegetarian diet have lower body weight and blood pressure, lower blood lipid levels and improved blood glucose levels compared to non-vegetarians, which may reduce their risk for obesity, hypertension, dyslipidemia and dysglycemia.[74-77] As such, adherence to a vegetarian diet may be effective in reducing diabetes risk and the development of diabetes related complications. There are several types of vegetarian diets, including vegan (i.e. no consumption of dairy, eggs, meat, poultry or seafood), lacto-vegetarian (i.e. consumption of dairy but no eggs, meat, poultry or seafood), lacto-ovo-vegetarian (i.e. consumption of dairy and eggs but no meat, poultry or seafood); pesco-vegetarian (i.e. consumption of dairy, eggs and seafood but no meat or poultry); and semi-vegetarian (i.e. occasional consumption of meat, poultry or seafood).

Many South Asians practice vegetarianism for purity, cultural, religious, and traditional reasons.[78] Paradoxically, despite approximately 40.0% of the population practicing vegetarianism, the incidence and prevalence of diabetes is amongst the highest in South Asians compared to the rest of the global population.[27, 41] The South Asian vegetarian diet, which is traditionally high in vegetables, whole grains, legumes, and lentils, has undergone an unhealthy dietary transition and now incorporates more processed foods with low nutritional value.[52-58] As such, the healthfulness of South Asian vegetarian diets is in question. In particular, the distribution of macronutrients and micronutrients in addition to the foods and eating habits comprising the South Asian vegetarian diet may be contributing towards rather than protecting against the development of cardiometabolic risk factors and diabetes in this ethnic population.

1.6 Macronutrient function and intake in South Asians

Daily calorie requirements for adults are impacted by various factors such as age, sex, height, weight, health status and overall levels of physical activity.[79] For individuals above the age of 19, Health Canada recommends that total daily calorie intake should consist of 10–35% protein, 45–65% carbohydrate, 20–35% fat, 5–10% omega-6 fatty acids, and 0.6–1.2% omega-3 fatty acids.[80] Dietary macronutrients help sustain bodily processes and regulate cellular growth.[81] Macronutrient intake has crucial implications on maintaining overall energy balance, which is defined as the difference between total energy intake (e.g. caloric intake) and total energy expenditure (e.g. calories burned).[82-83] Protein, carbohydrates and fat each contribute a certain amount of energy: protein and carbohydrates each contribute four calories per gram, while fat, which is the most energy-dense macronutrient, contributes nine calories per gram. Dietary imbalance resulting from consumption of macronutrients at a level that exceeds overall caloric expenditure can lead to obesity and cardiometabolic complications over time.[83-84]

1.6.1 Protein

Protein is an energy source, and is necessary for metabolic processes, bodily functions, and repair. Dietary protein sources include both animal-based protein (e.g. red meat, poultry, eggs, and dairy) and plant-based protein (e.g. tofu, pulses, and legumes). In recent years plant-based sources of protein have been emphasized by Health Canada and the United States Departments of Health and Human Services, and Agriculture.[59, 85] Consuming more plant-based protein has been associated with reduced incidence of risk factors for the metabolic syndrome.[86] Moreover, a recent systematic review and meta-analysis found that diets high in plant-based proteins may improve blood glucose and insulin levels relative to animal-based proteins.[87] South Asians reportedly receive lower amounts of their total energy intake from protein compared to their Western counterparts (13.1 to 13.8% versus 15.1%).[88] Although these amounts are within the 10-35% protein range outlined by Health Canada, low protein intake is an important concern in South Asians, particularly amongst vegetarians.[89] As such, promoting high-protein diets comprised of predominantly plant-based protein is an important consideration to increase protein intake and reduce cardiometabolic risk.

1.6.2 Carbohydrates

Dietary carbohydrates include sugars, starches, and fibers. Digestible carbohydrates are derived from starches and sugars, while indigestible carbohydrates are derived from fiber sources. It has been well recognized that dietary carbohydrates are a major contributing factor to the development of cardiometabolic risk factors and can lead to subsequent changes in glycemic control.[64, 90-92] Simple carbohydrates (e.g. monosaccharides or disaccharides), commonly known as refined carbohydrates, which are found in foods such as confectionary and sugar-sweetened beverages, are easily digestible and are thought to raise blood glucose faster than complex carbohydrates (e.g. oligosaccharides or polysaccharides), which are found in fruits and vegetables and are digested at a slower rate.[64, 90] For this reason, refined carbohydrates are also considered to be less nutritious than complex carbohydrates as they are typically processed and contain low amounts of fiber, vitamins and minerals.[64] Additionally, dietary fiber, which contains indigestible complex carbohydrates, contains soluble and insoluble forms. Soluble fiber sources, such as fleshy fruits, have several beneficial cardiometabolic functions, and have been associated with reduced LDL-C, TC and blood glucose levels.[64, 91] Insoluble fiber sources, such as wheat brans, have limited cardiometabolic function but help foods pass more easily through the digestive tract.[91]

The traditional South Asian diet consists of several carbohydrate-based staple foods (e.g. rotis, chapattis, cereals). However, contemporary South Asian diets have incorporated more refined carbohydrates and processed foods.[57, 92-93] Although it has been found that South Asian immigrants tend to decrease their carbohydrate consumption the longer they reside in Western countries, South Asians reportedly consume greater amounts of carbohydrates relative to other ethnic groups. [53-56, 92, 94-95] For example, a study investigating carbohydrate intake and cardiometabolic outcomes in 619 Canadians found that South Asians consumed significantly more carbohydrates relative to Caucasian, Indigenous and Chinese persons.[95] As South Asians are at greater risk for cardiovascular disease and diabetes, the type of dietary carbohydrates consumed is critically important. Glycemic index and glycemic load are measures that can assess the quality of dietary carbohydrates.[64] Glycemic index is a tool used to measure the individual effects of carbohydrate-containing foods on blood glucose. Foods with a high glycemic index, such as refined grains and potatoes, raise blood glucose quickly, and if consumed consistently can lead to increased risk for obesity, diabetes and cardiovascular disease.[64, 90] In contrast, foods with a low-glycemic index such as whole grains and green leafy vegetables cause slow and incremental increases in blood glucose.[64, 90] Glycemic load is a measure that considers the portion size in addition to the glycemic index of a carbohydrate-containing food, providing a more precise assessment of the effect's carbohydrate-containing foods will have on blood glucose levels.

1.6.3 Fats

Dietary fats are the highest energy providing macronutrient and have critical roles in cellular function and gene expression, metabolic processes, and protection of the body's organs.[92] It has been widely demonstrated that the amount and type of dietary fat has implications for health. While reducing overall fat intake was commonly recommended as a method to reduce cardiometabolic risk, dietary fats were often replaced with refined carbohydrates, which has been hypothesized to lead to increased rates of obesity and diabetes.[96-97] Rather, moderate consumption of foods containing saturated fats (e.g. ghee, vegetable ghee, butter, red meat) and minimal artificial trans fats (e.g. bakery goods, fried foods), are recommended. An emphasis on monounsaturated fats (e.g. avocados, nuts), and polyunsaturated fats (e.g. olive oil, soybean oil, salmon, flax seeds) is suggested to support cardiometabolic health and reduce diabetes risk.[98-99]

The ADA has recommended that saturated fats account for less than 7% of total calorie intake.[100] The ADA also recommends that individuals limit trans-fat consumption to reduce LDL-C and increase HDL-C levels.[100] Omega-3 and omega-6 fatty acids are essential polyunsaturated fats. Amongst South Asians, there has been a marked increase in consumption of omega-6 fatty acids relative to omega-3 fatty acids.[101] Omega-3 fatty acids have been shown to reduce inflammation, atherosclerosis and reduce the overall risk for cardiovascular disease.[102-103] In contrast, higher omega-6 fatty acids are associated with atherosclerosis in addition to increased risk of obesity and diabetes.[102-103] Two studies in India have demonstrated an increase in consumption of omega-6 fatty acids relative to omega-3 fatty acids, which may be a contributing factor to the increased risk for obesity, diabetes and cardiovascular disease experienced by South Asians.[101, 104]

1.7 Micronutrient function and intake in South Asians

Micronutrients; vitamins and minerals, are required by the body in smaller amounts than macronutrients, and are necessary for several enzyme, hormone and metabolic processes.[81] In general, micronutrients are positively associated with glycemic control and if consumed in adequate amounts, can reduce diabetes risk.[81] Unfortunately, micronutrient deficiencies are common amongst South Asians, which can negatively affect glucose metabolism, glycemic control and blood pressure possibly contributing to the onset of diabetes and its complications.[105-106] In particular, inadequate intake of vitamin D and iron has led to deficiencies across several South Asian countries.[105-106]

1.7.1 Vitamin D

Vitamin D is a fat-soluble vitamin that contributes to the structural integrity of bones and teeth; regulates the immune system, cell growth and inflammation; and participates in neuromuscular function.[107] The relationship between vitamin D and diabetes has been widely investigated as many people living with chronic diseases worldwide are vitamin D deficient.[108] Vitamin D deficiency has been linked with insulin resistance, while increased consumption of vitamin D can improve insulin sensitivity, beta cell function and glucose tolerance.[107, 109-110] Inadequate vitamin D intake is particularly pronounced amongst South Asian immigrants. For example, in a study with 210 South Asians in the United Kingdom, more than 80.0% of participants had vitamin D deficiency and inadequate vitamin D levels were particularly pronounced amongst those living with diabetes.[111-112] The main source of vitamin D for most people is through exposure to ultraviolet B (UVB) which provides energy for vitamin D synthesis.[113] As such, vitamin D levels tend to be lower amongst those living in northern latitudes where exposure to UVB is limited.

1.7.2 Iron

Iron is an essential micronutrient in the body, required for hemoglobin and myoglobin production, oxygen transport, DNA production and metabolic processes.[114] Previous literature reviews have shown that despite consuming similar amounts of iron to their non-vegetarian counterparts, vegetarians store less iron, and often have lower amounts of bioavailable iron in the blood.[115-116] This may be due to the fact that plant-based foods have higher amounts of less absorbable non-heme iron, while meat, poultry and fish have higher amounts of absorbable heme iron.[115-116] As such, iron deficiency is particularly common in South Asian vegetarians, especially amongst females.[117] It has been recommended that vegetarians consume up to 1.8 times more dietary iron than non-vegetarians to maintain sufficient levels of iron in the body.[116] It has also been suggested that vitamin C (e.g. orange juice) be consumed with iron-based foods to aid with non-heme iron absorption.[115-116]

1.7.3 Vitamin B-12

In addition to inadequate iron intake, deficiency in Vitamin B-12 is common amongst South Asians and is highly prevalent amongst vegetarians.[118-119] A retrospective chart review of 988 South Asian Canadians found that 46.0% of individuals were deficient in vitamin B-12, and that deficiency in vitamin B-12 was more common amongst vegetarians.[119] Vitamin B-12, also known as cobalamin, is required to make red blood cells and for maintaining normal nerve function.[120-121] This micronutrient is most commonly found in animal-based foods such as organ meat, red meat, poultry, fish and dairy products. Sub-optimal intake can lead to anemia as well as nerve damage if deficiency is long-term.[120-121] Vitamin B-12 supplements are often needed for vegans as well as lacto-vegetarians and lacto-ovo-vegetarians.[120]

1.7.4 Sodium and potassium

Sodium and potassium requirements are generally met and potentially exceeded by both vegetarians and non-vegetarians. Sodium and potassium are minerals and electrolytes that help the body regulate fluid balance, blood volume and subsequently BP. Sodium and potassium also participate in nerve signaling and musculoskeletal functions.[122] Despite these important functions, sodium is a primary component of salt and has been widely recognized as a leading cause of hypertension, a major cardiometabolic risk factor and contributor to the development of cardiovascular disease and diabetes induced microvascular complications such as retinopathy and nephropathy.[12-15, 123-125] Augmenting the increased consumption of processed and refined foods on a global scale, the intake of sodium-rich foods has markedly increased amongst South Asians in recent years, in parallel to the rise in rates of obesity and diabetes.[53-56] As a result, sodium restriction has often been recommended for individuals high risk or living with diabetes.[123-125] Similar to sodium, a recent systematic review and past literature review have demonstrated that vegetarian diets are typically rich in potassium, helping to reduce and maintain blood pressure through regulation of fluid and water balance.[63, 122] However, amongst South Asians, potassium intake tends to decrease with increasing length of residence in country of migration.[88] For example, Talegawkar and colleagues conducted a dietary intake study with 874 American immigrants of South Asian descent, and found that potassium intake was inversely associated with length of residence in the United States.[57] Moreover, South Asian immigrants appear to consume less potassium-dense diets relative to their Western counterparts.[126]

1.8 Study overview

Dietary intake is influenced by a number of factors including neighbourhood environments, geography, SES, demographics, culture and religion.[127-130] Studies have shown that nutrition and lifestyle interventions are more likely to be successful when tailored to a given population.[131] The South Asian community is heterogenous with several distinct cultures, religions and dialects. In Canada, each province and territory has a unique South Asian demographic.[30-31] In BC, the South Asian population is primarily Sikh, with the majority of individuals having emigrated from the state of Punjab, India.[31] Comparatively, the remainder of the South Asian population in Canada is primarily divided amongst Sikhs, Hindus and Muslims, with a majority of South Asians originating from Bangladesh, Nepal, India, Pakistan and Sri Lanka.[30] As such, characterizing the dietary intake of South Asians while considering their geography, demographic data and culture is an important step towards developing effective strategies to improve dietary habits in this ethnic group. Moreover, investigating dietary intake and exploring if diet may be associated with adverse health outcomes such as overweight and obesity is important to informing dietary guidelines and reducing cardiometabolic risk in South Asian Canadians.

Few studies have investigated dietary intake in South Asian Canadians and based on existing data, there have been no studies investigating vegetarian diets and adiposity measures (e.g. BMI and WC) amongst South Asians living in BC. This study takes a two-pronged approach. A systematic review was first completed to examine the existing evidence on vegetarian diets and cardiometabolic risk factors in South Asian populations. Secondly, a local evaluation of South Asians living in BC was conducted. Using a South Asian culturally tailored dietary assessment tool, macronutrient, micronutrient and food group intake was evaluated in-depth amongst vegetarians and omnivores, and associations between diet (i.e. vegetarian and omnivore) and adiposity measures were examined. Moreover, associations between sociodemographic characteristics and adiposity measures were explored to assess potential covariates for adiposity amongst South Asians living in BC. The findings from this study may help to inform future lifestyle interventions and education programs to support overall health including reducing the risk of diabetes and cardiovascular disease in South Asians living in BC.

1.9 Objectives and hypotheses

1.9.1 Objective 1

To explore the associations between vegetarianism and cardiometabolic risk factors (e.g. BMI, WC, SBP, DBP, LDL-C, HDL-C, TG, TC and FBG) in South Asian populations.

1.9.1.1 Hypothesis 1

In South Asian populations, following a vegetarian diet will not be associated with improved cardiometabolic measures compared to a non-vegetarian diet irrespective of geographic location (e.g. inside or outside the South Asian sub-continent).

1.9.2 Objective 2

To examine the dietary intake (e.g. total calorie intake, macronutrients, micronutrients, and food groups) of South Asian vegetarians and omnivores living in Metro Vancouver, BC.

1.9.2.1 Hypothesis 2

There will be no difference in total caloric intake and intake frequency of refined carbohydrates, fats and sodium between South Asian vegetarians and omnivores.

1.9.3 Objective 3

To evaluate the relationship between vegetarian diets and adiposity measures and explore the associations between sociodemographic characteristics and adiposity in South Asians living in Metro Vancouver, BC.

1.9.3.1 Hypothesis 3

A vegetarian diet will not be associated with improved adiposity measures amongst South Asians living in Metro Vancouver, BC.

1.10 Rationale for objectives and hypotheses

Although several studies in Western populations have found a vegetarian diet to be associated with cardiometabolic benefits, these results are not fully applicable to the South Asian community.[74-77] Previous studies investigating vegetarianism and cardiometabolic risk factors in South Asian populations have found no differences in cardiometabolic measures between vegetarians and omnivores.[132-134] In fact, these studies have reported anthropometric indices considered above target range according to South Asian criteria.[42, 132-134] Even amongst studies that have reported improved cardiometabolic measures amongst South Asian vegetarians compared to omnivores, elevated adiposity markers are prevalent amongst both diet groups.[135-137] These findings that South Asian vegetarians have elevated adiposity profiles is inconsistent with several studies in non-South Asian populations that report vegetarians have lower adiposity and reduced body fat compared to omnivores.[138-141] Although it is likely that a vegetarian diet is not associated with adiposity in the South Asian community, it is important to investigate the role diet has in contributing to poor adiposity measures in this ethnic group, as diet is a critical and important component of the South Asian culture.

Despite many South Asians practicing vegetarianism for religious and/or traditional reasons, dietary intake is not uniform across or even within countries.[78] Furthermore, the processes of Westernization and dietary acculturation may be negatively affecting individual dietary choices amongst both South Asian vegetarians and omnivores, as previous studies have noted increased consumption of processed and refined foods as well as sugar-sweetened beverages amongst South Asian populations.[52-58] It is also possible that the influence of sociological factors (e.g. neighbourhood environments, demographics, SES) may exacerbate unhealthy dietary choices.[127-130] Although a vegetarian diet in the South Asian community may be limited to the restriction of animal products rather than serving as a healthier lifestyle alternative, it is important to investigate dietary intake and dietary composition amongst both South Asian vegetarians and omnivores to identify areas for dietary intervention.

Chapter 2: Systematic Review

2.1 Objective 1: Exploring the associations between vegetarianism and cardiometabolic risk factors in South Asian populations

The purpose of this systematic review is to examine the relationship between vegetarianism and cardiometabolic risk factors including BMI, WC, SBP, DBP, LDL-C, HDL-C, TG, TC and FBG for diabetes in South Asians in North America and globally. The methodology used to assess diets, reporting of cardiometabolic measures, and geographic variability (e.g. South Asian and non-South Asian countries) were considered to help inform interpretation of study results.

2.2 Methods

The organization and reporting of this review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[142] The protocol for this review was registered with the International Prospective Register of Systematic Reviews (PROSPERO), registration number CRD42018097394.

2.2.1 Eligibility

Observational studies that compared vegetarian diets (including vegetarian diet sub-groups: vegan, lacto-vegetarian, lacto-ovo-vegetarian, pesco-vegetarian, and semi-vegetarian diets) with non-vegetarian diets and assessed cardiometabolic measures in South Asian adults (≥ 21 years of age) were eligible for inclusion in this review. Due to the limited amount of studies exploring vegetarianism and cardiometabolic risk factors for diabetes in South Asians, multiple designs of observational studies (e.g. cross-sectional, cohort, case-control) were considered for inclusion. Studies needed to report at least one cardiometabolic measure such as BMI, WC, SBP, DBP, LDL-C, HDL-C, TG, TC or FBG to be included in this review. Additional inclusion criteria were use of interview administered or self-reported dietary intake (e.g. FFQ, 24-hour recall, dietary record, dietary history), and peer-reviewed, English-language articles published between January 2000 and December 2019. Studies that did not provide a definition for vegetarian diets or identify differences in dietary intake between vegetarian and non-vegetarian diets were excluded. There were no restrictions on geographic location.

2.2.2 Information sources

Five databases were searched to identify observational studies that met the eligibility criteria: Medline (Ovid), EMBASE (Ovid), Web of Science, CAB Direct and the Cumulative Index to Nursing and Allied Health Literature (CINAHL).

2.2.3 Search strategy

The Populations/People/Patient/Problem, Intervention, Comparison Group and Outcome (PICO) method was followed to develop a comprehensive search strategy.[143] Using this method, the population of interest was South Asian adults ($\geq$ 21 years of age); the intervention was studies that assessed vegetarian diets; the comparison group, where applicable, included studies that also assessed non-vegetarian diets relative to vegetarian diets; and the outcomes included cardiometabolic risk factors (e.g. BMI, WC, SBP, DBP, LDL-C, HDL-C, TG, TC and FBG) for diabetes. The search strategy was limited to published research since the year 2000. A university librarian with expertise in human nutrition provided guidance on Medical Subject Headings (MeSH) and free text words to use and combine in the searches. A search strategy for Medline (Ovid) was first developed and subsequently tailored to search each database thereafter. The search strategy for Medline (Ovid) is outlined in Figure 2.1.

Figure 2.1 Medline (OVID) Search Strategy.

1. ("South Asia*" or India* or Punjab* or Hindu or Sikh* or Pakistan* or Sri Lanka* or Bangladesh* or Nepal* or Maldives* or Bhutan* or Afghanistan* or Afghani*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
2. asia, western/ or bangladesh/ or bhutan/ or india/ or nepal/ or pakistan/ or sri lanka/
3. exp Asian Americans/
4. exp Indian Ocean Islands/
5. exp "Emigrants and Immigrants"/
6. 1 or 2 or 3 or 4 or 5
7. diabetes mellitus, type 2/ or diabetes mellitus, lipoatrophic/
8. diabetes.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
9. cardiovascular diseases/ or cardiovascular abnormalities/ or heart diseases/ or vascular diseases/
10. cardiovascular diseases.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
11. 7 or 8 or 9 or 10
12. 6 and 11
13. (vegetarian* or "vegetarianism" or "vegetarian diet" or "plant-based diet*" or "meatless diet*" or "vegan*" or "lacto-vegetarian*" or "lactovegetarian*" or "lacto-ovo-vegetarian*" or "lactoovovegetarian*" or "ovo-vegetarian*" or "ovovegetarian*" or "pesco-vegetarian*" or "pescovegetarian*" or "semi-vegetarian*" or "semivegetarian*").mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
14. vegetarians/ or vegans/
15. diet, vegetarian/ or diet, vegan/
16. 13 or 14 or 15
17. 6 and 16
18. 6 and 11 and 16
19. limit 18 to yr="2000–Current"

2.2.4 Study selection

The search strategy identified 566 articles across the five included databases and one article through a manual search. Grey literature (e.g. conference abstracts, proceedings and presentations) was also searched for studies not published in academic journals. All citations were exported into RefWorks Legacy and duplicates were removed resulting in 357 unique articles. At Level 1 screening, two authors (RJ, FK) independently reviewed the titles and abstracts of all unique articles. At Level 2 screening, RJ and FK independently reviewed the full text of articles identified at Level 1. Any discordance during the screening process was resolved by consensus or consultation with a third author (TT), who made the final decision. In instances where there were multiple publications from the same study or data sample, only one article that best met the eligibility criteria was included. A forward (Google Scholar) and backward (article bibliography) citation search was also conducted to identify any additional studies that may have been missed using the search strategy developed and tailored in this review.

2.2.5 Data extraction process and data items

A standardized data extraction form was developed using the Cochrane Data Extraction and Assessment template.[144] Two authors (RJ, FK) independently extracted the following data items from each included article: study author; year of publication; primary study objectives, study setting and design; recruitment methods; sample size; population characteristics; dietary assessment methodology; definitions of vegetarian diets; food intake differences between vegetarians and non-vegetarians; cardiometabolic measures assessed; diabetes prevalence in study sample; and main study findings. The authors of one study were contacted but did not provide further clarification regarding the dietary assessment administered.[132]

2.2.6 Summary measures and synthesis of results

The reporting of cardiometabolic measures was stratified based on geography and included adiposity (BMI and WC); SBP and DBP; lipid profile (LDL-C, HDL-C, TG and TC) and FBG. Adiposity, lipid profile and FBG measures were reported using the International System of Units (SI), and blood pressure using conventional units (mmHg). Included studies heterogeneously reported cardiometabolic measures using mean (± standard deviation), parameter estimate (95% Confidence Interval) or beta coefficient (95% Confidence Interval). Where applicable, cardiometabolic measures adjusted for variables such as age, sex, sociodemographic characteristics, study site, and smoking were reported. Due to heterogeneity in the methods used to measure cardiometabolic measures and reporting inconsistencies between studies, a narrative synthesis was conducted instead of a meta-analysis to identify and compare cardiometabolic measures between vegetarians and non-vegetarians of South Asian origin.

2.2.7 Diagnostic criteria for cardiometabolic measures

Cardiometabolic measures were defined and classified based on South Asian specific guidelines for adiposity, blood pressure, lipid profile and blood glucose levels outlined in ICS-DOAMS,[42] which has incorporated and modified guidelines provided by the IDF-CWDMS.[145] The following definitions from ICS-DOAMS were used to classify cardiometabolic measures in this review: BMI cut-points were defined as normal if between 18.0–22.9 kg/m^2, overweight if between 23.0–24.9 kg/m^2, and obese if >25.0 kg/m^2. Abdominal obesity was defined as WC measurements of ≥90 cm in males and ≥80 cm in females. Hypertension was defined as SBP ≥130 mmHg or DBP ≥85 mmHg. For lipid and cholesterol abnormalities, LDL-C was considered elevated if ≥3.4 mmol/L, low HDL-C if <1.0 mmol/L in males and if <1.3 mmol/L in females, elevated TGs if ≥1.7 mmol/L, and elevated TC if ≥5.2 mmol/L. Lastly, impaired FBG was defined as blood glucose ≥5.6 mmol/L, whereas diabetes was defined as FBG ≥7.0 mmol/L or by self-report.[42, 145]

2.2.8 Quality assessment and risk of bias

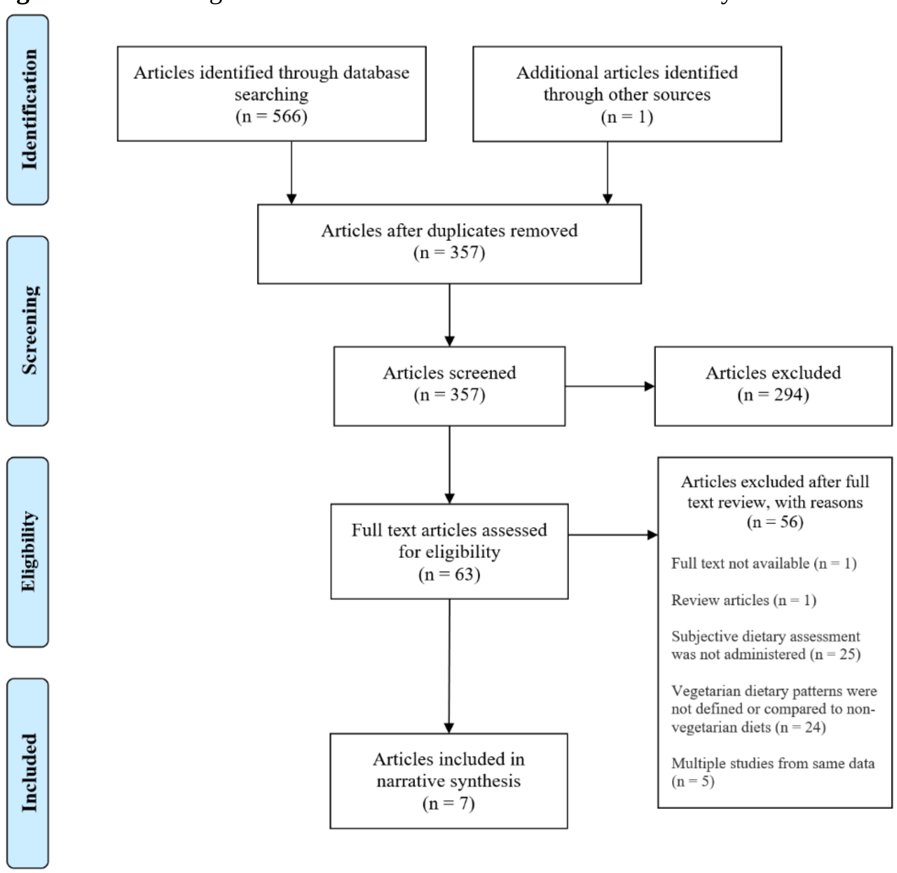
The methodological quality of included studies was assessed using the Newcastle Ottawa Quality Assessment Scale (NOS).[146] Using a star scoring system, the NOS can be used to evaluate the quality of studies based on three domains related to study participants: selection, comparability and outcomes. As the NOS has traditionally been used to assess the risk of bias for case-control and cohort studies, an adapted version of the NOS was developed to evaluate cross-sectional studies. A key strength of the NOS scale is that it can be adapted across systematic reviews and meta-analyses for different topics.[147] Items on the NOS (Appendix A) were modified to reflect the objectives of this review and to evaluate the quality of studies with regard to the collection of dietary information, comparison of diets (vegetarian and non-vegetarian) and the assessment of cardiometabolic measures. Two authors independently assessed the risk of bias for included studies. A study could receive a maximum of 12 stars based on the adapted NOS scale and was rated using the following categories: “good”, “fair” or “poor” quality. A good quality study received five or six stars in the selection domain, one or two stars in the comparability domain and three or four stars in the outcomes domain. A fair quality study received three or four stars in the selection domain, one or two stars in the comparability domain and three or four stars in the outcomes domain. A poor quality study received two or less stars in the selection domain, zero stars in the comparability domain or a maximum of one star in the outcomes domain. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were also used to determine the reporting quality of included articles.[148] This tool provides a checklist of 22-items that should be included in the title, abstract, introduction, methods, results and discussion sections of observational research articles. The reporting quality of studies is outlined in Appendix B.

2.3 Results

2.3.1 Selected studies

The search strategy identified 567 articles. No relevant studies from grey literature were found. After removal of 210 duplicates, the titles and abstracts of the remaining were screened, and 63 full text articles were retrieved to assess for eligibility and inclusion. Reasons for exclusion are outlined in Figure 2.2. Following a manual search, one additional article that met the inclusion criteria was identified. In total, seven unique studies were included in this review.

Figure 2.2 Flow diagram of studies considered for inclusion in the systematic review.



2.3.2 Study characteristics

Study characteristics are outlined in Table 2.1. Of the seven studies, four were conducted in South Asia (India and Pakistan); and three were conducted outside South Asia (United States and the United Kingdom). All seven studies used a cross-sectional study design. Studies collected dietary information using a variety of methods, such as FFQ (food and beverage consumption collected using frequency and portion size), semi-quantitative FFQ (food and beverage consumption collected using frequency and predetermined portion size), food propensity questionnaire (FFQ that does not collect information on portion size), 24-hour recall and interview administered questionnaire. Detailed methodology and characteristics of each dietary assessment administered is further elaborated in the Discussion section. one study administered a 24-hour dietary recall to a sub-sample of study participants to validate information collected in the semi-quantitative FFQ. Two studies defined vegetarian diet sub-groups (e.g. vegan, lacto-vegetarian, lacto-ovo-vegetarian, pesco-vegetarian and semi-vegetarian) and all studies compared dietary intake between vegetarians and non-vegetarians. Moreover, all studies differed in which outcomes (e.g. BMI, WC, SBP, DBP, LDL-C, HDL-C, TG, TC and FBG) they compared between vegetarians and non-vegetarians. Two studies compared vegetarian and non-vegetarian diets in South Asians to individuals of other ethnic backgrounds.

Table 2.1 Characteristics of studies included in the systematic review.

Study Author	Study Country	Source of Data	Sample Size (N)	Age (Yrs.)	Prevalence of Diabetes	Study Quality[a]
Agrawal et al. (2014)	India	National Family Health Survey (NFHS–3), India (2005–2006)	156,316 (56,742 males, 99,574 females)	(Range: 20–49 yrs.) 20–29: 66,038 30–39: 52,567 40–49: 37,711	1,769 (1.1% of sample)[b]	Fair
Gadgil et al. (2014)	United States	Metabolic Syndrome and Atherosclerosis in South Asians Living in America (MASALA) Pilot Cohort (2006–2007)	150 (53 males, 97 females)	Pooled Mean (SD): 57.2 (8.0)	43 (28.7% of sample)	Fair
Jaacks et al. (2016)	India and Pakistan	Centre for Cardiometabolic Risk Reduction in South-Asia (CARRS) Cohort (2010–2011)	15,665 (7,372 males, 8,293 females)	(Range: 20–69 yrs.) 20–29: 2,902 30-39: 4,384 40–49: 4,338 50–59: 2,580 60–69: 1,461	4,057 (24.9% of sample)[c]	Good
Jin et al. (2018)	United States	Mediators of Atherosclerosis in South Asians Living in America (MASALA) Cohort (2010–2013)	892 (473 males, 419 females)	Mean (SD): 55.3 (9.4)	143 (16.0% of sample)	Good

Study Author	Study Country	Source of Data	Sample Size (N)	Age (Yrs.)	Prevalence of Diabetes	Study Quality[a]
Praharaj et al. (2017)	India	Original Study	259 (152 males, 107 females)	Mean: ~ 50.0	Participants with diabetes were excluded from study analyses.	Poor
Shridhar et al. (2014)	India	The Indian Migration Study (2005–2007)	6,555 (3,814 males, 2,741 females)	Pooled Mean (SD): 40.9 (10.3)	658 (10.0% of sample)	Good
Tong et al. (2018)	United Kingdom	UK Biobank Cohort (2006–2010)	4,508 (2,325 males, 2,183 females)	Pooled Mean (SD): 53.6 (8.3)	Not reported.	Fair

a) Study quality was evaluated using an adapted version of the New Castle Ottawa scale. Good quality: five or six stars in selection, one or two stars in comparability and three or four stars in outcomes. Fair quality: three or four stars in selection, one or two stars in comparability and three or four stars in outcomes. Poor quality: two or less stars in selection, zero stars in comparability or a maximum of one star in outcomes.
b) Researchers could not differentiate between Type 1 and Type 2 diabetes cases due to survey instrument.
c) CARRS sample included 16,288 participants, ≥ 20 years of age. Jaacks et al. included 15,665 participants from the CARRS cohort within age range 20-69 years in their analyses.

2.3.3 Study quality

Overall, the studies included in this review were moderate in quality. One study was classified as ‘poor’, three studies as ‘fair’ and three studies as ‘good’. Studies primarily lost points if they did not control for important variables that may influence diet intake such as SES or if characteristic comparisons (e.g. age, sex, income, education) between study participants and individuals that declined to participate in the study were not established. Five studies administered a validated dietary assessment and all studies objectively measured cardiometabolic measures (e.g. BMI, WC, SBP, DBP, LDL-C, HDL-C, TG, TC and FBG). The quality assessment of studies included in this systematic review is outlined in Appendix C.

2.3.4 Participant characteristics

There were 184,345 South Asian participants (sample size range 150 to 156,316) enrolled across the seven studies, of which 62% were women. Amongst five studies, the mean (SD) age of participants ranged from 40.9 (±10.3) to 57.2 (±8.0) years.[133, 149] Agrawal et al., and Jaacks et al., reported age ranges for their study samples of 20–49 years and 20–69 years, respectively.[136, 149] The prevalence of diabetes varied across study samples, from 1.1% to 28.7%.[133, 149] Across all studies, 36% of participants identified as vegetarian, including vegan, lacto-vegetarian, lacto-ovo-vegetarian, pesco-vegetarian and semi-vegetarian. Information on participant sociodemographic characteristics could not be summarized collectively due to heterogeneous and unstandardized methods of reporting education, income and employment status. This limited the ability to identify overall sociodemographic trends and their associations with vegetarian or non-vegetarian diets and reported cardiometabolic risk factors.

2.3.5 Food intake differences between vegetarians and non-vegetarians

Each study included in this review provided unique definitions of vegetarian and non-vegetarian diets. Diets assessed in the identified studies are in Table 2.2. Four studies provided detailed dietary intake information consumed by vegetarians and non-vegetarians. Amongst studies conducted in South Asia, vegetarians more frequently consumed vegetables, fruits, dairy, legumes and grains relative to non-vegetarians.[132, 136] Jaacks et al., also found that vegetarians were more likely to consume desserts, fried foods and fruit juices compared to non-vegetarians.[136] In contrast, non-vegetarians in South Asia were more likely to consume refined cereals, coffee, eggs, meat, poultry and seafood compared to vegetarians.[132, 136] Amongst studies conducted outside South Asia, vegetarians were more likely to consume beans, legumes, nuts, whole grains, rice, and snacks compared to non-vegetarians,[133, 137] however, Gadgil and colleagues also found that a vegetarian diet was associated with higher consumption of sugar-sweetened beverages.[133] Meanwhile, non-vegetarians consumed more alcohol, coffee, eggs, fried snacks, desserts, potatoes, meat, poultry and seafood relative to vegetarians.[133, 137]

Table 2.2 Dietary assessment methodology; definitions of vegetarian and non-vegetarian diets.

	Dietary Assessment	Exposure Diet	Definition of Exposure Diet	Comparator Diet	Definition of Comparator Diet
Agrawal et al. (2014)	NFHS–3 (FFQ queried data on consumption of select food items)[a]	Vegan (n = 2,560) Lacto-vegetarian (n = 37,797) Lacto-ovo vegetarian (n = 5,002) Pesco-vegetarian (n = 3,446) Semi-vegetarian (n = 8,140)	Vegans: No consumption of animal products (i.e. poultry, meat, fish, eggs, milk, curd). Lacto-vegetarian: Consume fruits, vegetables, pulses, beans, milk and curd, either daily, weekly or occasionally; but no fish, eggs, poultry or meat. Lacto-ovo vegetarian: Consume fruits, vegetables, pulses, beans, milk, curd and eggs, either daily, weekly or occasionally; but no fish, poultry or meat. Pesco-vegetarian: Consume fruits, vegetables, pulses, beans, milk, curd, eggs and fish, either daily, weekly or occasionally; but no poultry or meat. Semi-vegetarian: Consume fruits, vegetables, pulses, beans and animal products (i.e. poultry, meat, eggs, milk, curd), either daily, weekly or occasionally; but no fish.	Non-vegetarian (n = 99,372)	Consume fruits, vegetables, pulses, beans and animal products (i.e. poultry, meat, fish, eggs, milk, curd), either daily, weekly or occasionally.
Gadgil et al. (2014)	Study of Health Assessment and Risk in Ethnic groups (SHARE) South Asian FFQ	Vegetarian (n = 91)	Consume legumes, nuts, rice and sugar-sweetened beverages, but not fish, eggs, poultry or meat.	Western (n = 59)	Consume eggs, fish, high-fat dairy, poultry, and red meat.

	Dietary Assessment	Exposure Diet	Definition of Exposure Diet	Comparator Diet	Definition of Comparator Diet
Jaacks et al. (2016)	Food Propensity Questionnaire (Adapted from the INTERHEART Study)[136]	Vegan (n = 449) Lacto-vegetarian (n = 1,802) Lacto-ovo vegetarian (n = 507) Pesco-vegetarian (n = 193) Semi-vegetarian (n = 2,017)	Vegans: Consume meat, poultry, fish, eggs and dairy never or less than one time per month. Lacto-vegetarian: Consume meat, poultry, fish and eggs never or less than one time per month. Lacto-ovo vegetarian: Consume meat, poultry and fish never or less than one time per month. Pesco-vegetarian: Consume meat and poultry never or less than one time per month. Semi-vegetarian: Consume meat, poultry and fish one time per month but less than one time per week.	Non-vegetarian (n = 10,697)	No restrictions on the consumption of animal products (i.e. meat, poultry, fish, eggs and dairy).
Jin et al. (2018)	Study of Health Assessment and Risk in Ethnic (SHARE) groups South Asian FFFQ	Vegetarian (n = 335)	Consume eggs and dairy products but no meat, poultry or fish in the year prior to data collection.	Non-vegetarian (n = 557)	Consume poultry, meat and fish.
Praharaj et al. (2017)	Food consumption survey administered through personal interview.	Lacto-vegetarian (n = 119)	Consume dairy products but no eggs, beef, meat, pork, fish or poultry.	Non-vegetarian (n = 284)	Consume eggs, meat, seafood or poultry at least twice per week.
Shridhar et al. (2014)	Semi-Quantitative FFQ (All Participants) followed by 24-Hour Recall (Sub-Sample)	Lacto-vegetarian (2,148)	No consumption of eggs, meat, fish or poultry.	Non-vegetarian (n = 4,407)	No restrictions on the consumption of animal products (i.e. meat, poultry, fish, eggs and dairy).
Tong et al. (2018)	Food consumption survey (All Participants); Oxford WebQ 24-Hour Assessment Tool (Sub-Sample)	Vegetarian (n = 1,186)	Consume eggs and/or dairy products, but no meat or fish.	Meat eater (n = 3,322)	Consume red meat, processed meat or poultry.

a) National Family Health Survey 2005-2006 (NFHS-3) India Reports. Retrieved from http://hetv.org/india/nfhs

2.3.6 Cardiometabolic measures

2.3.6.1 BMI

All studies reported BMI (n = 184,345) (Table 2.3). Amongst studies conducted in South Asia, mean BMI of vegetarians ranged from 20.9 (± 4.4) kg/m^2 to 25.2 (± 0.43) kg/m^2 compared to non-vegetarians, where mean BMI ranged from 20.7 (± 4.1) kg/m^2 to 25.6 (± 0.28) kg/m^2.[136, 149] Amongst studies conducted outside South Asia, mean BMI of vegetarians ranged from 25.5 (± 0.2) kg/m^2 to 26.8 (± 0.3) kg/m^2 compared to non-vegetarians, where mean BMI ranged from 26.2 (± 0.2) kg/m^2 to 26.9 (± 0.3) kg/m^2.[134, 137] One study conducted within South Asian and one study conducted outside South Asia found that vegetarians had significantly lower mean BMI compared to their non-vegetarian counterparts (Jaacks et al., $p < 0.05$; Jin et al., $p = 0.023$), while one South Asian study reported vegetarians had significantly higher mean BMI compared to non-vegetarians (Praharaj et al., $p = 0.05$).[132, 136-137] Two studies conducted within South Asia and two studies conducted outside South Asia did not find significant differences in mean BMI between vegetarians and non-vegetarians (Agrawal et al., $p > 0.05$; Gadgil et al., $p = 0.30$; Shridhar et al., $p = 0.99$; Tong et al., $p > 0.05$).[133-135, 149]

2.3.6.2 WC

Three studies reported measures for WC (n = 5,659) (Table 2.3). Mean WC of vegetarians ranged from 85.2 (± 0.8) cm to 95.0 (± 1.0) cm compared to non-vegetarians, where mean WC ranged from 85.1 (± 0.6) cm to 94.8 (± 0.4) cm.[134, 137] One study conducted within South Asia reported a non-significant difference in mean WC between vegetarians (84.23 (± 13.18) cm) and non-vegetarians (83.68 (± 8.68) cm) (Praharaj et al., $p = 0.53$).[132] Two studies conducted outside South Asia reported inconsistent findings. Tong et al., reported a non-significant difference in mean WC between vegetarians and non-vegetarians ($p > 0.05$), whereas Jin et al., reported vegetarians had significantly lower mean WC compared to non-vegetarians ($p = 0.044$).[134, 137]

2.3.6.3 SBP

Three studies reported measures for SBP (n = 11,955) (Table 2.3). Mean SBP in vegetarians ranged from 125.0 (± 0.8) mmHg to 136.8 (± 1.6) mmHg compared to non-vegetarians, where mean SBP ranged from 125.0 (± 0.6) mmHg to 137.8 (± 0.7) mmHg.[134, 137] One study conducted within South Asia found a non-significant difference in SBP between vegetarians and non-vegetarians (Shridhar et al., $p = 0.07$).[135] Similarly, two studies conducted outside South Asia reported non-significant differences in mean SBP between vegetarians and non-vegetarians (Tong et al., $p > 0.05$; Jin et al., $p = 0.910$).[134, 137]

2.3.6.4 DBP

Four studies reported measures for DBP (n = 27,620) (Table 2.3). Mean DBP in vegetarians ranged from 73.0 (± 0.5) mmHg to 83.8 (± 1.0) mmHg compared to non-vegetarians, where mean DBP ranged from 73.6 (± 0.4) mmHg to 84.2 (± 0.5) mmHg.[134, 137] Of the two studies conducted within South Asia, both Shridhar et al., ($p = 0.02$) and Jaacks et al., ($p < 0.05$) reported that vegetarians had significantly lower DBP compared to non-vegetarians.[135-136] In contrast, two studies conducted outside South Asia reported non-significant differences in mean DBP between vegetarians and non-vegetarians (Jin et al., $p = 0.363$; Tong et al., $p > 0.05$).[134, 137]

2.3.6.5 LDL-C

Five studies reported measures for LDL-C (n = 23,521) (Table 2.3). Mean LDL-C ranged from 2.75 (± 0.04) mmol/L to 3.15 (± 0.80) mmol/L in vegetarians, and 2.85 (± 0.04) mmol/L to 3.16 (± 0.74) mmol/L in non-vegetarians.[132, 136] Amongst three studies conducted within South Asia, Jaacks et al., ($p < 0.05$) and Shridhar et al. ($p = 0.03$) reported that vegetarians had significantly lower LDL-C compared to non-vegetarians, while Praharaj et al., reported a non-significant difference in mean LDL-C between vegetarians and non-vegetarians ($p = 0.62$).[132, 135-136] Two studies conducted outside South Asia reported inconsistent findings. Compared to a western dietary pattern, Gadgil et al., did not find a significant association between a vegetarian dietary pattern and LDL-C ($p > 0.05$).[133] Meanwhile, Jin et al., reported that vegetarians had significantly lower mean LDL-C compared to non-vegetarians ($p = 0.004$).[137]

2.3.6.6 HDL-C

Four studies reported measures for HDL-C (n = 7,856) (Table 2.3). Mean HDL-C ranged from 1.10 (± 0.21) mmol/L to 1.30 (± 0.02) mmol/L in vegetarians, and 1.14 (± 0.27) mmol/L to

1.29 (± 0.01) mmol/L in non-vegetarians.[132, 137] Two studies conducted within South Asia did not find significant differences in HDL-C between vegetarians and non-vegetarians (Praharaj et al., $p = 0.31$; Shridhar et al., $p = 0.13$).[132, 135] Similarly, two studies conducted outside South Asia reported non-significant differences in HDL-C between vegetarians and non-vegetarians (Gadgil et al., $p > 0.05$; Jin et al., $p = 0.399$).[133, 137]

2.3.6.7 TGs

Five studies reported measures for TG (n = 23,521) (Table 2.3). Five studies reported measures for TG (n = 23,521) (Table 3). Mean TG values ranged from 1.48 (± 0.05) mmol/L to 1.81 (± 1.07) mmol/L in vegetarians, and 1.48 (± 0.04) to 1.68 (± 0.05) mmol/L in non-vegetarians.[132, 136-137] Amongst three studies conducted within South Asia, Jaacks et al., ($p < 0.05$) and Shridhar et al., ($p = 0.02$) found that vegetarians had significantly lower TG compared to non-vegetarians.[135-136] Praharaj et al., reported a non-significant difference in mean TG between vegetarians and non-vegetarians ($p = 0.12$).[132] Two studies conducted outside South Asia did not find significant differences in TG between vegetarians and non-vegetarians (Gadgil et al., $p > 0.05$; Jin et al., $p = 0.601$).[133, 137]

2.3.6.8 TC

Four studies reported measures for TC (n = 7,856) (Table 2.3). Mean TC values ranged from 4.77 (± 0.05) mmol/L to 4.78 (± 1.07) mmol/L in vegetarians, and 4.75 (± 1.03) mmol/L to 4.92 (± 0.04) mmol/L in non-vegetarians.[132, 137] Two studies conducted within South Asia reported inconsistent findings. Shridhar et al., found that vegetarians had significantly lower TC compared to non-vegetarians ($p = 0.006$), whereas Praharaj et al., reported a non-significant difference in mean TC between vegetarians and non-vegetarians ($p = 0.37$).[132, 135] Two studies conducted outside South Asia also reported inconsistent findings. Compared to a western dietary pattern, Gadgil et al., did not find a significant association between a vegetarian dietary pattern and TC ($p > 0.05$).[133] Meanwhile, Jin et al., reported that vegetarians had significantly lower mean TC compared to non-vegetarians ($p = 0.027$).[137]

2.3.6.9 FBG

Four studies reported measures for FBG (n = 7,856) (Table 2.3). Mean FBG values ranged from 4.59 (± 0.57) mmol/L to 5.49 (± 0.07) mmol/L in vegetarians, and 4.54 (± 0.48) mmol/L to 5.72 (± 0.06) mmol/L in non-vegetarians.[132, 137] Two studies in South Asia did not find significant differences in FBG between vegetarians and non-vegetarians (Praharaj et al., $p = 0.34$; Shridhar et al., $p = 0.09$).[132, 135] Two studies outside South Asia reported inconsistent findings. Compared to a western dietary pattern, Gadgil et al., did not find a significant association between a vegetarian dietary pattern and FBG ($p > 0.05$).[133] Meanwhile, Jin et al., reported that vegetarians had lower FBG compared to non-vegetarians ($p = 0.015$).[137]

Table 2.3 Reported cardiometabolic outcomes between vegetarians and non-vegetarians by geographic region.

		BMI (kg/m^2) (n = 7)	WC (cm) (n = 3)	SBP (mmHg) (n = 3)	DBP (mmHg) (n = 4)	LDL-C (mmol/L) (n = 5)	HDL-C (mmol/L) (n = 4)	TGs (mmol/L) (n = 5)	TC (mmol/L) (n = 4)	FBG (mmol/L) (n = 4)
Studies conducted in South Asia	**Agrawal et al. (2014)**	Vegetarian: 20.9 (± 4.4)[a] Non-Vegetarian: 20.7 (± 4.1) ***$p > 0.05$***								
	Jaacks et al. (2016)[b]	Vegetarian: 25.22 (± 0.43) Non-Vegetarian: 25.62 (± 0.28) ***$p < 0.05$***			Vegetarian: 80.66 (± 0.68) Non-vegetarian: 81.75 (± 0.57) ***$p < 0.05$***	Vegetarian: 2.75 (± 0.04) Non-vegetarian: 2.85 (± 0.04) ***$p < 0.05$***		Vegetarian: 1.57 (± 0.06) Non-vegetarian: 1.68 (± 0.05) ***$p < 0.05$***		
	Praharaj et al. (2017)	Lacto-vegetarian: 24.47 (± 5.55) Non-vegetarian: 23.50 (± 3.06) ***$p = 0.05$***	Lacto-vegetarian: 84.23 (± 13.18) Non-vegetarian: 83.68 (± 8.68) ***$p = 0.53$***			Lacto-vegetarian: 3.15 (± 0.80) Non-vegetarian: 3.16 (± 0.74) ***$p = 0.62$***	Lacto-vegetarian: 1.10 (± 0.21) Non-vegetarian: 1.14 (± 0.27) ***$p = 0.31$***	Lacto-vegetarian: 1.81 (± 1.07) Non-vegetarian: 1.63 (± 0.99) ***$p = 0.12$***	Lacto-vegetarian: 4.78 (± 1.07) Non-vegetarian: 4.75 (± 1.03) ***$p = 0.37$***	Lacto-vegetarian: 4.59 (± 0.57) Non-vegetarian: 4.54 (± 0.48) ***$p = 0.34$***
	Shridhar et al. (2014)[c]	Lacto-vegetarian: 23.9 (± 4.4) Non-vegetarian: 23.9 (± 4.5) ***$p = 0.99$***		Lacto-vegetarian: −0.9 (−1.9, 0.08) ***$p = 0.07$***	Lacto-vegetarian: −0.7 (−1.2, −0.07) ***$p = 0.02$***	Lacto-vegetarian: −0.06 (−0.005, −0.1) ***$p = 0.03$***	Lacto-vegetarian: −0.01 (−0.03, 0.003) ***$p = 0.13$***	Lacto-vegetarian: −0.05 (−0.007, −0.01) ***$p = 0.02$***	Lacto-vegetarian: −0.1 (−0.03, −0.2) ***$p = 0.006$***	Lacto-vegetarian: −0.07 (−0.2, 0.01) ***$p = 0.09$***

		BMI (kg/m^2)	WC (cm)	SBP (mmHg)	DBP (mmHg)	LDL-C (mmol/L)	HDL-C (mmol/L)	TGs (mmol/L)	TC (mmol/L)	FBG (mmol/L)
Studies conducted outside South Asia	**Gadgil et al. (2014)**[d]	Vegetarian: 25.8 (± 4.3) Western: 26.6 (± 5.1)				Vegetarian: 0.082 (−0.263, 0.427)	Vegetarian: −0.125 (−0.275, 0.025)	Vegetarian: 0.075 (−0.247, 0.398)	Vegetarian: 0.015 (−0.369, 0.399)	Vegetarian: −0.504 (−1.062, 0.054)
		***p* = 0.30**				***p* > 0.05**	***p* > 0.05**	***p* > 0.05**	***p* > 0.05**	***p* > 0.05**
	Jin et al. (2018)	Vegetarian: 25.5 (± 0.2) Non-Vegetarian: 26.2 (± 0.2)	Vegetarian: 91.8 (± 0.6) Non-vegetarian: 93.2 (± 0.4)	Vegetarian: 125.0 (± 0.8) Non-vegetarian: 125.0 (± 0.6)	Vegetarian: 73.0 (± 0.5) Non-vegetarian: 73.6 (± 0.4)	Vegetarian: 2.80 (± 0.04) Non-vegetarian: 2.95 (± 0.03)	Vegetarian: 1.31 (± 0.02) Non-vegetarian: 1.29 (± 0.01)	Vegetarian: 1.48 (± 0.05) Non-vegetarian: 1.48 (± 0.04)	Vegetarian: 4.77 (± 0.05) Non-vegetarian: 4.92 (± 0.04)	Vegetarian: 5.49 (± 0.07) Non-vegetarian: 5.72 (± 0.06)
		***p* = 0.023**	***p* = 0.044**	***p* = 0.910**	***p* = 0.363**	***p* = 0.004**	***p* = 0.399**	***p* = 0.601**	***p* = 0.027**	***p* = 0.015**
	Tong et al. (2018)	Vegetarian: Males 26.5 (± 0.4) Meat eater: Males 26.7 (± 0.2) Vegetarian: Females 26.8 (± 0.3) Meat eater: Females 26.9 (± 0.3)	Vegetarian: Males 95.0 (± 1.0) Meat eater: Males 94.8 (± 0.4) Vegetarian: Females 85.2 (± 0.8) Meat eater: Females 85.1 (± 0.6)	Vegetarian: Males 136.8 (± 1.6) Meat eater: Males 137.8 (± 0.7) Vegetarian: Females 133.0 (± 1.3) Meat eater: Females 132.4 (± 1.0)	Vegetarian: Males 83.8 (± 1.0) Meat eater: Males 84.2 (± 0.5) Vegetarian: Females 81.2 (± 0.8) Meat eater: Females 81.5 (± 0.6)					
		***p* > 0.05**	***p* > 0.05**	***p* > 0.05**	***p* > 0.05**					

a) Pooled mean BMI and SD. A pooled mean was calculated for uniform inter-study comparison between vegetarians and non-vegetarians.
b) Jaacks et al., combined vegetarian diet sub-groups into a single 'vegetarian' group.
c) Shridhar et al. provided Beta Coefficients (95% Confidence Interval).
d) Gadgil et al. provided Parameter Estimates (95% Confidence Interval).
e) To convert mmol/L LDL-C, HDL-C or TC to mg/dL, multiply mmol/L by 38.6. To convert mg/dL cholesterol to mmol/L, multiply mg/dL by 0.0259.
f) To convert mmol/L TGs to mg/dL, multiply mmol/L by 88.5. To convert mg/dL TGs to mmol/L, multiply mg/dL by 0.0113.
g) To convert mmol/L glucose to mg/dL, multiply mmol/L by 18.02. To convert mg/dL glucose to mmol/L, multiply mg/dL by 0.0555.

2.4 Discussion

2.4.1 Summary of systematic review findings

This is the first systematic review of observational studies investigating vegetarianism and cardiometabolic risk factors for diabetes in South Asian adults. Seven studies were identified that utilized subjective assessments to compare dietary composition and objective measures to evaluate cardiometabolic risk factors between vegetarians and non-vegetarians. Not surprisingly, non-vegetarians inside and outside South Asia consumed more sources of protein from eggs, meat, poultry, and seafood compared to vegetarians. Although findings pertaining to cardiometabolic risk factors between these two dietary groups were largely inconsistent, the three studies deemed highest in quality found that adherence to a vegetarian diet was associated with lower BMI,[136-137] WC,[136] DBP,[135-136] LDL-C,[135-137] TGs,[135-136] TC,[135, 137] and FBG[137] compared with other diets.

2.4.2 Comparisons to other studies

This review of South Asian populations did not find a clear relationship between vegetarianism and cardiometabolic measures. A large body of evidence from other countries have found vegetarian diets are linked with lower adiposity, blood pressure, lipid profiles, and metabolic markers. In fact, according to a recent 2019 meta-analysis of nine randomized-controlled trials (RCTs) conducted in the United States, South America, Central and Southeast Europe, and East Asia, adherence to a vegetarian diet was associated with lower body weight, BMI, WC, LDL-C, FBG and HbA1c compared to a non-vegetarian diet.[74] Similarly, a meta-analysis of 11 RCTs in the United States, Northern and Central Europe, and Australia also reported that participants assigned to a vegetarian diet intervention had significantly lower LDL-C, HDL-C, and TC compared to an omnivorous diet.[76] Additionally, of 7 randomized-controlled trials and 32 observational studies examining vegetarianism and blood pressure in North America, Europe, East Asia, the Middle East, Australia, and South Asia (one study), Yokoyama and colleagues found that a vegetarian diet was associated with a significant reduction in both SBP and DBP relative to non-vegetarian diets.[75] Finally, a meta-analysis of 14 observational studies (three studies targeted South Asian populations) concluded that adoption of a vegetarian diet was associated with a reduced risk for developing diabetes with a tighter correlation for studies conducted in Western regions of the world.[73] Considering the findings in the present review compared to these four meta-analyses, it is important to explore what might contribute to discrepancies.

Notably, only three studies in this review found that vegetarian diets were associated with better cardiometabolic measures in South Asians. The research design of these studies were evaluated to be of higher quality compared to other studies included in this review. Relative to non-vegetarians, Jaacks et al., found that a vegetarian diet was associated with improved BMI, DBP, LDL-C and TG; Shridhar et al., found that a vegetarian diet was associated with improved DBP, LDL-C, TG and TC; and Jin et al., found that a vegetarian diet was associated with improved BMI, WC, LDL-C, TC and FBG.[135-137] Each of these studies implemented rigorous methodology including the use of large samples, administration of validated dietary assessment tools, and the objective measurement of cardiometabolic measures. Therefore, it is possible that the inconsistent and/or inconclusive evidence reported in the other studies in this review was due to limitations in methodological design, such as non-random sampling, small or statistically underpowered sample size, the administration of unvalidated dietary assessments, or the absence of statistical consideration for factors that may influence diet including SES.

2.4.3 Heterogeneity in dietary assessment methodology

Significant variability in dietary assessment methodology limited the ability to compare diet composition between vegetarians and non-vegetarians. In total, seven different dietary assessments were used to measure diet amongst the seven studies included in this review (two studies used the same SHARE FFQ, one study utilized both an FFQ and 24-hour recall). There are important and unique differences between dietary assessments.[150] FFQs, including the semi-quantitative FFQ and food propensity questionnaire, contain a pre-defined list of foods items and can measure food and beverage consumption over a long period of time (e.g. weeks or months). As such, FFQs can account for fluctuations in dietary intake and can report usual intake, an important consideration when assessing the potential associations between diet and cardiometabolic risk factors, which can develop over time. In contrast, 24-hour recalls capture food and beverage consumption over a 24-hour time period, including very detailed information about mealtimes, sources of food and portion sizes. However, due to their limited time period 24-hour recalls cannot report usual dietary intake unless administered at multiple time points, as demonstrated in the UK Biobank cohort.[134] Moreover, 24-hour recalls are more expensive that FFQs, which may limit their use in studies with large sample sizes. Both FFQs and 24-hour recalls rely on participant self-report and are therefore, subject to recall bias. However, FFQs are more prone to systematic error whereas 24-hour recalls are more likely to be affected by random error.[150] As conducted in the Indian Migration Study, an FFQ and 24-hour recall may both be administered to validate dietary information collected and reduce the inherent biases associated with each measurement tool.

Different dietary assessment tools include non-uniform lists of food items and varying numbers of food items collected. One inherent limitation of the FFQ is that the pre-defined food list may exclude culturally important foods. However, some studies included in this review used tools that were tailored to include food items specific to the target population being studied. For example, the SHARE FFQ and the CARRS food propensity questionnaire were frequency questionnaires tailored to South Asians but differed in the number and category of foods they assessed. The SHARE FFQ assessed food frequency and quantity over the previous 12-months using a list of 163-items, from which 61 items were unique to the South Asian community.[151] Similarly, the CARRS food propensity questionnaire was culturally tailored and assessed dietary intake over the previous 12-months, but only included 26 items and was semi-quantitative, assessing food frequency but not quantity.[136] Additionally, as part of a larger national health survey in India, the NFHS-3 questionnaire queried consumption frequency of seven items either daily, weekly or occasionally, including milk, curd, pulses, beans, dark green leafy vegetables, fruits, eggs, fish, chicken and meat, but did not include food items specific to South Asians.[149]

Definitions and classifications of diets can also be determined differently between studies based on the assessment tool administered. Diets (e.g. vegetarian and non-vegetarian), may be dependent on self-identification, the types of foods and individual consumes and reports, or could be classified based on statistical methods, which may be used to find correlations between foods or examine differences in mean intake between food items to identify dietary patterns. For instance, Gadgil et al., and Jin et al., administered the same SHARE FFQ to their respective participants, but differed in the methods they applied to classify vegetarians.[133, 137] Gadgil et al., used principal component analysis to identify people who followed a vegetarian or western dietary pattern.[133] Alternatively, Jin et al., classified vegetarians based on food intake data collected from the SHARE FFQ.[137]

Dietary information can also be reported differently based on the assessment tool administered. For example, the NFHS-3 Questionnaire only reported the eating occasions (daily, weekly, occasionally or never) of certain food groups such as fruits, vegetables and dairy.[149] Meanwhile, the SHARE FFQ collected information on 163-items. From this data, daily nutrient information such as total caloric intake, macronutrient and micronutrient consumption in addition to the eating occasions of food groups (including those assessed in the NFHS-3 questionnaire) were calculated and reported.[151] With the exception of 24-recalls which do not have a pre-defined list of food items, it is important to culturally tailor existing FFQs and other diet measures when investigating dietary intake of specific ethnic populations. Ethnic groups consume specific foods that may be overlooked if a dietary assessment is not adapted or culturally tailored, leading to potential dietary inaccuracies or misrepresentation. While two studies administered 24-hour recalls, only three studies in this review administered an FFQ that was customized for the foods specific to the South Asian population.[133, 136-137]

2.4.4 Elevated adiposity and blood pressure profile for both vegetarians and non-vegetarians

Studies conducted with American, European and East Asian populations have demonstrated that adherence to a vegetarian diet is associated with lower body weight, WC and lower abdominal obesity relative to a non-vegetarian diet.[74, 136, 138, 152-155] Previous studies have also demonstrated that adherence to a vegetarian diet can reduce the risk of hypertension by improving body weight and blood viscosity, thereby lowering mean SBP and DBP relative to a non-vegetarian diet. [74-75, 122, 156] Despite high levels of vegetarianism, South Asians experience obesity and high blood pressure at earlier ages and at higher rates compared to their Caucasian and East Asian counterparts.[35-41, 157]

Inconsistencies across studies notwithstanding, the adiposity and BP profiles for South Asian vegetarians and non-vegetarians across studies was elevated. Using the South Asian specific BMI cut points for overweight and obesity outlined in ICS-DOAMS,[42] six of the seven studies in this review reported mean BMI values for vegetarians in the overweight range (23.0-24.9 kg/m^2);[132, 135] or obese range (> 25.0 kg/m^2).[133-134, 136-137] Moreover, across all seven respective studies, mean BMI for non-vegetarians was classified in the same BMI range as vegetarians. Of the three studies that reported WC, both vegetarians and non-vegetarians had mean WC measures considered to be centrally obese.[42, 132, 134, 137] Similarly, according to ICS-DOAMS as well as other pre-existing guidelines for the diagnosis and treatment of hypertension, mean SBP and DBP values were elevated or above target range for both vegetarians and non-vegetarians in Jaacks et al's (DBP only) and Tong et al's investigations.[42, 134, 136, 158] Clearly, obesity and blood pressure are prevalent health problems in the South Asian community regardless of diet preference.

2.4.5 Cultural differences in vegetarian diets and impact of Westernization

Individuals may adopt a vegetarian diet for unique social or personal reasons. In the South Asian community, a vegetarian diet is often adopted early in life and is an essential component of many cultural, ethical and religious practices.[78] In contrast, vegetarians in Western countries typically adopt a vegetarian diet for individual health and lifestyle and may be motivated to restrict consumption of animal products due to environmental concerns or animal welfare**.**[159-160] Collectively, vegetarian diets in Western countries are typically healthier than their non-vegetarian alternatives, and are characterized by increased consumption of fruits, vegetables, whole grains, legumes, and nuts; and lower consumption of refined grains, desserts, fried foods, and sugar sweetened beverages.[136, 161]

The healthfulness of vegetarian diets does not transcend across ethnic groups, however. According to studies included in this review, South Asian vegetarians were more likely to eat sweets, desserts, fried foods, and sugar-sweetened beverages compared to non-vegetarians.[133, 136] In South Asian culture, sweets and desserts are a fundamental part of celebrations such as festivals and weddings.[162] Unfortunately, many South Asian dishes, snacks, and desserts are high in refined carbohydrates, deep fried and contain high amounts of added sugars, sodium, saturated and trans fats.[163-164] In contrast to vegetarians in Western countries, the South Asian vegetarian diet is characterized by unhealthier foods, which may provide a possible explanation for why consistent associations between vegetarian diets and improved cardiometabolic risk factors have been observed in non-South Asian populations but not in South Asians.

The process of Westernization and dietary acculturation may further exacerbate intake of unhealthy foods. Following immigration to Western countries, unhealthy dietary habits develop such as eating fast food, having meals outside of the home, and adding energy dense Western foods in addition to less healthy South Asian foods already consumed.[93] Moreover, South Asian immigrants report decreased intake of fiber and vegetarian foods such as whole grains, beans, and lentils, and increased intake of foods rich in fats and refined carbohydrates with longer residence in their country of migration.[56-57, 94] Since both vegetarian and non-vegetarian diets in many South Asian communities consist of both healthy and less healthy foods, it is not surprising that this ethnic minority group both inside and outside of South Asia is at greater risk for developing cardiometabolic conditions.

2.4.6 Strengths and limitations

This review provides a unique perspective on cardiometabolic measures and vegetarianism in South Asian communities. A comprehensive search strategy was used including published articles and grey literature to identify relevant research studies among five databases with no restrictions on geographic location. Culturally-specific diagnostic guidelines for South Asians were used to classify risk factors for diabetes in vegetarians relative to non-vegetarians. However, this study is not without its limitations. Considerable heterogeneity in reporting of outcomes limited the ability to conduct a meta-analysis and reach definitive conclusions about cardiometabolic associations by vegetarian status in South Asians. Each study included in this review used a cross-sectional design, restricting examination to correlational (versus causal) relationships between vegetarian diets and cardiometabolic risk factors. It is also important to recognize the ethnocultural diversity of South Asia with respect to geography, language, traditions and religious practices. Therefore, diets amongst South Asians within and beyond the sub-continent may differ based on cultural customs and habits. As such, caution should be exercised when generalizing results from the included studies across the South Asian demographic.

2.4.7 Future studies

Future studies need to incorporate robust methodology including standardized culturally tailored questionnaires and surveys, consistent definitions of which foods and dietary behaviors constitute a vegetarian diet, and reporting methods that can be appropriately adapted across countries. The use of similar culturally tailored dietary instruments can improve inter-study consistency and comparability of dietary intake between studies, and potentially inform the development of geographically tailored dietary guidelines to reduce cardiometabolic risk factors in South Asians. For example, the SHARE FFQ should be modelled, adapted and implemented outside North America to accurately compare dietary intake across studies investigating diet in South Asians. Furthermore, if economically feasible the administration of 24-hour recalls should be used to validate dietary information collected from FFQs. Moreover, accurately measuring socioeconomic variables such as education, income and employment status would provide useful information and context for measured and reported dietary intake, while statically adjusting for SES can address any potential confounding that may affect associations between diet and cardiometabolic measures. In combination with representative samples and longitudinal designs, these studies can accurately assess diet and changes in cardiometabolic measures, from which dietary recommendations can be made that are applicable to the large, diverse and heterogenous South Asian community.

2.5 Conclusion

This review raises important questions surrounding the cardiometabolic relationships of vegetarian diets and identifies important areas for future research in South Asians. Ultimately, there should be longitudinal studies that assess diet and cardiometabolic measures in South Asians. Despite many South Asians practicing vegetarianism early in life, the South Asian vegetarian diet may consist of unhealthy foods that can elevate cardiometabolic risk. Therefore, identifying any potential associations between dietary intake and cardiometabolic risk factors is important to improving the long-term health of this population. Moreover, genetic susceptibility for cardiometabolic complications within the South Asian community highlights the importance of using ethnic specific guidelines such as ICS-DOAMS to diagnose cardiometabolic risk factors.[42] By implementing such guidelines, cardiometabolic risk factors in South Asians can be identified and intervened at an earlier stage, culturally tailored diet programs can be appropriately implemented, and diabetes risk can be potentially reduced amongst this diverse ethnic group.

Chapter 3: Methods

3.1 Study overview

Prevention Matters: Reducing the diabetes burden in the South Asian community, hereby referred to as Prevention Matters, is a mixed-methods study involving a cross-sectional evaluation of cardiovascular risk factors and lifestyle behaviors (e.g. diet and physical activity) in South Asian Canadians at high risk for diabetes. From this study, South Asians living in the Metro Vancouver area were recruited for a sub-study to examine dietary intake amongst vegetarians and omnivores, explore relationships between diet and adiposity measures, and identify associations between sociodemographic characteristics and adiposity on a community level. This sub-study will hereby be referred to as Prevention Matters S-S and/or the "present study". The Prevention Matters study received human ethics approval from the Fraser Health Research Ethics Board in 2013 (FHREB 2013-030).

3.2 Methods and study population

Twelve South Asian centres of worship (e.g. Gurdwara's and Mandir's) in the Metro Vancouver area collaborated with study staff to advertise Prevention Matters and recruit the study population. South Asian centres of worship were chosen as these sites typically involve active community participation and are commonly frequented by adult and elderly community members that are at higher risk for developing metabolic complications. Verbal announcements promoting the study were made at collaborating Gurdwara's and Mandir's, and flyers were posted at local community complexes, senior's centres, health centres, and food markets with a large South Asian client base. Study advertisements were also placed in local Punjabi and Hindi newspapers.

Prospective study participants were invited to attend a diabetes risk screening event at a collaborating Gurdwara or Mandir. In total, twelve diabetes risk screenings were conducted between July 2013 and June 2014, including one at each collaborating Gurdwara and Mandir. Prior to participating in a screening event, study details and responsibilities were explained to prospective participants. An individual was considered to be eligible for inclusion in Prevention Matters if they met the following criteria:

1. **Self-identify as South Asian**
2. **Are adults ≥ 21 years of age**
3. **Speak Punjabi, Hindi, or English**
4. **Are a resident of the Metro Vancouver area (including Surrey, Richmond, Abbotsford, and New Westminster)**
5. **No prior history of diabetes**
6. **Considered at-risk for diabetes (scored ≥ 5 out of 11 on the ADA Diabetes Risk Test)**

Participants were excluded from Prevention Matters for the following reasons:

1. **Individuals living with a serious health condition (e.g. terminal cancer) or psychiatric illness**
2. **Persons reporting a major physical disability**
3. **Excessive alcohol intake or illicit drug use that would impede meaningful participation in the study**

Upon providing informed consent, participants were enrolled in the study and were asked to complete a diabetes risk assessment using the ADA Diabetes Risk Test (Appendix D). Outlined in Table 3.1, The ADA Diabetes Risk Test is a 7-item assessment (out of 11 points) that evaluates the following criteria:

Table 3.1 ADA Diabetes Risk Test.

Age Less than 40 years (0 points) 40 to 49 years (1 point) 50 to 59 years (2 points) 60 years or older (3 points)
Sex Male (1 point) Female (0 points)
History of gestational diabetes Yes (1 point) No (0 points)
Family history of diabetes Yes (1 point) No (0 points)
Diagnosis of hypertension Yes (1 point) No (0 points)
Physically active Yes (0 points) No (1 point)
Weight class by BMI ≤ 24.9 kg/m^2 (0 points) 25 kg/m^2 to 29 kg/m^2 (1 point) 30 kg/m^2 to 39 kg/m^2 (2 points) 40 kg/m^2 or more (3 points)

If a participant scored greater than 5 out of 11 on the ADA Diabetes Risk Test, they were considered to be high risk for diabetes and were eligible for further screening, including measurements of weight, height, BMI, WC and BP; a blood draw to measure cholesterol, HbA1c and ApoB; a sociodemographic questionnaire, participant data collection form and questionnaires assessing lifestyle and psychosocial measures. It is important to note that the ADA Diabetes Risk Test was administered with the purpose of screening South Asian adults determined to be at risk for diabetes and subsequently developing a registry to support South Asians in future diabetes research programs. All individuals who participated in a diabetes risk screening event at a collaborating Gurdwara or Mandir were eligible for inclusion in the registry.

All research staff in Prevention Matters were trained to administer study questionnaires and take anthropometric measurements such as weight, height BMI, WC and BP. As Prevention Matters spanned 12-months, new staff joined the research team at different time points of the study. Refresher training on administering questionnaires and taking anthropometric measurements were provided to all new staff members as well as continuing staff members as needed. Trained and certified phlebotomists collected blood from each participant through venipuncture. Upon collection of all anthropometric and blood test measures, results were aggregated to create participant diabetes risk profiles, upon which diabetes education sessions were held at collaborating Gurdwaras and Mandirs to discuss participant risk profile results, diabetes risk factors, and chronic disease prevention and management methods, including healthy eating and physical activity. Overall, 551 South Asian adults participated in the diabetes risk screening events, from which 425 individuals met the study eligibility criteria and were enrolled in Prevention Matters.

In total, six different English-language consent forms were devised and administered to all 425 study participants. All research staff were trained on consent procedures, privacy, and confidentiality. Research staff who spoke Punjabi and/or Hindi were trained by a senior team member on how to administer, ask and describe prompts on the consent form to study participants. If the consent forms were read to or interpreted for a participant, it was noted in the consent form. All study details and participant responsibilities were explained by research staff in simple terms. Each consent form discussed the benefits and risks associated with participating in the research and outlined that participation in Prevention Matters was voluntary. Each consent form also contained a clause that would allow the Principal Investigator (Dr. Tricia S. Tang) to contact participants for enrolment in future studies, including a sub-study investigating dietary intake. Only those participants who agreed to be contacted for future studies were approached to participate in the Prevention Matters S-S.

From the larger study population of 425 participants, a sample of 100 participants was selected to participate in the Prevention Matters S-S. Briefly, the sample size of 100 participants was derived based on requirements to conduct multivariate statistical models including age, sex, education, annual income, and depression as independent variables. Associations between these independent variables and lifestyle behaviors (e.g. diet and physical activity) were to be explored. As multivariate models generally require 10 to 30 participants per independent variable, five independent variables multiplied by 20 participants per independent variable resulted in a sample size of 100 participants. Using random stratified sampling all 425 participants were stratified into six distinct categories based on age and sex: 1) men 21–40 years, 2) men 41–60 years, 3) men 61 years and older, 4) women 21–40 years, 5) women 41–60 years, and 6) women 61 years and older. An approximately equal number of participants from each category were then randomly selected until a sample of 100 participants was achieved. Potential participants for the sub-study were contacted by telephone, where a research staff member explained the purpose of the project. Each participant was informed about the time commitment for the study as well as the types of questions they would be asked to complete, including the Study of Health Assessment and Risk in Ethnic groups FFQ (SHARE FFQ). Participants were also informed about anthropometric measures (e.g. height, weight, and WC) included as part of the Prevention Matters S-S. If the participant agreed to participate in this research, a meeting was organized at either the participants' home or at one of the twelve South Asian centres of worship where diabetes risk screenings were held during Prevention Matters.

3.3 Prevention Matters study questionnaires

The following questionnaires were administered to participants at the twelve diabetes risk screenings described previously. All 425 participants enrolled in Prevention Matters completed these questionnaires.

3.3.1 Participant data collection form

Participants who scored greater than 5 out of 11 on the ADA Risk Test were asked to fill out a data collection form. This form asked for the participants full name, date of birth, personal health number (PHN), mailing address, phone number and contact information for their family physician (e.g. full name, mailing address and phone number). Each participant was also asked to provide two emergency contacts, who would only be contacted in circumstances where the participant was unreachable in person or by phone. Emergency contacts were asked to inform participants about the diabetes education sessions or to obtain updated participant contact information if they had consented to participate in the Prevention Matters S-S investigating dietary intake.

3.3.2 Sociodemographic questionnaire

During the diabetes risk screenings, participants were asked to complete 14 sociodemographic questions, including age, sex, country of birth, years lived in Canada (if the participant had immigrated to Canada), annual household income, highest level of education achieved, languages spoken, religion, marital status, employment status and smoking status. For smoking status, participants were asked to select if they were a current smoker, had smoked within the past twelve months or had never smoked.

3.4 SHARE FFQ

The SHARE FFQ is a culturally tailored dietary assessment tool that was administered during the Prevention Matters S-S to assess dietary intake over the previous twelve months. The Population Health Research Institute at McMaster University developed the SHARE FFQ and tailored this assessment tool for South Asian, Chinese and European populations.[151] Each FFQ was created using similar methodology. To create a list of ethnic specific food items for each SHARE FFQ, 29 South Asian, 25 Chinese and 20 European adults were first randomly selected from a pilot study that took place between 1995 to 1996 in Hamilton, Ontario.[151] All participants were between the ages of 35 to 75 and were asked to complete multiple 24-hour dietary recalls or four-day dietary records, which would then be used to analyze dietary data and compile lists of ethnic specific foods for each SHARE FFQ.[151]

Prior to compiling ethnic-specific food lists, a 164-item FFQ created by the CSDLH was used as a template to develop the three SHARE FFQ's.[151, 165] Based on dietary data collected from the 29 South Asian participants in the pilot study, South Asians reportedly consumed 110 of the 164 items on the CSDLH FFQ in addition to 90 unique items. After analyzing data collected from Chinese and European participants in the pilot study, 90 items on the CSDLH FFQ in addition to 12 items that were reported from 24-hour recalls or dietary records in the pilot study were common across the three ethnic groups, resulting in 102 items that were shared across the three different versions of the SHARE FFQ.[151] The 90 unique items which the 29 South Asians reported from the pilot study were then analyzed and compiled into a food list to be added to the 102 items. Any food or beverage item that was reported more than twice by the 29 South Asian participants in the pilot study was eligible for inclusion in the SHARE FFQ.[151] Using input from South Asian community members and local businesses, 61 items unique to the South Asian community were added to the 102-item food list to create the South Asian SHARE FFQ, resulting in a final version that contained 163 items.[151] The South Asian version of the SHARE FFQ will hereby be referred to as the SHARE FFQ.

The efficacy of the SHARE FFQ was assessed in the national Study of Health Assessment and Risk in Ethnic groups (SHARE study) between 1996 and 1998.[151] Along with a seven-day dietary record, the SHARE FFQ was administered to 342 South Asians. The dietary record was used to query all foods and beverages consumed over the previous seven days post-administration and results were compared to the SHARE FFQ.[151] To determine the reliability and validity of the SHARE FFQ, a second SHARE FFQ along with another seven-day dietary record were administered and completed by a subset of 58 South Asian participants eight to ten months after the administration of the first SHARE FFQ and seven-day dietary record. Overall, the calorie-adjusted, deattenuated correlation coefficients between the two dietary records and the second SHARE FFQ administered were 0.45 ($p < 0.001$) for protein, 0.60 for carbohydrates ($p < 0.001$), 0.62 for total fat ($p < 0.001$) and 0.70 ($p < 0.001$) for total fiber.[151]

Participants reported their intake frequency (per day, per week, per month, per year or never) and serving size of each food item included in the SHARE FFQ. Participants compared the serving size of each food item they consumed with a reference (i.e. average) serving size and were asked to specify if their serving size was less than average, average or more than average. To help participants estimate serving sizes for certain food items, visual presentations of an item were displayed on a 9-inch plate. Participants were also able to report foods not listed on the questionnaire in a separate section, such as consumption of solid fat, fast food and the type of dietary fat used for cooking, frying and for baking. The SHARE FFQ also assesses vegetarian status using pre-defined categories of vegetarianism: vegan (i.e. no consumption of dairy, eggs, meat, poultry or seafood), lacto-vegetarian (i.e. consumption of dairy but no eggs, meat, poultry or seafood), lacto-ovo-vegetarian (i.e. consumption of dairy and eggs but no meat, poultry or seafood); semi-vegetarian (i.e. occasional consumption of meat, poultry or seafood); individual that eats chicken and fish but no meat; and non-vegetarian (i.e. consume dairy, eggs, meat, poultry and seafood).

3.5 Anthropometric measurements

To assess adiposity measures amongst participants enrolled in the Prevention Matters S-S, height, weight, and WC were measured. BMI was also calculated upon collecting height and weight. Anthropometric measures were assessed using the methods outlined below.

3.5.1 Height measurement

Height was measured using a portable stadiometer (Seca 213). The height rule was vertically setup against a hard-flat wall with the base of the stadiometer placed flat on a level floor surface. All participants were asked to remove their shoes as well as any heavy outer garments, keep their feet together and stand straight so that their posterior (i.e. back and buttocks) were against the height rule. Participants were also asked to tilt their head back, with the top of their ear canal (i.e. external auditory meatus) was level with their cheek bone (i.e. inferior margin of the bony orbit). The participant was asked to look straight.

To measure height for participants wearing religious headwear (e.g. turban, hijab), the head piece of the stadiometer was lowered, and pressure was gently applied so that the head garment was pressed as flat as possible to collect accurate measurements. Height was measured twice and averaged to calculate a final height measurement. If the first and second height measurements differed by more than 0.4 cm, a third measurement was taken and the median of the three measurements was calculated.

3.5.2 Weight measurement

Weight was measured using a portable electronic scale (Seca 874). All participants were asked to take off their shoes, empty their pockets, and remove any accessories (e.g. watches and belts) and/or heavy outer garments. Participants were asked to stand straight on the scale with their feet spread evenly apart to distribute their body weight evenly on the scale. Body weight was measured twice to the nearest 0.1 kg and averaged to calculate a final weight measurement. If the two weight measures differed by more than 0.2 kg, a third measurement was taken, and the median of the three measurements was calculated.

3.5.3 WC measurement

In accordance with guidelines outlined by the World Health Organization, WC was measured using a flexible Seca measuring tape around two midpoints between the lower rib margin and the iliac crest. To obtain accurate measurements, participants were asked to remove any heavy or thick outer garments (e.g. jackets, coats, sweaters) that could inflate their WC. If the participant was comfortable, they were asked to lift their shirt above their waist (e.g. to their belly button). Participants were asked to stand with their feet close together (e.g. approximately 12 to 15 cm apart) with their weight equally distributed to each leg. During WC measurement, participants were asked to breathe normally, and each waist measurement was taken at the end of exhalation. The measuring tape was held firmly yet snugly around the participant, with enough space for the research staff member to place one finger between the measuring tape and the subject's body. WC was measured twice to the nearest 0.1 cm and averaged to calculate the final WC. If the second WC measurement differed by more than 0.2 cm, a third measurement was taken and the median of the three measurements was calculated to find the final WC measurement. WC values were classified based on ICS-DOAMS criteria.[42] Males and females were classified as abdominally obese at WC ≥90 cm and ≥80 cm, respectively.

3.5.4 BMI calculation

BMI was calculated for each participant using the height and weight values collected from the methods above. Weight, which was measured in kilograms, was divided by height (cm were converted to meters squared) (e.g. kg/m^2). BMI was classified as normal weight, overweight, or obese. BMI classifications were made and compared using both NIDDK and ICS-DOAMS guidelines.[42] Table 3.2 outlines BMI cut points for NIDDK and ICS-DOAMS:

Table 3.2 BMI cut points for NIDDK and ICS-DOAMS.

BMI Classification	NIDDK	ICS-DOAMS
Normal	18.5 to 24.9 kg/m^2	18.0 to 22.9 kg/m^2
Overweight	24.9 to 29.9 kg/m^2	23.0 to 24.9 kg/m^2
Obese	>30 kg/m^2	>25 kg/m^2

3.6 Statistical methods and data analysis

3.6.1 Sociodemographic characteristics and diet classification

Participants in the Prevention Matters S-S were classified as vegetarian or omnivore based on their responses to the vegetarian status prompt in the SHARE FFQ. Due to limitations with a small sample size, sub-groups of vegetarians (e.g. vegan, lacto-vegetarian, lacto-ovo vegetarian, semi-vegetarian) could not be compared. As such, individuals were classified as vegetarian if they identified as vegan (i.e. no consumption of animal products), lacto-vegetarian (i.e. consumption of dairy but no animal products) or lacto-ovo-vegetarian (i.e. consumption of dairy and eggs but no animal products); and omnivore if they identified as non-vegetarian (consume all animal products), semi-vegetarian (i.e. consumption of meat occasionally), or ate chicken and fish but not meat. Descriptive analysis were used to report sociodemographic characteristics. Sociodemographic characteristics were compared between participants enrolled in the Prevention Matters S-S (i.e. vegetarians and omnivores) as well as between participants enrolled in the Prevention Matters S-S (n = 100) and participants not selected to be part of the sub-study (n = 325). Two-sample t-test or Wilcoxon Rank Sum test were used to compare continuous sociodemographic variables (e.g. age, years lived in Canada, BMI and WC). The Fisher's Exact test or Pearson’s Chi Squared Test were used to compare categorical sociodemographic variables (e.g. sex, marital status, first language, religion, education, annual household income, employment status and smoking status). Mean ± SD was reported for continuous sociodemographic variables, while frequencies and percentages were reported for categorical sociodemographic variables.

3.6.2 Objective 2: Examining dietary intake (e.g. total calorie intake, macronutrients, micronutrients, and food groups) of South Asian vegetarians and omnivores living in Metro Vancouver, BC

All statistical analysis for dietary intake were completed using SAS 9.4 statistical software. For each participant that completed a SHARE FFQ, nutrient profiles including macronutrient, micronutrient and caloric intake were derived using the Food Processor nutrient analysis software (Version 6.11, EHSA, Salem OR). The methodology used to derive macronutrient, micronutrient and total calorie data from the SHARE FFQ has been reviewed previously.[151] The macronutrients and micronutrients included in the nutrient profiles are outlined in Figure 3.1:

Figure 3.1 Macronutrients and micronutrients evaluated between vegetarians and omnivores.

Total Calories	Total Sugar	Vitamin C
	Total Fat	Vitamin D
Glycemic Load	Saturated Fat	Vitamin E
Glycemic Index	Monounsaturated Fat	Folate
	Polyunsaturated Fat	Calcium
Macronutrients	Trans Fat	Chromium
Total Protein	Total Cholesterol	Iron
Animal Protein		Potassium
Vegetarian Protein	**Micronutrients**	Selenium
Carbohydrates	Vitamin A	Sodium
Total Fiber	Niacin	Zinc
Soluble Fiber	Vitamin B-6	Omega 3 Fatty Acid
Insoluble Fiber	Vitamin B-12	Omega 6 Fatty Acid

Using data from Canadian Nutrient File, the Food Processor nutrient analysis software provided glycemic index values for food items collected on the SHARE FFQ. Any foods missing glycemic index values were obtained and estimated by searching relevant literature. Daily glycemic index and glycemic load were calculated using existing formulas outlined in a previous study which also used data from the SHARE FFQ.[166]

Linear regression was used to compare daily macronutrient and micronutrient intake between vegetarians and omnivores. Age, sex and caloric intake have been recognized as important variables to adjust for when investigating dietary intake of macronutrients and micronutrients.[167-168]As such, these variables were adjusted for in the models. Estimated mean nutrient intake, 95% confidence intervals and p-values were calculated. Mean values for nutrient intake were reported to compare the average amounts of macronutrients and micronutrients consumed between vegetarians and omnivores. A sensitivity analysis with log transformation of macronutrients and micronutrients was also performed to normalize dietary variables and remove outliers. Currently, there is no standard approach to removing outliers in dietary research. Outliers were identified based on statistical thresholds defined as participants whose intake for a macronutrient or micronutrient was below the 25th percentile or above the 75th percentile, plus two times the interquartile range.

Two-sample t-test was used to assess and compare the mean percentage of calories consumed from macronutrients, including protein, carbohydrates and fat, between vegetarians and omnivores. Moreover, based on established guidelines by Health Canada, the proportion of participants meeting, not meeting, or exceeding their recommended macronutrient requirements, as well as the proportion of participants above or below the EAR for micronutrients were also reported. The EAR is a measure of nutritional adequacy and is defined as “the median daily intake value that is estimated to meet the requirement of half the healthy individuals in a life-stage and gender group”.[80] If an EAR was not present, such as the case for chromium, potassium and sodium, the AI value was reported. The AI defined as “the recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people who are assumed to be maintaining an adequate nutritional state”.[80] The prevalence of supplement use was also reported for both vegetarians and omnivores.

Macronutrient and micronutrient intake provide important information about whether or not individuals are meeting their nutrient requirements to maintain their health and prevent the onset of diet related complications such as obesity and diabetes. However, it is also important to consider the sources of these macronutrients and micronutrients by examining the foods and food groups that comprise the diet (i.e. food items with distinct nutritional characteristics such as fruits, vegetables, dairy products, grains). As such, the composition of vegetarian and omnivorous diets was examined through comparisons of food group intake. The 2019 EWCFG and the ADA have established dietary recommendations but with a limited number of food groups (e.g. fruits and vegetables, grains, protein).[59, 169] As such, the diverse amount of items included on the SHARE FFQ may not be adequately captured by only using the food groups recommended by the 2019 EWCFG and ADA alone.[59, 169] Therefore, foods on the SHARE FFQ were categorized into 18 specific food groups based on previous criteria established by the MASALA study, which also used the SHARE FFQ to assess dietary intake between vegetarians and their omnivorous counterparts.[137] The composition of vegetarian and omnivore diets were compared by assessing the frequency of weekly food group intake using the Wilcoxon Rank Sum test and was reported using median (IQR). Daily servings of food groups were also reported using median (IQR). Individual food groups are outlined in Figure 3.2 below:

Figure 3.2 Categories of food groups based on food items included in the SHARE FFQ.

Alcohol

Beer
White Wine
Red Wine
Spirits

Some Whole Grains

60% Whole Wheat Bread (e.g. Light Rye)
Naan
Paratha (Oil, Ghee, Vegetable Ghee)
Puri

Fruits

Apple
Citrus
Banana
Grapes
Berries
Peach
Cantaloupe
Watermelon
Mango
Other Fruit
Canned Fruit
Dried Fruit

Beans and Legumes

French Beans
Other Beans
Lentils
Sambhar
Tofu
Chickpeas

Refined Grains

White Bread
Sugar Cereal
Muffins
Crackers
Rice
Fried Rice

Meat, Poultry and Seafood

Beef Curry
Ground Beef
Other Beef
Pork Curry
Other Pork
Goat Curry
Other Goat
Hot Dogs
Lunch Meat
Liver

Whole Grains

Whole Wheat Bread (e.g. Dark Rye)
Whole Wheat Rolls
Roti
Bran Cereal
Whole Wheat Cereal
No Sugar Cereal
Cooked Cereal

Fats and Oils

Butter on Bread
Margarine on Bread
Butter on Dal
Margarine on Dal
Oil Dressing
Mayonnaise

Eggs

Boiled Egg
Fried Egg

Dairy

Whole Milk
Regular Cheese
Skim Cheese
Regular Yogurt

Starchy Vegetables

Peas
Potatoes

Mixed Dishes

Cream Soup
Non-Cream Soup
Vegetarian Pizza
Meat Pizza
Macaroni
Tomato Pasta
Cream Pasta
Carrot Sabji
Other Vegetable Curry
Potato Sabji
Potato Curry
Vegetable Kofta

Sweets and Desserts

Cake
Donut
Ice Cream
Pies
Cookies
Milk Barfi
Lentil Barfi
Chumchum
Gulab Jamun
Halwa
Rasmalai
Kheer

Fried Chicken
Chicken Curry
Roast Chicken
Fresh Fish
Fish Curry
Canned Fish
Fried Fish
Seafood

Nuts and Oil Seed

Coconut
Nuts
Peanut Butter

Sugar, Candy and Jam

Sugar
Chocolate
Candy
Sugar Substitute
Jam

Vegetables

Sweet Potato
Broccoli
Okara
Dark Vegetables
Tomato
Onions
Yellow Squash
White Squash
Lettuce
Cucumber
Carrots
Mixed Vegetables
Other Fried Vegetables
Cauliflower
Green Pepper

Skim Yogurt
Raita
2% Milk
Fruit Yogurt
Paneer
1% Milk
Cream, Half/Half in Tea
Homo, 2%/1%, Skim Milk in Tea
Skim Milk

Snacks

Fries
Vegetable Samosa
Meat Samosa
Pakora
Papad
Dal Ki Pakori
Dahi Papri
Bhujia
Crisp Snacks
Tikia
Dhokla
Dosa

Sugar-Sweetened Beverages

Tea
Coffee
Decaf Coffee
Colas
Diet Colas
Fruit Drinks
Other Pop
Orange Juice
Apple Juice
Vegetable Juice

3.6.2.1 Response rates and missing data

All 100 participants enrolled in the Prevention Matters S-S were asked to complete the SHARE FFQ (Appendix E), of which 96 participants completed the FFQ. Total calories, macronutrient and micronutrient intake were calculated for the 96 participants. The four participants who did not complete the SHARE FFQ were excluded from all dietary analyses. Study participants were contacted regarding any missing data from the SHARE FFQ, and any remaining missing data was handled using listwise deletion in the linear regression models. Food group comparisons and subsequent p-values were not provided for three food groups due to limited sample size and response rate: alcohol (e.g. one vegetarian); meat, poultry and seafood (e.g. zero vegetarians); and eggs (two vegetarians).

3.6.3 Objective 3: Evaluating the associations between vegetarian diets and sociodemographic characteristics with adiposity in South Asians living in Metro Vancouver, BC

All statistical analyses were completed using SAS 9.4 and SPSS Build 1.0.0.1327 statistical software. The statistical analysis for this objective is split into two components. In the first component, associations between vegetarian diets and adiposity measures are explored using data from the 96 participants that completed the SHARE FFQ. Descriptive analyses were used to discuss differences in adiposity (BMI and WC) between vegetarians and omnivores. Logistic regression was performed using BMI as a measure of adiposity to explore the associations between vegetarian diet and overweight/obese BMI with omnivores as a reference group. Due to sample size limitations, overweight and obese participants were collectively examined as overweight/obese. Therefore BMI was a binary outcome variable (normal weight or overweight/obese). First, using South Asian BMI criteria for the diagnosis of overweight and obesity,[42] odds ratios adjusted for age and sex were calculated. For comparison, odds ratios adjusted for age and sex were also calculated using NIDDK BMI guidelines. In the logistic regression model, odds ratios, 95% confidence intervals and p-values were reported.

The second component of this objective explores associations between sociodemographic characteristics and adiposity using data from all 100 participants enrolled in the Prevention Matters S-S irrespective of dietary status. Linear regression models were used to assess associations between sociodemographic characteristics and adiposity. Sociodemographic characteristics included the continuous variables age and years lived in Canada; as well as categorical variables such as sex, education, annual household income, marital status and employment status. Education and annual household income, which each had three levels, were first reduced to two levels prior to coding dummy variables. Dummy variables were then coded as follows:

- Sex: 0 = Male, 1 = Female
- Education: 0 = < High school, 1 = ≥ High school
- Annual Household Income: 0 = < $49,999 CAD, 1 = > $50,000 CAD

Univariate (simple) linear regression was first performed to explore the associations between individual continuous and categorical sociodemographic variables and adiposity measures (BMI and WC). Unstandardized β coefficients, 95% confidence intervals, and p-values were calculated. HMLR was then performed to explore how sociodemographic characteristics may have collectively been associated with adiposity measures (BMI and WC). HMLR is a form of multiple linear regression where variables (i.e. sociodemographic characteristics) are added to the regression model using a block-wise approach. By adding sociodemographic characteristics in blocks, certain variables entered in earlier blocks can be controlled for in later blocks.

Sociodemographic characteristics were entered in two blocks using forced entry. Age and sex are well known biological characteristics that can lead to metabolic changes and subsequently affect the amount and distribution of an individual's body fat.[170-171] As such, age and sex were entered into block 1 and subsequently controlled for in block 2. The variance in BMI and WC explained by age and sex in block 1 was then determined. In block 2, age and sex were entered again along with the following sociodemographic characteristics: SES variables (education, annual income, employment status), marital status and years lived in Canada. SES variables, marital status and years lived in Canada were entered in block 2 to examine the associations between these variables with BMI and WC after statistically adjusting for age and sex–the variance in BMI and WC explained by age and sex was already known from block 1. The variance in BMI and WC explained by SES variables, marital status, and years lived in Canada was determined by changes in adjusted R^2 from block 1 to block 2. Overall, the variables were entered in the HMLR model as follows:

- Block 1: Age and sex
- Block 2: Age, sex, education, annual income, employment status, marital status, years lived in Canada

All linear regression models (univariate linear regression and HMLR) were assessed for linearity, multicollinearity, residual normality, homoscedasticity, and outliers. To assess multicollinearity, explanatory variables were examined for tolerance values greater than 0.2 and variance inflation factors less than 2.5. Normality of residuals was assessed using P-P plots and homoscedasticity was examined using scatterplots of standardized residuals versus standardized predicted residuals. The Durbin-Watson test was used to determine if autocorrelation was present amongst residuals from each linear regression model. The assumptions for linearity, multicollinearity, residual normality, and homoscedasticity were met, therefore, HLMR analysis was deemed appropriate. Analysis of variance was used to assess whether models (blocks 1 and 2) were significantly associated with BMI and WC. Adjusted R^2, standardized β coefficients, unstandardized β coefficients and standard errors, 95% confidence intervals, *t* statistics and p-values were reported for the HMLR analysis. When examining the associations between sociodemographic characteristics and adiposity measures, p-values < 0.05 were considered statistically significant.

3.6.3.1 Response rates and missing data

All 100 participants enrolled in the Prevention Matters S-S completed the sociodemographic questionnaire and were assessed for BMI and WC. Study participants were contacted regarding missing sociodemographic data, upon which pairwise deletion was used to handle any remaining missing data in the multiple linear regression analyses. Overall, data was missing for two participants for education, employment and marital status; four participants for years lived in Canada; and eleven participants for annual income.

Chapter 4: Results

4.1 Baseline sociodemographic characteristics of study participants in the Prevention Matters S-S

425 participants were enrolled in Prevention Matters of which 100 participants were randomly stratified and selected to participate in the Prevention Matters S-S. Of the 100 participants selected to participate in the Prevention Matters S-S, 43.0% were females and the mean age of participants was 65.4 (± 9.8) years. Participants lived in Canada for an average of 25.8 (±14.5) years, 89.8% identified as Sikh, and 63.3% reported than English was their first language. 73.5% of participants had equal to or less than a high school education, 24.5% were currently employed, and 70.8% reported an annual income of less than $50,000 CAD. Participants selected to participate in the Prevention Matters S-S significantly differed from the 325 participants not selected to be part of the Prevention Matters S-S with regards to marital status. 92.9% of participants in the Prevention Matters S-S were married compared to 84.0% of the 325 participants not selected for the sub-study ($p = 0.03$). Other than marital status, participants in the Prevention Matters S-S did not significantly differ from participants not selected to be part of the sub-study with regards to age ($p = 0.92$), sex ($p = 0.82$), years lived in Canada ($p = 0.14$), first language ($p = 0.43$), religion ($p = 0.69$), education level ($p = 0.22$), annual household income ($p = 0.57$), employment status ($p = 0.60$), and smoking status ($p = 1.00$). Participants in the Prevention Matters S-S also did not differ in adiposity measures, including mean BMI ($p = 0.76$) or WC ($p = 0.55$) compared to participants not selected to participate in the sub-study. The sociodemographic characteristics of the 100 participants enrolled in the Prevention Matters S-S are outlined and compared to the 325 participants not selected to participate in the Prevention Matters S-S in Table 4.1.

Table 4.1 Sociodemographic characteristics of participants in the Prevention Matters S-S and participants not selected to participate in the Prevention Matters S-S.

		Prevention Matters Participants (Excluded from S-S)[a] N = 325	Prevention Matters S-S Participants[b] n = 100	p-value
Age (Years) [Mean ± SD]		65.3 ± 10.6	65.4 ± 9.8	0.92
Sex (%)				0.82
	Female	134 (41.2%)	43 (43.0%)	
	Male	191 (58.8%)	57 (57.0%)	
Marital Status (%)				0.03
	Married	273 (84.0%)	91 (92.9%)	
	Not Married	52 (16.0%)	7 (7.1%)	
First Language (%)				0.43
	English	190 (58.5%)	62 (63.3%)	
	Hindi	1 (0.3%)	1 (1.0%)	
	Punjabi	134 (41.2%)	35 (35.7%)	
Religion (%)				0.69
	Hindu	28 (8.6%)	10 (10.2%)	
	Sikh	291 (89.5%)	88 (89.8%)	
Years Lived in Canada [Mean ± SD]		23.2 ± 15.7	25.8 ± 14.5	0.14
Education Level (%)				0.22
	< High school	164 (50.8%)	40 (40.8%)	
	High school	87 (26.9%)	32 (32.7%)	
	> High school	72 (22.3%)	26 (26.5%)	
Annual Household Income (%)				0.57
	<$20,000	75 (27.6%)	22 (24.7%)	
	$20,000–$49,999	108 (39.7%)	41 (46.1%)	
	>$50,000	89 (32.6%)	26 (29.2%)	
Employment Status (%)				0.60
	Not Working	234 (72.2%)	74 (75.5%)	
	Working	90 (27.8%)	24 (24.5%)	
Smoking Status (%)				1.00
	Last 12 Months	6 (0.6%)	1 (1.0%)	
	Never	316 (99.4%)	97 (99.0%)	
BMI (kg/m^2) [Mean ± SD]		28.2 ± 4.1	28.0 ± 3.6	0.76
WC (cm) [Mean ± SD]		101.6 ± 10.2	101.6 ± 9.2	0.55

a) Data Missing: 6 participants for religion, 2 participants for education level, 53 participants for annual household income, 1 participant for employment status, 13 participants for years lived in Canada, 3 participants for smoking status.

b) Data Missing: 2 participants for marital status, first language, religion, education level, employment status and smoking status, 11 participants for annual household income, 4 participants for years lived in Canada.

4.2 Sociodemographic characteristics of vegetarians and omnivores in the Prevention Matters S-S

The sociodemographic characteristics of vegetarians and omnivores are outlined in Table 4.2. Of the 96 participants included in the dietary analyses, there were 46 omnivores and 50 vegetarians. Amongst the 50 vegetarian participants, there were no vegans (i.e. no consumption of animal products), 42 lacto-vegetarians (i.e. consumption of dairy but no animal products) and 8 lacto-ovo-vegetarians (i.e. consumption of dairy and eggs but no animal products). Amongst the 46 omnivore participants, there were 23 omnivores (consume all animal products), 8 semi-vegetarians (i.e. consumption of meat occasionally), and 15 participants that consumed chicken and fish but not meat.

The mean age of vegetarians was 64.9 (± 9.0) years, compared to omnivores, whose mean age was 65.6 (± 10.5) years ($p = 0.72$). On average, vegetarians lived in Canada for 22.5 (± 14.5) years compared to omnivores, who had lived in Canada for an average of 27.8 (± 13.2) years ($p = 0.07$). The majority of vegetarians were females (54.0%) whereas the majority of omnivores were males (65.2%, $p = 0.07$). Most vegetarians (92.0%) and 95.5% of omnivores identified as Sikh ($p = 0.68$). 92.6% of all participants were married and 61.7% reported that English was their first language. Differences in education were not significant between vegetarians and omnivores, with 72.0% of vegetarians and 79.6% of omnivores achieving equal to or less than a highschool education ($p = 0.66$). Employment across the study sample was low, with 20.5% of omnivores and 26.0% of vegetarians holding work or employment ($p = 0.63$). Income did not differ significantly between vegetarians and omnivores, with 72.8% of vegetarians and 73.2% of omnivores reporting an annual household income of less than $50,000 CAD ($p = 0.61$).

Table 4.2 Sociodemographic characteristics of vegetarians and omnivores.

	Omnivores[a] (n = 46)	Vegetarians[b] (n = 50)	p-value
Age (Years) [Mean ± SD]	65.6 ± 10.5	64.9 ± 9.0	0.72
Sex (%)			0.07
Female	16 (34.8%)	27 (54.0%)	
Male	30 (65.2%)	23 (46.0%)	
Marital Status (%)			0.25
Married	39 (88.6%)	48 (96.0%)	
Not Married	5 (10.9%)	2 (4.0%)	
First Language (%)			0.83
English	28 (63.6%)	30 (61.2%)	
Hindi	0 (0.0%)	1 (2.0%)	
Punjabi	16 (36.4%)	19 (38.8%)	
Religion (%)			0.68
Hindu	2 (4.5%)	4 (8.0%)	
Sikh	42 (95.5%)	46 (92.0%)	
Years Lived in Canada [Mean ± SD]	27.8 ± 13.2	22.5 ± 14.5	0.07
Education Level (%)			0.66
< High school	19 (43.2%)	21 (42.0%)	
High school	16 (36.4%)	15 (30.0%)	
> High school	9 (20.5%)	14 (28.0%)	
Annual Household Income (%)			0.61
<$20,000	12 (29.3%)	9 (20.5%)	
$20,000–$49,999	18 (43.9%)	23 (52.3%)	
>$50,000	11 (26.8%)	12 (27.3%)	
Employment Status (%)			0.63
Not Working	35 (79.5%)	37 (74.0%)	
Working	9 (20.5%)	13 (26.0%)	
Smoking Status (%)			0.48
Last 12 Months	1 (2.2%)	0 (0.0%)	
Never	44 (97.8%)	49 (100.0%)	
BMI (kg/m^2) [Mean ± SD]	28.5 ± 3.3	27.7 ± 3.9	0.26
WC (cm) [Mean ± SD]	102.8 ± 8.3	100.4 ± 10.1	0.21

a) Data Missing: 2 participants for marital status, first language, religion, education level, and employment status, 5 participants for annual household income, 1 participant for years lived in Canada and smoking status.
b) Data Missing: 6 participants for annual household income, 3 participants for years lived in Canada, 1 participant for smoking status.

4.3 Objective 2: Examining dietary intake (e.g. total calorie intake, macronutrients, micronutrients, and food groups) of South Asian vegetarians and omnivores living in Metro Vancouver, BC

4.3.1 Caloric intake

After adjusting for age and sex in the linear regression model, vegetarians and omnivores did not differ significantly ($p = 0.22$) with respect to total calorie intake. Omnivores consumed on average, 2069.0 (1915.4, 2222.6) calories daily compared to vegetarians, who consumed 1937.8 (1793.5, 2082.2) calories daily. After completing a sensitivity analysis, omnivores consumed more calories than vegetarians (1995.7 daily calories versus 1873.8 daily calories), however, the difference in caloric intake between the two diet groups remained non-significant ($p = 0.23$). Tables 4.3 (linear regression) and 4.4 (i.e. linear regression with log transformation and the exclusion of outliers) outline the daily mean caloric intake of vegetarians and omnivores.

4.3.2 Macronutrient intake

Tables 4.3 (linear regression) and 4.4 (i.e. linear regression with log transformation and the exclusion of outliers) outline the daily mean macronutrient intake of vegetarians and omnivores. Omnivores were found to consume greater amounts of protein ($p = 0.01$) relative to vegetarians after adjusting for age, sex and calorie intake. On average, omnivores consumed 78.9 (75.5, 82.4) grams of protein daily compared to vegetarians, who consumed 72.2 (68.9, 75.4) grams of protein daily. Protein accounted for a significantly higher percentage of total calories in omnivores compared to vegetarians ($p < 0.01$). Protein comprised 15.6% (± 2.2%) of total calorie intake for omnivores and 14.1% (± 2.1%) of total caloric intake for vegetarians (Table 4.5), however, both diet groups consumed adequate amounts of protein (Table 4.6). The types and sources of protein that vegetarians and omnivores consumed are detailed in Appendix F. These results for protein intake remained significant in the sensitivity analysis ($p < 0.01$), where omnivores were found to consume 74.6 (71.5, 77.9) grams of protein compared to vegetarians, who consumed 67.6 (64.9, 70.3) grams.

Mean daily carbohydrate intake did not initially differ between vegetarians and omnivores ($p = 0.07$). Omnivores had a daily mean carbohydrate intake of 287.6 (279.9, 295.4) grams and vegetarians had a daily mean carbohydrate intake of 297.4 (290.1, 304.7) grams.

However, in the sensitivity analysis, vegetarians were found to consume significantly more ($p = 0.05$) daily mean carbohydrates compared to omnivores (i.e. omnivores consumed 280.0 (273.0, 287.1) grams of carbohydrates relative to vegetarians, who consumed 290.1 (283.3, 297.0) grams of carbohydrates). Carbohydrates accounted for a significantly higher percentage of total calories in vegetarians compared to omnivores ($p = 0.04$). Carbohydrates comprised 60.3% (± 6.0) of total calorie intake for vegetarians and 57.7% (± 6.0) of total calorie intake for omnivores (Table 4.5). In both statistical models, vegetarians were found to have a significantly higher glycemic load and glycemic index relative to omnivores (linear regression model: $p = 0.01$, $p = 0.03$; sensitivity analysis: $p = 0.01$, $p = 0.04$). Overall, 99.0% of participants consumed adequate amounts of carbohydrates, with 14.6% exceeding their daily carbohydrate requirements (Table 4.6). Vegetarians did not differ significantly in total daily mean fiber ($p = 0.45$), soluble fiber ($p = 0.83$) or insoluble fiber ($p = 0.81$) intake compared to omnivores. These results remained non-significant in the sensitivity analysis for total daily mean fiber ($p = 0.16$), soluble fiber ($p = 0.76$) and insoluble fiber ($p = 0.89$) intake.

Total fat intake did not differ significantly ($p = 0.27$) between vegetarians and omnivores. Overall, 99.0% of participants consumed adequate amounts of fat, but 10.4% exceeded their daily requirements (Table 4.6). Omnivores consumed 65.9 (63.4, 68.4) grams of total daily fat, while vegetarians consumed 67.9 (65.5, 70.2) grams of total daily fat. Additionally, vegetarians and omnivores did not significantly differ in daily mean saturated fat ($p = 0.45$), monounsaturated fat ($p = 0.27$), polyunsaturated fat ($p = 0.35$) and trans fat intake ($p = 0.86$). Both diet groups obtained similar amounts of calories from fat. Fat accounted for 29.4% (± 4.8) of total calorie intake for vegetarians and 28.9% (± 4.1) of total calorie intake for omnivores (Table 4.5). Omnivores consumed significantly more dietary cholesterol than vegetarians ($p < 0.01$) in both statistical models. On average, omnivores consumed 161.5 (145.9, 177.2) mg of cholesterol, while vegetarians consumed 100.4 (85.6, 115.1) mg of cholesterol. In the sensitivity analysis, vegetarians and omnivores did not significantly differ in daily mean total fat ($p = 0.45$), saturated fat ($p = 0.71$), monounsaturated fat ($p = 0.58$), polyunsaturated fat ($p = 0.29$) and trans fat ($p = 0.85$) intake.

4.3.3 Micronutrient intake

Tables 4.3 (linear regression) and 4.4 (i.e. linear regression with log transformation and the exclusion of outliers) outline the daily mean micronutrient intakes of vegetarians and omnivores. Table 4.6 outlines the prevalence of vegetarians and omnivores above or below the EAR or AI for micronutrients, and Table 4.7 highlights the prevalence of vitamins and supplement use amongst vegetarians and omnivores. Vegetarians and omnivores differed significantly in daily mean consumption of several micronutrients. Omnivores consumed significantly more daily mean niacin ($p < 0.01$), vitamin B-12 ($p < 0.01$), potassium ($p = 0.02$) and zinc ($p < 0.01$). On average, omnivores consumed 161.5 (145.9, 177.2) mg of cholesterol, 2.9 (2.6, 3.3) niacin equivalents, 3.2 (2.9, 3.6) µg of vitamin B-12, 4370.3 (4207.4, 4533.3) mg of potassium, and 10.2 (9.9, 10.5) mg of zinc. In contrast, vegetarians consumed 100.4 (85.6, 115.1) mg of cholesterol, 1.9 (1.6, 2.2) niacin equivalents, 2.5 (2.2, 2.8) µg of vitamin B-12, 4091.7 (3938.1, 4245.2) mg of potassium and 9.6 (9.3, 9.8) mg of zinc. 14.0% of vegetarians also used vitamin B-12 supplements. In the sensitivity analysis, the daily mean intake of cholesterol ($p < 0.01$), niacin ($p < 0.01$), vitamin B-12 ($p < 0.01$), potassium ($p = 0.01$) and zinc ($p < 0.01$) remained significantly higher for omnivores compared to vegetarians. Additionally, omnivores consumed 7.8 (6.9, 8.7) mg of selenium compared to vegetarians, who consumed 6.6 (5.9, 7.3) mg of selenium ($p = 0.04$) in the sensitivity analysis. Despite only 12.0% of vegetarians using iron supplements compared to 15.2% of omnivores, vegetarians consumed significantly more iron than omnivores, (16.3 (15.6, 16.9) mg versus 15.2 (14.6, 15.9) mg) in the sensitivity analysis ($p = 0.03$).

Vegetarians and omnivores did not significantly differ in mean daily consumption of vitamin A ($p = 0.13$), vitamin-B6 ($p = 0.43$), vitamin C ($p = 0.07$), vitamin D ($p = 0.52$), vitamin E ($p = 0.61$), folate ($p = 0.32$), calcium ($p = 0.16$), chromium ($p = 0.95$), iron ($p = 0.39$), selenium ($p = 0.27$), sodium ($p = 0.19$), omega-3 fatty acid ($p = 0.27$) and omega-6 fatty acid ($p = 0.43$). In the sensitivity analysis, vegetarians and omnivores did not significantly differ in mean daily consumption of vitamin A ($p = 0.19$), vitamin-B6 ($p = 0.37$), vitamin C ($p = 0.15$), vitamin D ($p = 0.34$), vitamin E ($p = 0.63$), folate ($p = 0.48$), calcium ($p = 0.08$), chromium ($p = 0.99$), sodium ($p = 0.35$), omega-3 fatty acid ($p = 0.07$) and omega-6 fatty acid ($p = 0.74$). Amongst omnivores, 10.9% used vitamin C supplements, 15.2% used vitamin D supplements, and 13.0% used calcium supplements. In contrast, amongst vegetarians, 18.0% used vitamin C supplements, 14.0% used vitamin D supplements, and 22.0% used calcium supplements. Neither vegetarians nor omnivores reported the use of supplements for vitamin A, vitamin B-6, beta carotene or selenium. Overall, 100% of participants did not meet their EAR for niacin, 100% did not meet their EAR for vitamin E, 99.0% did not meet their EAR for vitamin D, 74.0% did not meet their AI for potassium, while 100% exceeded their AI for sodium.

Table 4.3 Daily mean nutrient intake between vegetarian and omnivores.[a]

	Omnivores (n = 46)	Vegetarians (n = 50)	p-value
Calorie Intake	2069.0 (1915.4, 2222.6)	1937.8 (1793.5, 2082.2)	0.22
Protein (g)	78.9 (75.5, 82.4)	72.2 (68.9, 75.4)	0.01
Carbohydrate (g)	287.6 (279.9, 295.4)	297.4 (290.1, 304.7)	0.07
Glycemic Load	110.4 (104.6, 116.3)	121.1 (115.6, 126.6)	0.01
Glycemic Index	42.3 (40.9, 43.7)	44.5 (43.1, 45.8)	0.03
Total Fiber (g)	26.1 (24.5, 27.7)	26.9 (25.4, 28.4)	0.45
Soluble Fiber (g)	10.9 (10.2, 11.5)	10.8 (10.2, 11.4)	0.83
Insoluble Fiber (g)	11.1 (10.2, 12.0)	10.9 (10.1, 11.8)	0.81
Total Fat (g)	65.9 (63.4, 68.4)	67.9 (65.5, 70.2)	0.27
Saturated Fat (g)	20.9 (19.3, 22.5)	21.7 (20.2, 23.2)	0.45
Monounsaturated Fat (g)	24.7 (23.6, 25.9)	25.7 (24.5, 26.8)	0.27
Polyunsaturated Fat (g)	13.5 (12.8, 14.3)	14.0 (13.3, 14.7)	0.35
Trans Fat (g)	0.4 (0.2, 0.5)	0.4 (0.2, 0.5)	0.86
Cholesterol (mg)	161.5 (145.9, 177.2)	100.4 (85.6, 115.1)	< 0.01
Vitamin A (IU)	18945.0 (16422.0, 21468.0)	16269.0 (13890.0 18647.0)	0.13
Niacin (NE)	2.9 (2.6, 3.3)	1.9 (1.6, 2.2)	< 0.01
Vitamin B-6 (mg)	2.3 (2.2, 2.4)	2.2 (2.1, 2.3)	0.43
Vitamin B-12 (µg)	3.2 (2.9, 3.6)	2.5 (2.2, 2.8)	< 0.01
Vitamin C (mg)	259.3 (230.6, 288.0)	222.7 (195.6, 249.8)	0.07
Vitamin D (IU)	113.2 (89.1, 137.4)	102.4 (79.6, 125.1)	0.52
Vitamin E (IU)	2.1 (1.8, 2.5)	2.0 (1.7, 2.3)	0.61
Folate (µg)	479.6 (450.5, 508.8)	459.2 (431.6, 486.7)	0.32
Calcium (mg)	1161.3 (1071.5, 1251.0)	1071.4 (986.8, 1156.0)	0.16
Chromium (µg)	14.9 (12.8, 17.1)	14.8 (12.8, 16.9)	0.95
Iron (mg)	16.3 (15.2, 17.4)	16.9 (15.9, 18.0)	0.39
Potassium (mg)	4370.3 (4207.4, 4533.3)	4091.7 (3938.1, 4245.2)	0.02
Selenium (mg)	10.8 (7.1, 14.6)	7.9 (4.4, 11.5)	0.27
Sodium (mg)	3367.7 (3146.5, 3589.0)	3163.5 (2955.0, 3372.0)	0.19
Zinc (mg)	10.2 (9.9, 10.5)	9.6 (9.3, 9.8)	< 0.01
Omega-3 Fatty Acid (g)	0.2 (0.1, 0.2)	0.12 (0.1, 0.2)	0.27
Omega-6 Fatty Acid (g)	0.5 (0.4, 0.6)	0.6 (0.5, 0.7)	0.43

a) Statistical model adjusted for age, sex, and calorie intake.

Table 4.4 Daily mean nutrient intake between vegetarians and omnivores with log transformation.[a]

	Omnivores (n = 46)	Vegetarians (n = 50)	p-value
Calorie Intake	1995.7 (1851.6, 2151.0)	1873.8 (1746.5, 2010.5)	0.23
Protein (g)	74.6 (71.5, 77.9)	67.6 (64.9, 70.3)	< 0.01
Carbohydrate (g)	280.0 (273.0, 287.1)	290.1 (283.3, 297.0)	< 0.05
Glycemic Load	107.4 (102.2, 112.7)	117.11 (111.9, 122.6)	0.01
Glycemic Index	42.0 (40.7, 43.5)	44.2 (42.8, 45.6)	0.04
Total Fiber (g)	24.5 (23.2, 25.9)	25.8 (24.6, 27.2)	0.16
Soluble Fiber (g)	10.3 (9.8, 10.9)	10.4 (9.9, 11.0)	0.76
Insoluble Fiber (g)	10.3 (9.6, 11.1)	10.4 (9.7, 11.1)	0.89
Total Fat (g)	62.1 (59.8, 64.5)	63.3 (61.1, 65.6)	0.45
Saturated Fat (g)	19.3 (17.9, 20.7)	19.6 (18.3, 21.0)	0.72
Monounsaturated Fat (g)	23.2 (22.1, 24.3)	23.6 (22.6, 24.7)	0.58
Polyunsaturated Fat (g)	12.7 (12.1, 13.4)	13.2 (12.6, 13.8)	0.29
Trans Fat (g)	0.2 (0.1, 0.2)	0.2 (0.1, 0.3)	0.85
Cholesterol (mg)	140.1 (125.8, 156.2)	83.8 (75.7, 92.8)	< 0.01
Vitamin A (IU)	16108.0 (14014.9, 18513.7)	14165.8 (12423.7, 16152.2)	0.19
Niacin (NE)	2.5 (2.2, 2.7)	1.7 (1.5, 1.8)	< 0.01
Vitamin B-6 (mg)	2.2 (2.07, 2.26)	2.1 (2.02, 2.19)	0.37
Vitamin B-12 (µg)	2.8 (2.5, 3.2)	2.1 (1.9, 2.3)	< 0.01
Vitamin C (mg)	228.2 (204.2, 254.9)	203.7 (183.5, 226.1)	0.15
Vitamin D (IU)	85.8 (67.3, 109.5)	72.9 (57.9, 91.7)	0.34
Vitamin E (IU)	1.8 (1.6, 2.0)	1.8 (1.6, 2.0)	0.63
Folate (µg)	456.8 (434.2, 480.7)	445.5 (424.4, 467.6)	0.48
Calcium (mg)	1099.3 (1020.4, 1184.4)	1002.7 (934.7, 1075.7)	0.08
Chromium (µg)	12.8 (11.1, 14.7)	12.8 (11.2, 14.6)	0.99
Iron (mg)	15.2 (14.6, 15.9)	16.3 (15.6, 16.9)	0.03
Potassium (mg)	4183.9 (4029.1, 4344.7)	3918.3 (3782.8, 4058.8)	0.01
Selenium (mg)	7.8 (6.9, 8.7)	6.6 (5.9, 7.3)	0.04
Sodium (mg)	3098.5 (2915.2, 3293.2)	2978.3 (2813.5, 3152.8)	0.35
Zinc (mg)	9.9 (9.6, 10.2)	9.2 (8.9, 9.5)	< 0.01
Omega-3 Fatty Acid (g)	0.1 (0.1, 0.1)	0.1 (0.1. 0.1)	0.07
Omega-6 Fatty Acid (g)	0.4 (0.4, 0.5)	0.5 (0.4, 0.5)	0.74

a) Statistical model adjusted for age, sex, and caloric intake (log transformation excluding outliers).

Table 4.5 Estimated mean percentage of daily calories from protein, carbohydrate and fat between vegetarians and omnivores.

	Omnivores (n = 46)	Vegetarians (n = 50)	p-value
Protein (%)	15.6 (± 2.2)	14.1 (± 2.1)	< 0.01
Carbohydrate (%)	57.7 (± 6.0)	60.3 (± 6.0)	0.04
Fat (%)	28.9 (± 4.1)	29.4 (± 4.8)	0.61

Table 4.6 Nutritional recommendations for macronutrients and micronutrients as outlined by Health Canada.

		Macronutrients		
	Distribution Range	% Participants Meeting Requirements	% Participants Exceeding Requirements	% Participants Below Requirements
Protein	10.0 – 35.0%	100%		
Carbohydrate	45.0 – 65.0%	84.4%	14.6%	1.0%
Fat	20.0 – 35.0%	88.5%	10.4%	1.0%
		Micronutrients		
	Males	Females	% Participants Above EAR	% Participants Below EAR
Vitamin A (IU)	2083	1667	100.0%	
Niacin (NE)	12	11		100.0%
Vitamin B-6 (mg)				
21–50 years	1.1	1.1	83.3%	16.7%
51+ years	1.4	1.3	95.6%	4.40%
Folate (µg)	320	320	89.6%	10.4%
Vitamin B-12 (µg)	2	2	69.8%	30.2%
Vitamin C (mg)	75	60	100%	
Vitamin D (IU)	400	400	1.00%	99.0%
Vitamin E (IU)	17.9	17.9		100%
Calcium (mg)				
21–50 years	800	800	66.7%	33.3%
51–70 years	800	1000	67.7%	32.3%
71+ years	1000	1000	53.6%	46.4%
Chromium (µg)[a]				
21–50 years	35	25		100.0%
51+ years	30	20	12.2%	87.8%

	Males	Females	% Participants Above EAR	% Participants Below EAR
Iron (mg)				
21–50 years	6	8.1	100.0%	
51+ years	6	5	100.0%	
Potassium (mg)[a]	4700	4700	26.0%	74.0%
Selenium (mg)	45	45	99.0%	1.0%
Sodium (mg)[a]				
21–50 years	1500	1500	100.0%	
51–70 years	1300	1300	100.0%	
71+ years	1200	1200	100.0%	
Zinc (mg)	9.4	6.8	67.7%	32.3%

a) AI value provided as EAR not available.

Table 4.7 Prevalence of supplement use between vegetarians and omnivores.

Supplement	% Omnivores (n = 46)	% Vegetarians (n = 50)
Vitamin B-12	10.9%	14.0%
Vitamin C	10.9%	18.0%
Vitamin D	15.2%	14.0%
Vitamin E	0.0%	4.0%
Calcium	13.0%	22.0%
Folate	4.3%	2.0%
Iron	15.2%	12.0%
Magnesium	2.2%	6.0%
Zinc	2.2%	4.0%

a) No participants reported supplement use for vitamin A, vitamin B-6, beta carotene or selenium.

4.3.4 Food group intake frequency

Vegetarians and omnivores did not significantly differ in their frequency of food group intake. Fruits and vegetables were consumed with the highest weekly frequency amongst both vegetarians and omnivores. Omnivores reported they consumed fruits 9.0 (5.0–12.0) times per week whereas vegetarians consumed fruits 9.0 (4.0–10.0) times per week. Meanwhile, median weekly consumption of vegetables was 9.0 (4.0–12.0) times per week for omnivores and 9.0 (6.0–13.0) times per week for vegetarians. Moreover, both vegetarians and omnivores obtained their highest daily servings of food items from fruits, vegetables, whole grains, dairy and sugar-sweetened beverages. Median daily servings of fruits and vegetables, respectively, were 2.7 (1.9–3.9) and 3.4 (2.6–5.4) per day for vegetarians, and 2.9 (2.0–3.9) and 3.8 (2.6–5.4) per day for omnivores. Omnivores also consumed 5.2 (3.5–6.4) daily servings of dairy and 2.8 (2.2–3.7) daily servings of whole grains compared to vegetarians, who consumed 4.8 (3.5–5.8) daily servings of dairy and 3.0 (2.2–3.7) daily servings of whole grains. For sugar-sweetened beverages, vegetarians consumed 2.8 (2.3–3.6) daily servings compared to omnivores, who consumed 3.2 (2.6–4.2) daily servings. The results for food group intake frequency between vegetarians and omnivores are outlined in Table 4.8.

Table 4.8 Weekly intake frequency and daily servings of food groups between vegetarians and omnivores.[a]

	Omnivore	Vegetarian	p-value
Alcohol	(n = 11)	(n = 1)	
Weekly Intake Frequency	3.0 (1.0–5.0)	2.0 (2.0–2.0)	
Daily Servings	0.4 (0.1–0.9)	0.3 (0.3–0.3)	
Beans and Legumes	(n = 40)	(n = 48)	0.27
Weekly Intake Frequency	3.5 (2.0–4.0)	4.0 (2.0–5.0)	
Daily Servings	1.0 (0.6 –1.5)	1.0 (0.6–1.5)	
Whole Grains	(n = 29)	(n = 34)	0.48
Weekly Intake Frequency	3.0 (3.0–6.0)	3.0 (2.0–7.0)	
Daily Servings	2.8 (2.2–3.7)	3.0 (2.2–3.7)	
Some Whole Grains	(n = 25)	(n = 22)	0.59
Weekly Intake Frequency	2.0 (1.0–2.0)	1.0 (1.0–2.0)	
Daily Servings	0.3 (0.2–0.5)	0.3 (0.2–0.5)	
Refined Grains	(n = 25)	(n = 29)	0.82
Weekly Intake Frequency	2.0 (1.0–3.0)	2.0 (1.0–3.0)	
Daily Servings	0.4 (0.2–0.7)	0.4 (0.3–0.7)	
Fats and Oils	(n = 25)	(n = 22)	0.33
Weekly Intake Frequency	2.0 (2.0–3.0)	3.0 (2.0–5.0)	
Daily Servings	1.1 (0.3–2.6)	0.8 (0.4–2.6)	
Fruits	(n = 44)	(n = 45)	0.54
Weekly Intake Frequency	9.0 (5.0–12.0)	9.0 (4.0–10.0)	
Daily Servings	2.9 (2.0–3.9)	2.7 (1.9–3.9)	

	Omnivore	Vegetarian	p-value
Meat, Poultry and Seafood	(n = 22)	(n = 0)	
Weekly Intake Frequency	2.0 (1.0–3.0)		
Daily Servings	0.5 (0.4–0.8)		
Eggs	(n = 29)	(n = 2)	
Weekly Intake Frequency	2.0 (1.0–3.0)	4.0 (4.0–4.0)	
Daily Servings	0.3 (0.2–0.6)	0.6 (0.6–0.6)	
Dairy	(n = 35)	(n = 43)	0.80
Weekly Intake Frequency	4.0 (2.0–7.0)	4.0 (2.0–7.0)	
Daily Servings	5.2 (3.5–6.4)	4.8 (3.5–5.8)	
Mixed Dishes	(n = 41)	(n = 46)	0.17
Weekly Intake Frequency	4.0 (2.0–6.0)	5.0 (3.0–7.0)	
Daily Servings	1.0 (0.6–1.3)	1.0 (0.6–1.3)	
Nuts and Oils Seeds	(n = 19)	(n = 25)	0.27
Weekly Intake Frequency	2.0 (1.0–4.0)	3.0 (2.0–5.0)	
Daily Servings	0.4 (0.2–0.9)	0.8 (0.4–1.5)	
Snacks	(n = 17)	(n = 21)	0.62
Weekly Intake Frequency	2.0 (1.0–4.0)	2.0 (2.0–2.0)	
Daily Servings	0.5 (0.3–0.8)	0.5 (0.4–0.6)	
Sweets and Desserts	(n = 31)	(n = 36)	0.91
Weekly Intake Frequency	3.0 (2.0–5.0)	3.0 (2.0–5.0)	
Daily Servings	1.0 (0.6–1.5)	1.2 (0.7–1.8)	
Sugar, Candy and Jam	(n = 18)	(n = 21)	0.06
Weekly Intake Frequency	2.0 (1.0–2.0)	3.0 (2.0–4.0)	
Daily Servings	0.5 (0.3–1.3)	0.3 (0.2–0.7)	
Sugar-Sweetened Beverages	(n = 31)	(n = 32)	0.49
Weekly Intake Frequency	3.0 (2.0–5.0)	3.0 (2.0–6.5)	
Daily Servings	3.2 (2.6–4.2)	2.8 (2.3–3.6)	
Starchy Vegetables	(n = 32)	(n = 28)	0.45
Weekly Intake Frequency	2.0 (1.0–2.5)	2.0 (1.0–2.0)	
Daily Servings	0.3 (0.2–0.4)	0.3 (0.1–0.4)	
Vegetables	(n = 41)	(n = 47)	0.38
Weekly Intake Frequency	9.0 (4.0–12.0)	9.0 (6.0–13.0)	
Daily Servings	3.8 (2.6–5.4)	3.4 (2.6–5.4)	

a) Reported values include median (IQR).

4.4 Objective 3: Evaluating the associations between vegetarian diets and sociodemographic characteristics with adiposity in South Asians living in Metro Vancouver, BC

4.4.1 BMI and WC measures in vegetarians and omnivores

In the Prevention Matters S-S, BMI and WC were assessed to evaluate adiposity in vegetarians and omnivores. Amongst all participants in the Prevention Matters S-S (n = 100), mean BMI was 28.0 (±3.6) kg/m^2 and mean WC was 101.6 ± 9.2 cm (Table 4.1). By comparison, the mean BMI of all participants in Prevention Matters (N = 425) was 28.1 (± 4.0) kg/m^2 and mean WC was 101.6 (± 9.9) cm (Table 4.1). Amongst vegetarians in the Prevention Matters S-S, mean BMI was 27.7 (± 3.9) kg/m^2 relative to omnivores, whose mean BMI was 28.5 (± 3.3) kg/m^2. Vegetarians had a mean WC of 100.4 (± 10.1) cm, relative to omnivores, who had a mean WC of 102.8 (± 8.3). Differences in BMI and WC between vegetarians and omnivores did not achieve statistical significance. These results are reported in Table 4.2. Using ICS-DOAMS guidelines for WC, 94.0% vegetarians and 95.7% of omnivores were abdominally obese (Table 4.9). According to ICS-DOAMS BMI guidelines, only nine participants were categorized as having normal BMI, while 87 participants were classified as either overweight or obese (Table 4.10). In comparison to NIDDK BMI guidelines, 18 participants were categorized as having normal BMI, while 78 participants were classified as either overweight or obese. The distribution of participants by dietary preference (i.e. vegetarian or omnivore) in the normal and abdominally obese categories by WC, as well as the normal, overweight and obese BMI categories are outlined in Tables 4.9 and 4.10, respectively.

Table 4.9 WC categorization of Prevention Matters S-S participants according to ICS-DOAMS guidelines.[a]

WC Category	Omnivores	Vegetarians	p-value
			1.00
Females < 80cm or Males < 90cm	2 (4.3%)	3 (6.0%)	
Females ≥ 80cm or Males ≥ 90cm	44 (95.7%)	47 (94.0%)	

a) n = 96.

Table 4.10 BMI categorization of Prevention Matters S-S participants according to ICS-DOAMS and NIDDK guidelines.[a]

	BMI Category	Omnivores	Vegetarians	p-value
ICS-DOAMS				0.74
	Normal (%)	4 (8.7%)	5 (10.0%)	
	Overweight (%)	3 (6.5%)	6 (12.0%)	
	Obese (%)	39 (84.8%)	39 (78.0%)	
NIDDK				0.34
	Normal (%)	7 (15.2%)	11 (22.0%)	
	Overweight (%)	23 (50.0%)	28 (56.0%)	
	Obese (%)	16 (34.8%)	11 (22.0%)	

a) n = 96.

4.4.2 Odds ratios for overweight/obese BMI by diet

Odds ratios were calculated to measure the association between dietary preference (i.e. vegetarian, omnivore) and overweight/obese BMI. These results are outlined in Table 4.11. Using guidelines provided by ICS-DOAMS, the odds ratio for overweight/obese BMI amongst vegetarians relative to omnivores was not significant (0.68 (0.16, 2.82)). Using NIDDK guidelines, the odds ratio for overweight/obese BMI amongst vegetarians relative to omnivores was also not significant (0.53 (0.18, 1.58)).

Table 4.11 Odds ratios for overweight/obese BMI of vegetarians compared to omnivores based on ICS-DOAMS and NIDDK guidelines.[a]

	Odds Ratios for Overweight/Obese BMI (Vegetarians to Omnivores)	p-value
ICS-DOAMS	0.68 (0.16, 2.82)	0.59
NIDDK	0.53 (0.18, 1.58)	0.25

a) Statistical model adjusted for age and sex.

4.4.3 Associations between sociodemographic characteristics and adiposity

4.4.3.1 Associations between sociodemographic characteristics and BMI

Female sex was positively associated with BMI in the univariate regression ($p < 0.01$) and the HMLR analyses ($p < 0.01$). In the univariate linear regression analysis, BMI was significantly higher: $\beta = 2.43$ (1.20, 3.66) kg/m^2 in females. In the HLMR analysis, age and sex were entered into block 1, however, sex was the only variable to achieve statistical significance and females were associated with a higher BMI compared to males ($\beta = 0.37$, $p < 0.01$). The variables in block 1 accounted for 12.3% of the variance in BMI. In block 2, age, sex, years lived in Canada, education, annual household income, employment status and marital status were entered. Sex ($\beta = 0.36$, $p < 0.01$) and education ($\beta = 0.20$, $p = 0.05$) were significantly associated with BMI. Females were more likely to have a higher BMI compared to males and individuals with a high school education or greater were associated with higher BMI compared to individuals with less than a high school education. The variables in block 2 accounted for 17.7% of the variance in BMI, representing a 5.40% change from the variables in model 2. No autocorrelation was present as the Durbin-Watson test score was 1.87, tolerance ranged from 0.69 to 0.93, and the variance inflation factor (VIF) ranged from 1.08 to 1.44. Associations between sociodemographic characteristics and BMI are outlined in Tables 4.12 and 4.13 for the univariate linear regression and HMLR, respectively.

Table 4.12 Univariate linear regression of sociodemographic characteristics and BMI amongst South Asians living in Metro Vancouver.

Outcome Variable: BMI		
Explanatory Variable (Reference Category)	**Unstandardized β (95% CI)**	**p-value**
Age	-0.02 (-0.09, 0.05)	0.51
Female (Male)	2.43 (1.20, 3.66)	< 0.01
Years Lived in Canada	-0.05 (-0.09, 0.00)	0.06
≥ High school (< High school)	1.02 (-0.29, 2.34)	0.13
> $50,000 CAD (< $49,999 CAD)	-1.32 (-2.80, 0.16)	0.08
Employed (Unemployed)	-0.77 (-2.29, 0.74)	0.31
Married (Unmarried)	1.40 (-0.85, 3.64)	0.22

Table 4.13 HMLR of sociodemographic characteristics and BMI amongst South Asians living in Metro Vancouver.

Outcome Variable: BMI						
	Explanatory Variable (Reference Category)	**Standardized β**	**Unstandardized β (SE)**	**95% CI**	***t***	**p-value**
Block 1 Adjusted R^2 = 12.3% F = 7.47 p-value < 0.01	Age	-0.05	-0.02 (0.03)	(-0.08, 0.05)	-0.55	0.59
	Female (Male)	0.37	2.42 (0.64)	(1.16, 3.68)	3.80	< 0.01
Block 2 Adjusted R^2 = 17.7% F = 3.83 p-value < 0.01	Age	-0.03	-0.01 (0.03)	(-0.08, 0.05)	-0.27	0.79
	Female (Male)	0.36	2.32 (0.66)	(1.01, 3.63)	3.53	< 0.01
	Years Lived in Canada	-0.18	-0.04 (0.02)	(-0.09, 0.01)	-1.65	0.10
	≥ High school (< High school)	0.20	1.30 (0.64)	(0.02, 2.58)	2.02	0.05
	> $50,000 CAD (< $49,999 CAD)	-0.17	-0.86 (0.77)	(-2.39, 0.67)	-1.12	0.27
	Employed (Unemployed)	-0.05	-0.34 (0.85)	(-2.03, 1.35)	-0.40	0.69
	Married (Unmarried)	0.11	1.22 (1.10)	(-0.95, 3.39)	1.12	0.27

4.4.3.2 Associations between sociodemographic characteristics and WC

Age was positively associated with WC in the univariate linear regression analysis (p = 0.04). A one-unit increase in age was associated with 0.17-cm increase in WC. In the HLMR analysis, age and sex were entered into block 1, however age was the only variable that was significantly associated with WC, accounting for 4.30% of the variance in WC (β = 0.21, p = 0.04). In block 2, age, sex, years lived in Canada, education, annual household income, employment status and marital status were entered. Although the association between age and WC was attenuated, the standardized β coefficient did not markedly decrease (0.21 in block 1 versus 0.20 in block 2). Over and above age, the variables in block 2 did not appear to contribute significantly to the variance in WC (adjusted R^2 changed by 2.70% from the variables in block 1, p = 0.31). No autocorrelation was present as the Durbin-Watson test score was 2.05, tolerance ranged from 0.69 to 0.93, and the variance inflation factor (VIF) ranged from 1.08 to 1.44. Associations between sociodemographic characteristics and WC are outlined in Tables 4.14 and 4.15 for the univariate linear regression and HMLR, respectively.

Table 4.14 Univariate linear regression of sociodemographic characteristics and WC amongst South Asians living in Metro Vancouver.

Outcome Variable: WC		
Explanatory Variable (Reference Category)	**Unstandardized β (95% CI)**	**p-value**
Age	0.18 (0.01, 0.34)	0.04
Female (Male)	-2.27 (-5.54, 0.99)	0.17
Years Lived in Canada	-0.05 (-0.16, 0.07)	0.44
≥ High school (< High school)	-1.55 (-4.84, 1.75)	0.35
> $50,000 CAD (< $49,999 CAD)	-2.13 (-5.85, 1.58)	0.26
Employed (Unemployed)	-1.26 (-5.04, 2.52)	0.51
Married (Unmarried)	0.73 (-4.90, 6.37)	0.80

Table 4.15 HMLR of sociodemographic characteristics and WC amongst South Asians living in Metro Vancouver.

Outcome Variable: WC						
	Explanatory Variable (Reference Category)	**Standardized β**	**Unstandardized β (SE)**	**95% CI**	***t***	**p-value**
Block 1 Adjusted R^2 = 4.30% F = 3.05 p-value = 0.05	Age	0.21	0.17 (0.08)	(0.01, 0.34)	2.05	0.04
	Female (Male)	-0.13	-2.15 (1.65)	(-5.44, 1.14)	-1.30	0.20
Block 2 Adjusted R^2 = 1.60% F = 1.21 p-value = 0.31	Age	0.20	0.16 (0.09)	(-0.03, 0.35)	1.725	0.09
	Female (Male)	-0.16	-2.63 (1.79)	(-6.19, 0.93)	-1.47	0.15
	Years Lived in Canada	-0.10	-0.06 (0.06)	(-0.19, 0.07)	-0.91	0.36
	≥ High school (< High school)	-0.06	-0.94 (1.75)	(-4.42, 2.53)	-0.55	0.59
	> $50,000 CAD (< $49,999 CAD)	-0.07	-1.23 (2.09)	(-5.38, 2.93)	-0.59	0.56
	Employed (Unemployed)	-0.05	-0.98 (2.31)	(-5.57, 3.62)	-0.42	0.67
	Married (Unmarried)	0.03	0.77 (2.97)	(-5.13, 6.68)	0.26	0.80

Chapter 5: Discussion

5.1 Objective 2: Examining dietary intake (e.g. total calorie intake, macronutrients, micronutrients, and food groups) of South Asian vegetarians and omnivores living in Metro Vancouver, BC

5.1.1 Summary of findings

This study compared dietary intake between vegetarians and omnivores in the South Asian, faith-based community of Metro Vancouver. Participants were identified as high risk for diabetes based on the ADA diabetes risk test. Aside from meat, seafood, and eggs, vegetarians and omnivores consumed fruits, vegetables, refined grains, snacks, sweets and desserts, and sugar-sweetened beverages at similar frequencies. 84.4% of participants consumed adequate amounts of carbohydrates, however, vegetarians received more of their total caloric intake from carbohydrates and consumed foods with a higher glycemic load and glycemic index. Moreover, saturated fat intake for both dietary groups was also elevated. While omnivores reported higher intake of several micronutrients (niacin, vitamin B-12, potassium, selenium and zinc), both dietary groups fell short of the AI for potassium and the EAR for niacin and vitamin D but exceeded the AI for sodium.[80]

5.1.2 Differences in vegetarian dietary intake between South Asians and Western populations

While the types of foods that make up vegetarian diets are not uniform and vary culturally, demographically and geographically, large studies conducted in Western populations (Adventist-2, NHANES) have generally found that vegetarians consume more fruits, vegetables, whole grains, legumes and nuts and less processed and refined foods, sweets, and desserts than omnivores.[136, 161] For example, the Adventist-2 study assessed dietary intake in 89,455 Seventh day Adventist men and women living in Canada and the United States between 2002 and 2007.[161] After adjusting for age, sex and race, vegetarians were found to consume more fruits, vegetables, whole grains, legumes, nuts and soy-based foods; and less dairy, eggs, refined grains, added fats, sweets, snack foods, sugar-sweetened beverages, coffee and alcohol than omnivores. Similarly, amongst 2,159 American participants that completed the NHANES survey between

2003 and 2006, vegetarians consumed more fruits, legumes and whole grains, and less eggs, refined grains, fried foods, desserts and sugar-sweetened beverages than omnivores.[136] On the contrary, in the Prevention Matters S-S South Asian cohort, with the exception of meat, seafood, and eggs, vegetarians and omnivores did not differ in their frequency of consumption of any food groups. In fact, both dietary groups consumed traditional vegetarian foods (e.g., fruits, vegetables, whole grains, beans, legumes and nuts) and unhealthier foods (e.g., refined grains, sugar-sweetened beverages, snacks, sweets and desserts) at similar frequencies. It would appear that the vegetarian dietary profile in the Prevention Matters S-S South Asian community is different than that of a more representative Western sample.

In Western culture, a "vegetarian diet" is associated with a "healthy diet" and is often adopted to improve individual health and lifestyle.[159-160] In fact, the Health, Aging, and Body Composition (Health ABC) Study in the United States identified three pertinent dietary patterns: healthy foods, sweets and desserts, and high fat dairy.[172] The "healthy foods" dietary pattern included fruits, vegetables, whole grains, poultry, fish and low-fat dairy products while restricting consumption of red meat, fried foods, sweets and added fats. With the exception of poultry and fish, the "healthy foods" dietary pattern is very similar to vegetarian diets reported in the Adventist-2 study and the NHANES study.[136, 161] Alternatively, the vegetarian profile in the Prevention Matters S-S has greater overlap with the "sweets and desserts" and "high fat dairy" patterns. In other words, not all vegetarian diets are created equally nor can all vegetarian diets be classified as "healthy."

5.1.3 Comparing vegetarian dietary intake across South Asian populations

When comparing the results from the present study to other studies targeting South Asian populations, inconsistencies in dietary intake emerge across the different cohorts. In contrast to the Prevention Matters S-S, the CARRS, Indian Migration and MASALA studies reported vegetarians to consume more vegetables, legumes, and whole grains.[136-137, 173] However, in the CARRS and Indian Migration studies–both were conducted in India–vegetarians also reported a greater intake of unhealthier foods such as fried foods, desserts, and sugar compared to omnivores.[136, 173] Based on these data, vegetarians of South Asian descent living inside and outside of South Asia are eating foods high in fat and sugar at the same amount if not more than their omnivore counterparts. These findings offer additional support that, within South Asian culture, the vegetarian diet may not necessarily offer favourable health benefits compared to the omnivore alternative.

It should be noted that not all studies of South Asian adults have shown less healthy dietary intake amongst vegetarians. Similar to the Prevention Matters S-S, the MASALA study was conducted with South Asian adults living in North America and utilized the SHARE FFQ to assess dietary intake.[137, 151] In that study, vegetarians were found to more frequently consume whole grains, beans, legumes, fats and oils while omnivores consumed more eggs, alcohol, sweets and desserts.[137] In other words, the food intake pattern of vegetarians in the MASALA study matched more closely with the patterns reported in the Adventist-2 and NHANES studies.[136, 161]

Notably, omnivores in the Prevention Matters S-S also more frequently consumed unhealthier foods (e.g. sugar-sweetened beverages, sweets and desserts) and less frequently consumed healthier foods (e.g. fruits and vegetables) compared to omnivores in the MASALA study.[137] Ultimately, the contrast in both vegetarian and omnivorous diets between participants in the Prevention Matters S-S and MASALA study may be due to the sociodemographic characteristics of these two cohorts, which were markedly different. In the Prevention Matters S-S, 75.5% of participants had equal to or less than a high school education; 72.9% reported an annual income of less $50,000 CAD; and 76.6% of participants were retired or not currently working. On the other hand, in the MASALA study, 87.8% had an education equivalent of a Bachelor's degree or higher; and 73.6% reported an annual income of $75,000 USD or greater.[137] Clearly, participants in the MASALA study were of higher SES compared to participants in the Prevention Matters S-S, which may have led to their healthier dietary intake. Thus, differences in the vegetarian dietary profile between the two studies could be, in part, attributed to sociodemographic factors.

5.1.4 Sociodemographic factors and dietary intake

SES can have a substantial impact on lifestyle behaviours including dietary intake. Individuals reporting lower education and income may have less access to healthy food items such as fruits, vegetables and whole grains, while convenience foods and non-perishable items are more affordable.[126-127] A qualitative study conducted with 28 Canadians diagnosed with cardiovascular disease found that participants of all SES levels were aware of the nutritional value of different food items. However, decisions around food consumption were dependent on financial commitments, bill payments and transportation costs.[128] Moreover, a survey of 24,879 households in the United Kingdom found that, compared to their higher SES counterparts, lower SES households were more likely to shop at less expensive grocery stores, spend less on food items, and purchase more unhealthier energy-dense food items.[129] Future qualitative studies are warranted to understand the unique sociodemographic challenges that impact dietary choices in the South Asian community.

Age can also be a factor associated with dietary intake. Prevention Matters S-S participants were considerably older than those in the MASALA study (65.2 years versus 55.3 years). It is well known that malnutrition and micronutrient deficiencies are a growing health concern for older adults (≥ 65 years), as individuals in this age demographic are at higher risk for acute and chronic diseases. Typically, older adults have lower total calorie requirements than their younger counterparts (< 65 years) due to changes in physical activity and metabolism.[174] Although healthier dietary intake has been reported amongst older compared to younger adults,[175] a 2014 study investigating dietary trends in older adults reported increased consumption of energy-dense diets comprised of greater amounts of refined grains and saturated fats.[176] Moreover, a study using NHANES data between 2005 and 2016 reported that older adults consumed more meals rich in carbohydrates and low in protein compared to younger adults.[177] Overall, it appears that diets in older adults tend to diverge into either a "healthy and low-energy dense" dietary pattern or a "less healthy and energy-dense" dietary pattern.[178-180] As expected, the latter pattern which contains more refined grains, saturated fats, red meat, fried foods and starchy vegetables has been correlated with increased odds for obesity and all-cause mortality in older adults.[178-179] Dietary intake amongst older adults in the present study aligns more closely with the "less healthy and energy-dense" dietary pattern.

5.1.5 The effects of Westernization on dietary intake in South Asian populations

The process of Westernization also affects dietary behaviours. Westernization has fuelled what has been termed a "nutrition transition" across the South Asian sub-continent, introducing processed foods and convenience items high in saturated fat, refined carbohydrates, sodium and consumption of red and processed meat.[52-55] Moreover, immigrants to Western countries experience dietary acculturation, a sociological phenomenon whereby minority groups including

South Asians adopt Western foods into their own traditional diets.[181] As such, traditional South Asian staple foods including rice, cereals, lentils, legumes and vegetables are being replaced by nutrient-poor foods.

The deleterious impact of Westernization can vary for multiples reasons. One mitigating factor in dietary acculturation is SES. While the mean years of living in North America were similar for Prevention Matters S-S and MASALA studies, the latter cohort reported a substantially higher SES.[137] Individuals of higher SES have been found to consume greater amounts of fruits, vegetables, whole grains, lean meats, fish and low-fat dairy products and less fried foods, refined grains, processed meats, added fats and sugar compared to individuals of lower SES.[127] It is possible that in immigrant communities, SES serves as a protective factor against the negative health effects of Westernization.

5.1.6 Carbohydrate and fat intake in the South Asian community

Although there was no difference in total mean caloric intake between vegetarians and omnivores (1937.84 calories versus 2068.98 calories), each group relied on different sources of macronutrients to meet their total calorie requirements. Consistent with the Prevention Matters S-S, studies conducted in the United States, United Kingdom and India also found vegetarians to consume more carbohydrates than their omnivore counterparts.[57, 134, 137] For example, amongst 4,508 South Asians from the United Kingdom Biobank, Tong and colleagues found that vegetarians had a higher percentage of their total calorie intake from carbohydrates compared to omnivores.[134] Shridhar et al., also reported that vegetarians in the Indian Migration Study had higher daily consumption of carbohydrates than omnivores.[173]

While quantity of carbohydrate intake is a consideration with regard to cardiometabolic risk, the quality of carbohydrates consumed is also important.[19, 32-38] Similar to the MASALA study, Prevention Matters S-S vegetarians had a diet characterized by a higher glycemic load and glycemic index compared to omnivores. In contrast, the Adventist-2 study and the NHANES study,[136, 161] found that vegetarians consumed fewer foods with a high glycemic index compared to omnivores. The relative increased consumption of processed foods and convenience foods high in refined carbohydrates, added sugars and overall calories could contribute to the trends observed among South Asian immigrants living in Western countries. It should be noted that, despite vegetarians having consumed foods with a higher glycemic load and glycemic index, both diet groups consumed high glycemic index food groups (e.g. starchy vegetables, refined grains, sweets, snacks, desserts and sugar-sweetened beverages) in similar amounts in the Prevention Matters S-S sample.

No differences in total fat consumption, including saturated and trans fats were found between vegetarians and omnivores. However, after adjusting for age, sex, and total calorie intake, mean saturated fat intake for both groups exceeded the recommended levels outlined by the ADA (less than 7% of total calorie intake from saturated fats).[100] Similarly, Tong et al., also found that South Asians in the United Kingdom had mean saturated fat intake above 10% after adjusting for age.[134] Cooking with ghee, vegetable ghee and butter are common to the South Asian community and may account for the high intake of saturated fats in the Prevention Matters S-S cohort.

The fat intake profile amongst participants in the Prevention Matters S-S is consistent with that of other South Asian communities in Canada. In fact, the Alberta Tomorrow Project, which recruited 140 South Asians (77% vegetarian) found that processed foods high in total fat, trans fat and refined carbohydrates comprised approximately 35% of total calorie intake amongst all participants.[182] It appears that, amongst South Asians living in Canada, adhering to a vegetarian diet involves the restriction of certain animal products while still consuming other unhealthy foods that may elevate risk for cardiovascular disease and diabetes. As such, the composition of a vegetarian diet may differ across cultures (Western versus South Asian). Both vegetarians and omnivores in the present study could benefit from lower intake of carbohydrates and fat, while increasing their intake of whole grains and fiber rich foods to meet their dietary intake recommendations.

5.1.7 Micronutrient profile and cardiometabolic risk

Inadequate intake of niacin, potassium and vitamin D have been associated with increased risk for cardiometabolic complications and the development of diabetes.[109-110, 183-184] In the present study, both diet groups reported micronutrient intake below the AI for potassium and the EAR for niacin and vitamin D (Table 4.5).[80] When the intakes of niacin, potassium and vitamin D in the present study are compared to the general Canadian population using data from the CCHS, findings are mixed. For example, inadequate niacin intake is reportedly prevalent in less than 10% of the Canadian population, yet all participants in the Prevention Matters S-S did not meet the EAR for niacin.[185] Comparatively, when examining potassium intake from the 2015 CCHS, vegetarians (3,918.3 mg) and omnivores (4,183.9 mg) in the Prevention Matters S-S had greater mean intake than the general Canadian population (2,697 mg), although both groups had potassium intake below the AI.[80, 186] Additionally, 99.0% of participants in the Prevention Matters S-S were not meeting the EAR for vitamin D, even though 14.6% of participants were using vitamin D supplements. When compared to Canadians of similar age (50 to 71 years), 95.7% of Canadians not using vitamin D supplements were not meeting the EAR, compared to only 8.3% of Canadians (aged 50 to 71 years) that were using vitamin D supplements.[187]

Similar deficiencies in niacin, potassium and vitamin D have also been reported in other studies with South Asians. For example, both vegetarians and omnivores in the MASALA study were not meeting the nutritional recommendations (AI or EAR) for these three micronutrients.[137] Interestingly, a case-control study of South Asians adults living in the United States found that those with diabetes had a lower intake of these three micronutrients compared to those without diabetes.[188] However, intake for the latter group were still below the EAR for these micronutrients.[80]

Fruits, vegetables, beans, legumes, and whole grains are important sources of niacin and potassium, while dairy products are rich in vitamin D. It is possible that low consumption of foods and/or supplements high in these micronutrients may account for micronutrient deficiencies amongst Prevention Matters S-S participants. Moreover, although subjects in the MASALA study reported higher consumption of foods rich in niacin, potassium and vitamin D, participant intake was still below the EAR for each of these micronutrients. Clearly, inadequate micronutrient intake is a pertinent issue affecting South Asian populations in North America.

Similar to both the MASALA study and the Indian Migration study, sodium intake for both vegetarians and omnivores in this study were well above the AI guidelines of 2,300 mg.[80, 137, 173] Research in South Asian populations links high sodium intake to increased risk for hypertension.[189-190] In addition to cooking with high amounts of salt, the incorporation of processed and refined foods into South Asian diets could contribute to the high intake of sodium amongst vegetarians and omnivores. As South Asians are thought to be genetically predisposed to hypertension, diabetes, and cardiovascular disease at greater rates than Caucasians,[35-41] dietary interventions to reduce sodium intake may be particularly relevant.

5.1.8 Limitations and future implications

There are important limitations to consider in this study. Firstly, this study was cross-sectional and dietary intake was assessed at a single point in time. Therefore, causal relationships cannot be determined. Other lifestyle factors that may impact diet such as physical activity were also not addressed in this study. The SHARE FFQ captures self-reported dietary intake that can be subject to social desirability and recall bias. As such, it is possible that participants may have over or underreported their intakes of certain foods based on these factors. Moreover, despite being validated and culturally tailored to the South Asian community, the SHARE FFQ contains a pre-defined list of foods which may not have captured all possible food items consumed by the Prevention Matters S-S cohort. Moreover, this study examined macronutrients, micronutrients and food groups individually rather than focusing on dietary patterns. The sample size included in this study was relatively small and included older South Asian adults who predominantly lower SES and identified as Sikh Punjabi. Therefore, results may not be generalizable to the larger South Asian community and should be interpreted with caution. The small sample size also limited the ability to examine or compare dietary intake amongst sub-groups of vegetarians. Future studies should recruit a larger sample size that are also culturally and demographically representative of the South Asian population living in a specific region. Longitudinal designs should also be used to assess changes and measure dietary intake over time. If feasible, studies should incorporate additional dietary measures, such as 24-hour recalls or objective measurement of diet through nutritional biomarkers, to reduce recall bias and validate data collected through the FFQ.

5.1.9 Conclusion

Diet is an important modifiable risk factor for cardiovascular disease and Type 2 diabetes. While vegetarian diets have been traditionally associated with improved cardiovascular health, this study shows that the consumption of foods high in refined carbohydrates, sugar, saturated fat, and sodium are similar for both vegetarians and omnivores. Therefore, the assumption that vegetarians follow healthy diets is not necessarily true in this South Asian community. Indeed, factors such as age, SES, and Westernization may exert influence on food choice and accessibility and should be considered when developing future interventions.

Ultimately, findings from this study demonstrate that nutritional interventions are warranted to improve diet and reduce cardiometabolic risk in Canada's South Asian community.

5.2 Objective 3: Evaluating the associations between vegetarian diets and sociodemographic characteristics with adiposity in South Asians living in Metro Vancouver, BC

5.2.1 Summary of findings

This study examined the relationship between diet and adiposity amongst South Asian adults in the Metro Vancouver area. Dietary preference (i.e. vegetarian or omnivore) was not linked to overweight and obesity. In fact, as defined by ICS-DOAMS guidelines mean BMI was in the obese range for both vegetarians and omnivores, and overall 90.6% of study participants in the Prevention Matters S-S were either overweight or obese according to this criteria.[42] Additionally, mean WC for both vegetarians and omnivores were above the abdominal obesity cutoffs for South Asian males (≥ 90 cm) and females (≥ 80 cm).[42] Being female and more educated was associated with higher BMI, while age was associated with higher WC.

5.2.2 Comparisons of adiposity measures between vegetarians and omnivores

This study found no differences in adiposity measures between vegetarians and omnivores. In contrast, other studies in non-South Asian populations have reported healthier adiposity measures amongst vegetarians. For example, a matched-cohort study of vegetarians and omnivores in Taiwan found that vegetarians had lower BMI and WC, including reduced prevalence of abdominal obesity compared to omnivores.[138] Similarly, in the EPIC-Oxford cohort vegetarians were found to have reduced adiposity and significantly lower BMI compared to omnivores.[139] In North America, lower adiposity has also been found amongst vegetarians. Hispanic vegetarians in the Adventist Multi-Ethnic Nutrition (AMEN) study were found to have lower BMI, WC and total body fat compared to omnivores.[140] Moreover, Matsumoto and colleagues found that amongst non-Hispanic Caucasians enrolled in the Adventist-2 study, vegetarians had significantly lower BMI and WC, as well as lower prevalence of obesity and abdominal obesity compared to omnivores.[141] Overall, adherence to a vegetarian diet has generally been associated with lower adiposity. However, amongst South Asians living in North America, the relationship between vegetarian diets and markers of adiposity is complex.

5.2.3 Measures of adiposity amongst South Asian vegetarians in North America

While the present study found no differences in BMI or WC between vegetarians and omnivores, other studies of South Asian adults living in North American have been mixed. The Diabetes amongst Indian Americans (DIA) study of 1,038 South Asian adults living in the United States reported a high prevalence of overweight (25.0%) and obesity (49.8%), and also found that vegetarians did not have reduced risk for obesity compared to omnivores.[191] On the contrary, the MASALA study which also recruited American adults of South Asian descent, reported that vegetarians had significantly lower BMI and WC compared to omnivores.[137] A possible explanation for these discrepancies between studies could be the composition of dietary intake. Compared to vegetarians in the Prevention Matters S-S, vegetarians in the MASALA study consumed fruits, vegetables, beans, legumes and whole grains more frequently and sugar-sweetened beverages, sweets and desserts less frequently.[137] Alternatively, over 50% of participants in the DIA study did not consume enough fruits and vegetables.[191] Increased consumption of fiber and protein rich foods such as fruits, vegetables, whole grains, beans and legumes, in combination with caloric restriction and reduced intake of added sugars have been recommended to reduce body weight and prevent the development of obesity and obesity related comorbidities.[192-193]

Amongst South Asian immigrants, dietary acculturation had led to the decreased intake of fiber and protein rich foods and increased intake of refined carbohydrates, processed foods and sugar-sweetened beverages. [52-58, 93] These changes may account for the rise in obesity amongst South Asians and may be a contributing factor to the high prevalence of overweight and obesity observed amongst participants (vegetarians and omnivores) in the present study as well as the DIA study.[191]

5.2.4 Comparisons and implications of adiposity measures across South Asian vegetarians

Although mean BMI for vegetarians in the present study was higher than mean BMI for vegetarians in the MASALA study (27.7 kg/m^2 versus 25.5 kg/m^2),[137] both values are in the obese range based on South Asian criteria.[42] Similar observations were made for mean WC, as both the Prevention Matters S-S and the MASALA study reported abdominally obese values

(100.4 cm versus 91.8 cm) according to ICS-DOAMS.[42, 137] Similarly, omnivores in the present study and the MASALA study had elevated and obese mean BMI (28.5 kg/m^2 versus 26.2 kg/m^2),[137] as well as elevated and abdominally obese mean WC (102.8 cm versus 93.2 cm).[42] The DIA study provided a mean BMI for the entire study population (25.4 kg/m^2),[191] which was also in the obese range according to ICS-DOAMS.[42] It would appear that amongst the South Asian community in North America both vegetarians and omnivores may be at greater risk for obesity related comorbidities at their respective BMI and WC levels. Therefore, it is important to identify which risk factors other than diet may be contributing to elevated adiposity in this ethnic group.

5.2.5 Sex and BMI

Females in this study were more likely to have a higher BMI compared to males, which is consistent with other studies in South Asian populations.[194-195] According to a population-based study in India, female sex was a significant risk factor for higher BMI and obesity.[194] Similarly, a nationwide study in Pakistan reported that females had significantly higher BMI and body fat compared to males.[195] Several metabolic factors may contribute to higher BMI levels in females. High levels of total body fat, subcutaneous fat and leptin levels have led to increased prevalence of overweight, obesity and abdominal obesity amongst South Asian females.[196-197] Additionally, age and physical inactivity may also contribute to higher BMI levels in females. In fact, Kozakowski and colleagues reported that during and post-menopause, metabolic changes occur in females which can lead to weight gain and the redistribution of body fat from the lower body to the abdominal region.[198] Moreover, South Asian females consistently report lower levels of activity that their male counterparts.[45, 199] It is likely that a combination of metabolic and unhealthy lifestyle behaviors can lead to higher BMI in South Asian females compared to their male counterparts.

5.2.6 Education and BMI

Individuals who achieved a high school education or greater were more likely to have a higher BMI compared to individuals with less than a high school education in this study. These findings are consistent with other studies in South Asian populations who also found a positive association between education level and BMI.[200-202] For example, results from a national health survey in India demonstrated that individuals with a higher education were more likely to be overweight or obese compared to their less educated counterparts.[201] Moreover, a representative cross-sectional study in Mumbai, India, found that achieving more years of education was associated with higher BMI and greater risk for obesity.[202] While this direct relationship between education and BMI is common in lower-income countries, it runs counter to data reported in high-income countries including Canada.[203-204] In fact, educational achievement may serve as a protective factor against obesity in more affluent nations.[205] This protective effect remains consistent amongst South Asian immigrants as well. For example, education level was inversely associated with BMI amongst South Asians in the Norwegian Immigrant-HUBRO study.[206] Therefore, findings in the present study raise concerns about other factors such as unhealthy lifestyle or genetic predisposition that may lead to increased BMI in more educated South Asians. Ultimately, further investigation into the relationship between education and adiposity is warranted in South Asian Canadians.

5.2.7 Age and WC

Age was positively associated with WC in this study, which is consistent with existing evidence demonstrating that WC increases with age.[170] Participants in the present study were primarily older adults and had mean WC values well above abdominally obese cut-offs according to ICS-DOAMS.[42] As such, WC may have been elevated amongst participants in this study due to the declines in muscle mass and the redistribution of subcutaneous fat to the abdominal region that occurs with older age.[170-171] Moreover, compared to Caucasians, South Asians typically have increased amounts of visceral fat at lower WC.[207] As such, early interventions to improve abdominal adiposity may be relevant to reduce WC measures in South Asians.

5.2.8 Limitations and future implications

This study has several limitations. First, given that this study utilized a cross-sectional design only associations could be reported. Second, the sample size was small and comprised of predominantly immigrant Sikh Punjabi older adults, the majority of whom were of lower SES and were classified as being either overweight or obese. Therefore, results may not be generalized to the larger South Asian community and should be interpreted with caution. Third, obese BMI has worse health implications than overweight BMI, however, due to limitations in sample size overweight and obesity were examined collectively rather than separately. BMI as a marker of body fat has inherent limitations, as this measure does not consider age, sex, or differences in body composition, including muscle mass. Therefore, when used alone, it may be worthwhile to consider BMI as an indicator rather than a determining factor for overweight and obesity. In addition to adiposity, it is also important to consider other factors such as BP, lipid profile, FBG and HbA1c when assessing risk for adverse metabolic conditions in South Asians. Future studies should also recruit larger and diverse samples of South Asians so that lifestyle factors and sociodemographic measures that may affect adiposity can be explored, determined, and generalized to the greater South Asian community in Canada.

5.2.9 Conclusion

In the Prevention Matters S-S South Asian population, adherence to a vegetarian diet was not associated with adiposity measures. Instead, greater attention needs to be focused on the foods and dietary practices common to both vegetarian and omnivorous diets that may lead to increased risk for overweight, obesity and other cardiovascular risk factors. In addition to the consumption of foods high in added fats, sugar, salt, and refined carbohydrates, other diet and lifestyle factors warrant further exploration including how foods are prepared, what role culture exerts on dietary habits, and the interplay between sociodemographic variables and nutrition.. Given that South Asians living in Canada are at greater risk for developing obesity-related comorbidities such as cardiovascular disease and diabetes compared to other ethnic groups, it is important to gain a more comprehensive understanding of diet and nutrition in this visible minority group as this a modifiable lifestyle behavior in which public health efforts can be targeted.

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Appendices

Appendix A

Coding manual of the adapted New Castle Ottawa Scale (NOS) for quality assessment of studies included in the systematic review.

<u>SELECTION</u> (Maximum 6 stars)

1) *<u>Representativeness of the sample.</u> (Maximum 1 star)*

   a) Truly representative of the target population (e.g. random sampling).*
   b) Somewhat representative of the target population (e.g. non-random sampling).*
   c) The sample population was selected (e.g. vegetarians and non-vegetarians).
   d) No description of the sampling strategy.

This item is assessing the recruitment methods and representativeness of the sample in the target population. For example, an observational study that recruits South Asian adults from a specialty clinic or university would not be very representative of this ethnic group (e.g. 1c). Rather, depending on study goals (cohort versus case-control versus cross-sectional), recruiting a random sample using various methods, including South Asian community centres, market places, neighbourhoods with a high density of South Asians, or South Asian centres of worship (Gurdwara's, temples, mosques) would approximate a truly representative sample of the South Asian community. The maximum number of stars that can be allotted is one.

2) *<u>Sample size.</u> (Maximum 1 star)*

   a) Justified and Satisfactory.*
   b) Not Justified.

Studies need to justify the size of their included sample (i.e. power calculation). If the sample size is too small, the study may fail to detect important associations. For this review, dietary data collected at one time point (cross-sectional) or at baseline (cohort) was primarily used. There may be instances where a study analyzes data collected from another study (e.g. a study that analyzes cross-sectional data from a larger cohort study). In this case, literature from the study in which data was collected may need to be searched to justify sample size. The maximum number of stars that can be allotted (only if 2a is applicable) is one.

3) *<u>Study response rate and non-respondents.</u> (Maximum 2 stars)*

   a) The response rate is satisfactory.*
   b) Comparability between the responders and the non-responders has been established.*
   c) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.

This refers to response rate for the study – how many potential participants were enrolled and how many of those who were considered eligible for inclusion agreed to participate. A response rate of 70% or higher will be considered satisfactory. To rule out non-response bias, it is important that the study provides information on the characteristics of non-responders (individuals who did not complete a subjective dietary assessment or chose not to participate in the study). The study should establish whether there were any significant characteristic (e.g. age, sex, income, education) differences between those who responded and those who did not.

4) *<u>Ascertainment of dietary information.</u> (Maximum 2 stars)*
   a) A validated dietary instrument was administered.**
   b) A structured interview or non-validated dietary instrument was administered (tool is available or described).*

For the purpose of this review, the delivery of a subjective and validated dietary instrument, which is an open-ended survey or questionnaire (e.g. food frequency questionnaire, 24-hour recall, dietary record, dietary history), will be considered above satisfactory. Structured interviews or non-validated dietary instruments (i.e. the instrument has not been compared against a validated dietary instrument) will be considered satisfactory due to the potential for interviewer bias and social desirability bias. The maximum number of stars that can be allotted (only if 4a is applicable) is two. Only one star will be administered if 4b is applicable.

COMPARABILITY (Maximum 2 stars)

1) *Subjects across dietary groups (e.g. vegetarian, including vegan, lacto-vegetarian, lacto-ovo-vegetarian, pesco-vegetarian, semi-vegetarian; non-vegetarian) are comparable, based on the study design or analysis. (Maximum 2 stars)*

    a) The study controls for the most important factor (i.e. SES).*
    b) The study controls for any additional factors (e.g. age, sex/sex, alcohol consumption, smoking status).*

    This item focuses on the comparisons of cardiometabolic risk factors associated with vegetarian diets with each other (including vegetarian diet subgroups, such as vegan, lacto-vegetarian, lacto-ovo-vegetarian, pesco-vegetarian, semi-vegetarian) and/or with cardiometabolic risk factors associated with non-vegetarian diets. It is important that studies control for SES (i.e. education, income, employment), which is an important variable that can influence dietary behaviors and the subsequent development of cardiometabolic complications. The maximum number of stars that can be allotted to this item is two – one for adjusting for the most important factors and one for any additional factors.

OUTCOMES (Maximum 4 stars)

1) *Assessment of cardiometabolic outcomes. (Maximum 2 stars)*

    a) Cardiometabolic outcomes are self-reported and objectively measured.**
        - Outcomes (e.g. overweight/obesity, hypertension, LDL cholesterol, triglycerides and fasting blood glucose) are self-reported/reported through medical record and are measured objectively by research staff (e.g. using medical equipment, blood test). This makes it possible to corroborate and validate outcomes.
    b) Cardiometabolic outcomes are only objectively measured.**
        - Outcomes (e.g. overweight/obesity, hypertension, LDL cholesterol, triglycerides and fasting blood glucose) are only measured objectively by research staff (e.g. using medical equipment, blood test).
    c) Cardiometabolic outcomes are only subjectively measured.*
        - Outcomes (e.g. overweight/obesity, hypertension, LDL cholesterol, triglycerides and fasting blood glucose) are only self-reported or are reported through medical record.

2) *Statistical testing. (Maximum 2 stars)*

    a) The statistical test(s) used to analyze study data are clearly described and appropriate.*
    b) Outcome measures and associations are presented with confidence intervals (or standard deviations) and the probability level (p-value).*
    c) The statistical test(s) used to analyze study data are not described, inappropriate or incomplete.

Threshold Domains (Good, Fair or Poor Quality)

Good quality: 5 or 6 stars in selection domain AND 1 or 2 stars in comparability domain AND 3 or 4 stars in outcomes domain.

Fair quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 3 or 4 stars in outcomes domain.

Poor quality: ≤ 2 stars in selection domain OR 0 stars in comparability domain OR 0 or 1 stars in outcomes domain.

Appendix B

Reporting quality of studies included in the systematic review using STROBE guidelines.

Items	Item Number	Recommendation	Agrawal et al. (2014)	Gadgil et al. (2014)	Jaacks et al. (2016)	Jin et al. (2018)	Praharaj et al. (2017)	Shridhar et al. (2014)	Tong et al. (2018)
			Cross-Sectional (India)	Cross-Sectional (U.S)	Cross-Sectional (India)	Cross-Sectional (U.S)	Cross-Sectional (India)	Cross-Sectional (India)	Cross-Sectional (U.K.)
Title and Abstract	1	a) Indicate the study's design with a commonly used term in the title or the abstract	X - Pg. 1	Not Indicated	X - Pg. 975	Not Indicated	X - Pg. 351	Not Indicated	X - Pg. 909
		b) Provide in the abstract an informative and balanced summary of what was done and what was found	X - Pg. 1	X - Pg. 1	X - Pg. 975	X - Pg. 1	X - Pg. 351	X - Pg. 1	X - Pg. 909
Introduction									
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	X - Pgs. 1-2	X - Pg. 2	X - Pg. 976	X - Pgs. 1-2	X - Pg. 351-352	X - Pgs. 1-2	X - Pg. 909
Objectives	3	State specific objectives, including any prespecified hypotheses	X - Pg. 2	X - Pg. 2	X - Pg. 976	X - Pg. 2	X - Pg. 352	X - Pg. 2	X - Pg. 909
Methods									
Study design	4	Present key elements of study design early in the paper	X - Pg. 2	X - Pg. 2	X - Pg. 976-977	X - Pg. 2	X - Pg. 352	X - Pg. 2	X - Pg. 910
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	X - Pgs. 2-3	X - Pg. 2	X - Pg. 976	X - Pg. 2	X - Pg. 352	X - Pg. 2	X - Pg. 910
Participants	6	Give the eligibility criteria, and the sources and methods of selection of participants	X - Pg. 2	X - Pg. 2	X - Partially Described on Pg. 976 (Thorough Description in Original Study Methods)	X - Partially Described on Pg. 2 (Thorough Description in Original Study Methods)	X - Pg. 352	X - Partially Described on Pg. 2 (Thorough Description in Original Methods)	X - Partially Described on Pg. 910 (Thorough Description in Original Methods)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	X - Pgs. 2-3	X - Pg. 3	X - Pgs. 976-977	X - Pg. 3	X - Pg. 353	X - Pgs. 2-3	X - Pgs. 910-911
Data sources/Measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	X - Pgs. 2-3	X - Pg. 3	X - Pgs. 976-977	X - Pg. 3	X - Pg. 353	X - Pgs. 2-3	X - Pgs. 910-911
Bias	9	Describe any efforts to address potential sources of bias	X - Pg. 3 (Analysis Methods, Further Description in Original Study)	Not Specified (Description in Original Study)	Not Specified	Not Specified	Not Specified	X - Pg. 3 (Analysis Methods)	X - Pg. 919
Study size	10	Explain how the study size was arrived at	X - Pg. 2	Not Specified (Description in Original Study)	Not Specified (Description in Original Study)	Not Specified (Description in Original Study)	X - Pg. 352, 354	X - Pg. 2 (Further Description in Original Study)	X - Pg. 910 (Further Description in Original Study)
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	X - Pgs. 3, 6	X - Pg. 3	X - Pg. 977	X - Pg. 2	X - Pg. 354	X - Pg. 3	X - Pg. 911
Statistical Methods	12	a) Describe all statistical methods, including those used to control for confounding	X - Pg. 3	X - Pg. 3	X - Pg. 977	X - Pgs. 2-3	X - Pgs. 353-354	X - Pg. 3	X - Pg. 911
		b) Describe any methods used to examine subgroups and interactions	X - Pg. 3	Not Applicable	X - Pg. 976-977	Not Applicable	Not Applicable	Not Applicable	Not Applicable
		c) Explain how missing data were addressed	Not Specified	Not Specified	Not Specified	X - Pg. 2	Not Specified	Not Specified	X - Pg. 911
		d) If applicable, describe analytical methods taking account of sampling strategy	X - Pg. 3	Not Indicated	Not Indicated	Not Indicated	Not Indicated	X - Pg. 3	Not Indicated
		e) Describe any sensitivity analyses	Not Indicated	X - Pg. 3	X - Pg. 977	X - Pg. 3	Not Indicated	Not Indicated	Not Indicated

Items	Item Number	Recommendation	Agrawal et al. (2014)	Gagdil et al. (2014)	Jaacks et al. (2016)	Jin et al. (2018)	Praharaj et al. (2017)	Shridhar et al. (2014)	Tong et al. (2018)
			Cross-Sectional (India)	Cross-Sectional (U.S)	Cross-Sectional (India)	Cross-Sectional (U.S)	Cross-Sectional (India)	Cross-Sectional (India)	Cross-Sectional (U.K.)
Results									
Participants	13	a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	X - Pg. 2	X - Partially Described on Pg. 2 (Thorough Description in Original Study)	X - Partially Described on Pg. 976 (Thorough Description in Original Study)	X - Partially Described on Pg. 2 (Thorough Description in Original Study)	X - Pgs. 352, 354	X - Partially Described on Pg. 2 (Thorough Description in Original Study)	X - Pg. 911
		b) Give reasons for non-participation at each stage	Not Specified	Not Specified (Described in Original Study)	Not Specified	Not Specified (Described in Original Study)	X - Pgs. 352, 354	Not Specified (Described in Original Study)	Not Specified (Described in Original Study)
		c) Consider use of a flow diagram	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified
Descriptive Data	14	a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	X - Pgs. 2-3	X - Pgs. 2-3 Table 2	X - Pg. 976, Table 1	X - Pg. 3, Table 1, Supplementary Tables 1-4	X - Pgs. 354-355	X - Pg. 3	X - Pg. 911, Table 3
		b) Indicate number of participants with missing data for each variable of interest	Not Specified	Not Specified	Not Specified	X - Table 1	Not Specified	Not Specified	Not Specified
Outcome Data	15	Report numbers of outcome events or summary measures	X - Pg. 6, Tables 3-4	X - Pg. 4, Tables 2-3	X - Pg. 978, 980, Figure 2, Table 3	X - Pgs. 2-3, Tables 1, 4, Fig. 1	X - Pgs. 354, 358, Tables 1-4	X - Pg. 3, Tables 1, 3	X - Pg. 911, Table 3, Figs. 3-4
Main Results	16	a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included	X - Pg. 6, Tables 3-4, 6-7	X - Pg. 4, Tables 2-3	X - Pg. 978, 980, Figure 2, Table 3	X - Pgs. 2-3, Tables 1, 4, Fig. 1	X - Pgs. 354, 358, Tables 1-4	X - Pg. 3, Tables 1, 3	X - Pg. 911, Table 3, Figs. 3-4
		b) Report category boundaries when continuous variables were categorized	X - Pg. 3	X - Table 2	X - Pg. 977, Figure 2, Table 1, Table 3	X - Pg. 3, Table 1	X - Pg. 353	X - Pg. 3	X - Pg. 911
		c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Indicated	Not Indicated	Not Indicated	Not Indicated	Not Indicated	Not Indicated	Not Indicated
Other Analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses	X - Pg. 3, 6	X - Pg. 3	X - Pg. 977	X - Pg. 3	X - Pg. 354	X - Pg. 3	X - Pg. 911
Discussion									
Key Results	18	Summarise key results with reference to study objectives	X - Pgs. 6-7, 9	X - Pgs. 3-4	X - Pgs. 977-978, 980-981	X - Pgs. 4-6	X - Pgs. 358-359	X - Pgs. 3-5	X - Pgs. 911-912
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	X - Pgs. 13, 15	X - Pg. 5	X - Pgs. 982-983	X - Pg. 6	Not Specified	X - Pg. 7	X - Pg. 919
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	X - Pgs. 11, 13-16	X - Pgs. 4-5	X - Pgs. 982-983	X - Pgs. 4-6	X - Pgs. 358-360	X - Pgs. 4-5, 7	X - Pg. 912-914, 919
Generalisability	21	Discuss the generalisability (external validity) of the study results	X - Pgs. 15-16	X - Pg. 5	X - Pg. 982-983	X - Pg. 6	X - Pg. 360	X - Pgs. 4, 7	X - 919
Other Information									
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	X - Pg. 16	X - Pg. 5	X - Pg. 975	X - Pg. 1	X - Pg. 361	X - Pg. 1	X - Pg. 909

Appendix C

Quality assessment of studies included in the systematic reviews using the adapted NOS scale.

Adapted NOS items	Agrawal et al. (2014)	Gagdil et al. (2014)	Jaacks et al. (2016)	Jin et al. (2018)	Praharaj et al. (2017)	Shridhar et al. (2014)	Tong et al. (2018)
SELECTION (Maximum 6 stars)	Cross-Sectional (India)	Cross-Sectional (U.S)	Cross-Sectional (South Asia)	Cross-Sectional (U.S.)	Cross-Sectional (India)	Cross-Sectional (India)	Cross-Sectional (U.K.)
1) Representativeness of the sample. (Maximum 1 star)							
a) Truly representative of the target population (e.g. random sampling).*			*			*	
b) Somewhat representative of the target population (e.g. non-random sampling).*	*	*		*			*
2) Sample size. (Maximum 1 star)							
a) Justified and Satisfactory.*	* (Specified in Original Study)		* (Specified in Original Study)	* (Specified in Original Study)			
3) Study response rate and non-respondents. (Maximum 2 stars)							
a) The response rate is satisfactory.*	*		*	*	*	*	*
b) Comparability between the responders and the non-responders has been established.*						*	
4) Ascertainment of dietary information. (Maximum 2 stars)							
a) A validated dietary instrument was administered.**		**	**	**		**	**
b) A structured interview or non-validated dietary instrument was administered (tool is available or described).*	*				*		

Adapted NOS items	Agrawal et al. (2014)	Gagdil et al. (2014)	Jaacks et al. (2016)	Jin et al. (2018)	Praharaj et al. (2017)	Shridhar et al. (2014)	Tong et al. (2018)
COMPARABILITY (Maximum 2 stars)							
1) The subjects in different dietary groups (e.g. vegetarian or if applicable, vegan, lacto-vegetarian, lacto-ovo-vegetarian, pesco-vegetarian, semi-vegetarian; non-vegetarian) are comparable, based on the study design or analysis. (Maximum 2 stars)							
a) The study controls for the most important factor that can influence dietary choices (i.e. socioeconomic status).*	*	*				*	
b) The study controls for any additional factors that can influence dietary choices (e.g. age, sex/gender, alcohol consumption, smoking status).*	*	*	*	*	*	*	*
OUTCOMES (Maximum 4 stars)							
1) Assessment of cardiometabolic outcomes. (Maximum 2 stars)							
a) Cardiometabolic outcomes are self-reported and objectively measured.**							
b) Cardiometabolic outcomes are only objectively measured.**	**	**	**	**	**	**	**
c) Cardiometabolic outcomes are only subjectively measured.*							
2) Statistical testing. (Maximum 2 stars)							
a) The statistical test(s) used to analyze study data are clearly described and appropriate.*	*	*	*	*	*	*	*
b) Outcome measures and associations are presented with confidence intervals (or standard deviations) and the probability level (p-value).*	*	*	*	*	*	*	*
Quality of Study	Fair	Fair	Good	Good	Poor	Good	Fair

Appendix D

ADA Risk Test used to assess diabetes risk at 12 health screenings in the Prevention Matters study.

Are you at risk for type 2 diabetes?

WRITE YOUR SCORE IN THE BOX.

1. How old are you? ☐
- Less than 40 years (0 points)
- 40–49 years (1 point)
- 50–59 years (2 points)
- 60 years or older (3 points)

2. Are you a man or a woman? ☐
Man (1 point) Woman (0 points)

3. If you are a woman, have you ever been diagnosed with gestational diabetes? ☐
Yes (1 point) No (0 points)

4. Do you have a mother, father, sister or brother with diabetes? ☐
Yes (1 point) No (0 points)

5. Have you ever been diagnosed with high blood pressure? ☐
Yes (1 point) No (0 points)

6. Are you physically active? ☐
Yes (0 points) No (1 point)

7. What is your weight category? ☐
See chart at right.

ADD UP YOUR SCORE. ☐

Height	Weight (lbs.)		
4′ 10″	119–142	143–190	191+
4′ 11″	124–147	148–197	198+
5′ 0″	128–152	153–203	204+
5′ 1″	132–157	158–210	211+
5′ 2″	136–163	164–217	218+
5′ 3″	141–168	169–224	225+
5′ 4″	145–173	174–231	232+
5′ 5″	150–179	180–239	240+
5′ 6″	155–185	186–246	247+
5′ 7″	159–190	191–254	255+
5′ 8″	164–196	197–261	262+
5′ 9″	169–202	203–269	270+
5′ 10″	174–208	209–277	278+
5′ 11″	179–214	215–285	286+
6′ 0″	184–220	221–293	294+
6′ 1″	189–226	227–301	302+
6′ 2″	194–232	233–310	311+
6′ 3″	200–239	240–318	319+
6′ 4″	205–245	246–327	328+
	1 point	2 points	3 points

If you weigh less than the amount in the left column: 0 points

Adapted from Bang et al., Ann Intern Med 151:775–783, 2009.
Original algorithm was validated without gestational diabetes as part of the model.

If you scored 5 or higher:

You are at increased risk for having type 2 diabetes. However, only your doctor can tell for sure if you do have type 2 diabetes or prediabetes, a condition in which blood glucose levels are higher than normal but not yet high enough to be diagnosed as diabetes. Talk to your doctor to see if additional testing is needed.

Type 2 diabetes is more common in African Americans, Hispanics/Latinos, Native Americans, Asian Americans, and Native Hawaiians and Pacific Islanders.

Higher body weight increases diabetes risk for everyone. Asian Americans are at increased diabetes risk at lower body weight than the rest of the general public (about 15 pounds lower).

The good news is you can manage your risk for type 2 diabetes. Small steps make a big difference in helping you live a longer, healthier life.

For more information, visit us at **diabetes.org/alertday** or call **1-800-DIABETES (800-342-2383).**

American Diabetes Association.

Appendix E

Example of a completed SHARE FFQ administered to all study participants.

NutriMAPS **FFQ-SA Instructions**

HOW TO FILL OUT THIS QUESTIONNAIRE

We would like to know about your usual eating habits DURING THE LAST ONE YEAR.
Please complete this questionnaire without the help of your family or friends.
It will take you 30 minutes to 1 hour to finish.

1. For each food item listed in the booklet, choose **one** column (Per Day, Per Week, Per Month or Per Year/Never) that best describes HOW OFTEN you ate or drank that item. For example, if you ate EGGS 2 times per week during the last year, you would write | 0 | 2 | in the PER WEEK column.

   If you don't recognize the name, you probably don't eat it. If you never ate an item in the past year, fill in the last column (PER YEAR or NEVER) with 0 (= never eaten). DO NOT LEAVE BLANK.

2. We then want to know what size your USUAL SERVING is. We have given an example of an average serving size: is it less than that, the same, or more than that? Less than average = 3/4 or less than the average size. More than average = 1 1/4 times or more than the average size. Mark your serving size by putting an **X** in **one** of the boxes DO NOT LEAVE BLANK..

   Some questions ask you to refer to the picture page to help you to choose your usual serving size. Please use this page when filling out this questionnaire.

   If you never ate an item, it is not necessary to choose a serving size for that item.

3. Please try to average your seasonal use of foods over the entire year.

Please use a black pen to fill out this questionnaire.

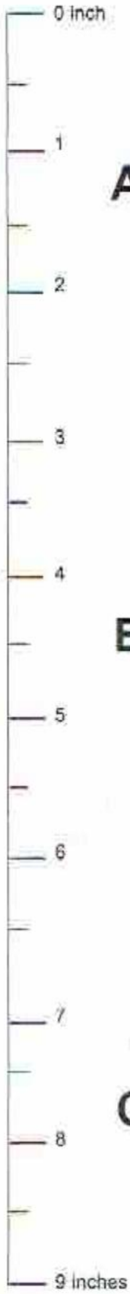
EXAMPLE

	How often? *Write in ONE column only*				Average Serving	Your Serving Size		
	Per Day	Per Week	Per Month	Per Year or Never		Less Than Average (small)	Average (medium)	More Than Average (large)
26. EGG, boiled, poached		0 2			1 egg	S	X	L
48. FRENCH FRIES and FRIED POTATOES			0 3		1 cup or small McDonald's	S	X	L
87. HOT DOGS, SAUSAGES (example pork, link sausages)				0 0	1hot dog or 2 links	S	M	L
112. BRAN or OAT MUFFINS		0 1			1 small or 1/2 large	S	M	X

QUESTIONS?
PLEASE CALL THE OFFICE AT 1-800-263-9428

Adapted from the Study of Health Assessment and Risk

Some foods in the questionnaire ask you to refer to either photo A, B or C to help you estimate your usual serving size. Please note that the dinner plate is 9 inches wide. The ruler on the left will help you to estimate this size.

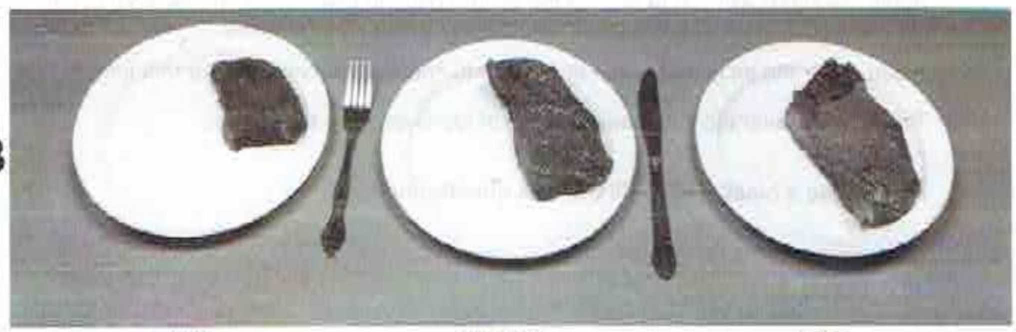


A

SMALL MEDIUM LARGE

Size of Dinner Plate Shown is 9 inches

B



SMALL MEDIUM LARGE

Size of Dinner Plate Shown is 9 inches

C

SMALL MEDIUM LARGE

Size of Dinner Plate Shown is 9 inches

NutriMAPS FFQ-SA **SA-FFQ 3**

DRFAT

ID#

			P	M	1	1	8

Client # *Participant #*

Date 14 07 05
year *month* *day*

BEVERAGES	How often? *Write in ONE column only* Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
1. WHOLE MILK (HOMO) (as beverage or in cereal, but not in coffee or tea)				00	1 cup or 250 ml			
2. 2% MILK (includes Lactaid) (as beverage or in cereal, but not in coffee or tea)	01				1 cup or 250 ml		X	
3. 1% MILK (as beverage or in cereal, but not in coffee or tea)				00	1 cup or 250 ml			
4. SKIM MILK (as beverage or in cereal, but not in coffee or tea)				00	1 cup or 250 ml			
5. COFFEE, regular (brewed or instant)				01	1 cup or 250 ml	X		
6. COFFEE, decaffeinated				00	1 cup or 250 ml			
7. TEA, regular (Red Rose, Salada)	03				1 cup or 250 ml		X	
8. MILK in Tea and Coffee Please mark type:								
Homo milk	01				2 tbsp or 30 ml			X
2%/1%	02				2 tbsp or 30 ml			X
Skim					2 tbsp or 30 ml			
9. CREAM in Tea and Coffee Please mark type:								
Coffee cream				00	1 tbsp or 15 ml			
Half & Half				00	1 tbsp or 15 ml			
Non dairy creamer				00	1 tbsp or 15 ml			

NutriMAPS FFQ-SA SA-FFQ 4

DRFAT

ID# | | Client # | Participant # 118

BEVERAGES cont.	How often? Write in ONE column only: Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
10. SUGAR or HONEY in Tea and Coffee	03				1 tsp or 1 pak	X	M	L
11. COLAS, non dietetic (Coca Cola, Pepsi)				04	1 can or 355 ml	X	M	L
12. OTHER SOFT DRINKS, non dietetic (7-Up)				04	1 can or 355 ml	X	M	L
13. DIET COLAS				00	1 can or 355 ml	S	M	L
14. ORANGE, GRAPEFRUIT JUICE			01		3/4 cup or 175 ml	X	M	L
15. APPLE, PINEAPPLE, OTHER JUICES				00	3/4 cup or 175 ml	S	M	L
16. FRUIT DRINK (iced tea, lemonade)				00	1 cup or 250 ml	S	M	L
17. VEGETABLE JUICE				00	3/4 cup or 175 ml	S	M	L
18. YOGURT DRINK (also Lassi with sugar)				00	1 cup or 250 ml	S	M	L
19. BEER, ALE				00	1 bottle or 355 ml	S	M	L
20. WHITE WINE				00	5 oz or 150 ml	S	M	L
21. RED WINE, SHERRY, PORT				00	5 oz or 150 ml	S	M	L
22. SPIRITS, Liquor only				00	1.5 oz or 45 ml	S	M	L

NutriMAPS **FFQ-SA** **SA-FFQ 5**

DRFAT

ID#

Client # | Participant # PM118

DAIRY PRODUCTS	Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Less Than Average (small)	Average (medium)	More Than Average (large)
23. EGG (ANDA), boiled, poached				00	1 egg	S	M	L
24. EGG, fried, scrambled, curry				00	1 egg	S	M	L
25. CHEESE, regular fat, CREAM CHEESE				00	1 slice or 2 tbsp	S	M	L
26. CHEESE, part-skim				00	1 slice or 30 gm	S	M	L
27. YOGURT, CURD, plain, regular fat		04			3/4 cup or 175 ml	X	M	L
28. YOGURT, Buttermilk, plain, low fat				00	3/4 cup or 175 ml	S	M	L
29. RAITA, with vegetables (cucumber, tomato, onion)				00	1/2 cup or 125 ml	S	M	L
30. YOGURT, fruit flavored			01		3/4 cup or 175 ml	S	X	L
31. PANIR, RICOTTA CHEESE in curry, Malai kofta, Matar pani				00	photo B, medium (1/2 cup)	S	M	L
VEGETABLES, PEAS AND BEANS								
32. POTATOES, boiled, mashed or baked			02		1 medium or 1/2 cup	X	M	L
33. POTATO SABJI, stir fried, dry or sukhi (made with no liquid, tari or sauce)			02		photo A, small (1/2 cup)	S	M	X
34. POTATO SABJI, curry (made with liquid, tari)			02		photo B, medium (1/2 cup)	S	M	X

NutriMAPS FFQ-SA SA-FFQ 6

DRFAT

ID# 118

Client # Participant #

VEGETABLES, PEAS AND BEANS cont.	How often? Write in ONE column only: Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
35. CAULIFLOWER or CABBAGE SABJI, stir fried			02		photo A, small (1/2 cup)			X
36. GREEN PEPPER SABJI, stir fried				06	photo A, small (1/2 cup)			X
37. FRENCH BEANS, STRING BEANS, stir fried			02		photo A, small (1/2 cup)			X
38. BROCCOLI SABJI, stir fried				00	photo A, small (1/2 cup)			
39. PEAS or MATAR CURRY (includes corn)			02		photo B, medium (1/2 cup)			X
40. OKRA or BHINDI, stir fried			02		photo A, small (1/2 cup)			X
41. DARK LEAFY VEGETABLES (example spinach, palak ka saag, sarson ka saag)		02			1/2 cup or 125 ml			X
42. TOMATO, fresh			02		1 medium	X		
43. ONIONS, raw, cooked, (alone or in mixed dishes such as curries)	02				1/2 cup or 125 ml	X		
44. YELLOW SQUASH, PUMPKIN				06	1/2 cup or 125 ml			X
45. WHITE SQUASH, GHIA, ZUCCHINI, EGGPLANT		01			1/2 cup or 125 ml			X
46. VEGETABLE KOFTA CURRY				04	photo B, medium (1/2 cup)			X
47. LETTUCE		01			1 cup or 250 ml	X		

DRFAT

ID#

Client # | Participant # PM118

VEGETABLES, PEAS AND BEANS cont.	How often? *Write in ONE column only* Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
48. CUCUMBER	01				1/2 cup or 125 ml	X	M	L
49. CARROTS, raw or boiled				00	1/2 cup or 125 ml	S	M	L
50. CARROTS SABJI, stir fried				06	photo A, small (1/2 cup)	S	M	X
51. MIXED VEGETABLE SALADS (kachumbar, onion, tomato, pepper)				00	1/2 cup or 125 ml	S	M	L
52. SWEET POTATO, LEEKS, RADISH, OTHER ROOTS	01				1/2 cup or 125 ml	X	M	L
53. OTHER VEGETABLES, CURRY (example mushrooms, celery)				00	photo B, medium (1/2 cup)	S	M	L
54. OTHER VEGETABLES, STIR FRIED (example mushrooms, celery)				00	photo A, small (1/2 cup)	S	M	L
COOKED DRIED BEANS AND LENTILS								
55. LENTIL/DAL CURRY (moong, masoor, urad, chana dal, split peas, besan curry)	01				photo B, medium (1/2 cup)	X	M	L
56. SAMBHAR, RASAM				00	photo B, medium (1/2 cup)	S	M	L
57. CHICK PEAS CURRY (chana, white gram)			03		photo B, medium (1/2 cup)	X	X	L
58. OTHER DRIED BEANS CURRY (kidney beans/Rajmah, black-eyed beans)			02		photo B, medium (1/2 cup)	S	X	L

ID# Client # Participant # 118

COOKED DRIED BEANS AND LENTILS cont.	Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Less Than Average (small)	Average (medium)	More Than Average (large)
	How often? *Write in ONE column only*					Your Serving Size		
59. DHOKLA, IDLI (includes KHICHRI, no ghee)				00	2, 2" pieces	S	M	L
60. DOSA				00	1 medium	S	M	L
61. BUTTER/PURE GHEE on lentils, baghar	02				1 tsp or 1 pat	X	M	L
62. MARGARINE on lentils, baghar				00	1 tsp or 1 pat	S	M	L
MEATS/GOSHT								
63. BEEF CURRY, kofta, no vegetables				00	photo B, medium (1/2 cup)	S	M	L
64. GROUND BEEF (mince, hamburger, keema kabob, dry kofta)				00	6" kabob or 2 kofta or 3" patty	S	M	L
65. OTHER BEEF (roast, steak)				00	photo C, medium	S	M	L
66. PORK CURRY, kofta, no vegetables				00	photo B, medium (1/2 cup)	S	M	L
67. OTHER PORK (pork chop, mince,keema, kabob, dry kofta)				00	6" kabob or 2 kofta or 3" patty	S	M	L
68. GOAT , LAMB CURRY, no vegetables				00	photo B, medium (1/2 cup)	S	M	L
69. OTHER GOAT, LAMB (mince, roast, steak, chop, keema, kabob, dry kofta, raan)				00	6" kabob or 2 kofta or 3" patty	S	M	L
70. HOT DOGS, SAUSAGES (example pork, link sausages)				00	1 hot dog or 2 links	S	M	L

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MEATS/GOSHT cont.	Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Less Than Average (small)	Average (medium)	More Than Average (large)
71. LUNCH MEAT (ham, salami, bologna, bacon)				00	1 slice (about 30 g)	S	M	L
72. LIVER, fried or tala kaleja				00	photo C, medium	S	M	L
73. FRIED CHICKEN, (includes chicken nuggets), CHICKEN WINGS				00	photo C, medium or 4 wings	S	M	L
74. CHICKEN CURRY (includes turkey, duck)				00	photo B, medium (1/2 cup)	S	M	L
75. ROAST, TANDOORI CHICKEN, tikka, in rice				00	photo C, medium	S	M	L
76. FRESH FISH, MACHLI, steamed, baked				00	photo C, medium	S	M	L
77. FISH CURRY, fish ball, kofta curry				00	photo B, medium (1/2 cup)	S	M	L
78. CANNED FISH, salmon, sardines				00	1/2 can or 50 gm	S	M	L
79. DEEP FRIED FISH, breaded, battered, fish stick, tali machli				00	photo C, medium or 5 fish sticks	S	M	L
80. SEAFOOD, SHRIMP CURRY				00	photo B, medium (1/2 cup)	S	M	L
BREADS, CEREALS AND GRAINS								
81. WHITE BREAD				00	1 slice	S	M	L
82. WHOLE WHEAT BREAD, 100% (includes dark rye)			01		1 slice	S	X	L
83. WHOLE WHEAT BREAD, 60% (includes light rye)				00	1 slice	S	M	L

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BREADS, CEREALS AND GRAINS cont.	How often? *Write in ONE column only* Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
84. BREAD ROLLS (white flour), kaisers, bagels, hamburger/ hot dog buns				00	1 medium	S	M	L
85. BREAD ROLLS (whole wheat), kaisers, bagels				02	1 medium	X	M	L
86. ROTI, CHAPATI	02				1, 6" diameter	S	X	L
87. NAAN, PITA BREAD				06	1, 6" diameter	X	M	L
88. PARATHA, made with: oil		02			1, 6" diameter	S	X	L
pure ghee				00	1, 6" diameter	S	M	L
vegetable ghee				00	1, 6" diameter	S	M	L
89. PURI / MATHRI, fried in oil			02		1, 4" diameter	S	M	X
90. BRAN/GRANOLA CEREALS Specify usual brand: unknown		02			3/4 cup or 175 ml	S	X	L
91. WHOLE WHEAT CEREALS (such as Shreddies) Specify usual brand:				00	1 cup or 250 ml	S	M	L
92. SUGAR COATED CEREALS (Frosted Flakes, Fruit Loops) Specify usual brand:				00	1cup or 250 ml	S	M	L
93. NO SUGAR CEREALS (Corn Flakes, Rice Krispies) Specify usual brand:				00	1cup or 250ml	S	M	L

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BREADS, CEREALS AND GRAINS cont.	How often? *Write in ONE column only* Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
94. COOKED CEREALS (porridge, oatmeal, dalia, bulgar) Specify usual brand: ______				00	1 cup or 250ml	S	M	L
95. SUGAR on cereal (white, brown)				00	1 tsp	S	M	L
96. CRACKERS (soda or snack type)			[illegible]	0[illegible]	2 crackers	S	X	L
97. MUFFINS (bran, oat, fruit, fruit breads)				00	1 small or 1/2 large	S	M	L
98. RICE, boiled		01	[illegible]		photo A, small (1/2 cup)	X	M	L
99. FRIED RICE, plain or pulao				00	photo A, small (1/2 cup)	S	M	L
100. BUTTER on breads, roti or boiled rice	02				1 tsp or 1 pat	X	M	L
101. MARGARINE on breads, roti or boiled rice				00	1 tsp or 1 pat	S	M	L
SNACKS								
102. FRENCH FRIED POTATOES			01		1 cup or small McDonald's	X	M	L
103. SAMOSA, vegetable			[illegible]	06	1 medium	S	X	L
104. SAMOSA, meat				00	1 medium	S	M	L
105. VEGETABLE PAKORAS				06	photo A, small (1/2 cup)	S	M	X
106. PAPAD				00	1 small	S	M	L

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SNACKS cont.	Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Less Than Average (small)	Average (medium)	More Than Average (large)
	How often? *Write in ONE column only*					Your Serving Size		
107. DAL KI PAKORI / VADA includes yogurt topping				00	1/2 cup or 125 ml	S	M	L
108. DAHI PAPRI includes yogurt topping				00	1/2 cup or 125 ml	S	M	L
109. BHAJIA, SEV, GATHIA			02		1/4 cup or 60 ml	X	M	L
110. CRISP SNACKS (popcorn, potato chips, nachos)			01	[illegible]	1/2 cup or 125 ml	X	M	L
111. TIKIA ,potato patties, vegetable cutlets				06	1, 3" diameter	S	X	L
112. NUTS	01				2 tbsp or 30 ml	X	M	L

MIXED DISHES, PIZZA AND PASTA

	Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Less Than Average (small)	Average (medium)	More Than Average (large)
113. SOUP, creamed				00	photo B, medium (1/2 cup)	S	M	L
114. SOUP, not creamed				00	photo B, medium (1/2 cup)	S	M	L
115. PIZZA, no meat				06	1 medium slice	S	X	L
116. PIZZA, with meat				00	1 medium slice	S	M	L
117. MACARONI, SPAGHETTI, boiled				00	photo A, medium (1 cup)	S	M	L
118. PASTA WITH TOMATO SAUCE, no meat				06	photo A, medium (1 cup)	S	X	L
119. PASTA WITH CREAM SAUCE, no meat				00	photo A, medium (1 cup)	S	M	L

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MIXED DISHES, PIZZA AND PASTA cont.	Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Less Than Average (small)	Average (medium)	More Than Average (large)
	How often? *Write in ONE column only*					Your Serving Size		
120. PASTA WITH CHEESE/MEAT				00	photo A, medium (1 cup)	S	M	L
FRUITS								
121. APPLE, PEAR		02			1 medium	X	M	L
122. CITRUS FRUITS (oranges, clementines, grapefruit)				00	1 orange or 2 clementines or 1/2 grapefruit	S	M	L
123. BANANA		03			1 medium	S	X	L
124. GRAPES	01	[illegible]			1/2 cup or 125 ml	X	M	L
125. BERRIES (strawberries, raspberries)			~~0~~	08	1/2 cup or 125 ml	S	M	L
126. PEACH, PLUM, NECTARINE		01			1 medium peach or 1 large plum	X	M	L
127. CANTELOUPE	01				1 slice or 1/2 cup	S	X	L
128. WATERMELON, HONEYDEW	01				1 wedge or 1 cup or 250 ml	X	M	L
129. MANGO, PAPAYA	01				1/2 mango or 1/2 cup	S	X	L
130. ALL OTHER FRUIT (such as pineapple, kiwi)		01			1 slice or 1/2 cup	X	M	L
131. CANNED FRUIT				00	1/2 cup or 125 ml	S	M	L
132. DRIED FRUIT (such as raisins, dates)	01				1 tbsp raisins or 2 dates	X	M	L

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DESSERTS AND SWEETS	How often? Write in ONE column only: Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
133. CAKES				00	1 slice or 2" x 4" x 1"	S	M	L
134. DOUGHNUTS, SWEET ROLLS				00	1 doughnut or 1 sweet roll	S	M	L
135. ICE CREAM			02		1/2 cup or 125 ml	X	M	L
136. PIES AND TARTS, danish				00	1 slice or 1/6 pie	S	M	L
137. COOKIE				00	1 cookie	S	M	L
138. CHOCOLATE (includes chocolate candy, bar)				00	1 small-size bar (45 gm) or 5 chocolates	S	M	L
139. CANDY, no chocolate				00	2 candies	S	M	L
140. BARFI / LADOO, milk based, gajjar halwa			02		1 piece, 1"	S	M	X
141. BARFI / LADOO, (lentil, chick pea flour, besan-based, fried jalebi, bundi)			02		1 piece, 1"	S	M	X
142. CHUMCHUM / RASGULLA - type desserts				06	1 piece	S	X	L
143. GULAB JAMUN - type desserts, fried				06	1 piece	S	X	L
144. SUJI KA HALWA / LENTIL HALWA				00	1/2 cup or 125 ml	S	M	L
145. RASMALAI - type desserts				06	1 piece	S	X	L
146. RICE KHEER (suji kheer, seviaan)			01		1/2 cup or 125 ml	S	X	L

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MISCELLANEOUS	How often? Write in ONE column only Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size Less Than Average (small)	Average (medium)	More Than Average (large)
147. TOFU			02		1/2 cup or 125 ml	S	X	L
148. PEANUT BUTTER				00	1 tbsp or 15 ml	S	M	L
149. JAM, SYRUP, HONEY (not used in beverages)			01		1 tsp	S	X	L
150. KETCHUP			02		1 tbsp or 15ml	X	M	L
151. SALAD DRESSING, creamy type, regular				00	1 tbsp or 15 ml	S	M	L
152. SALAD DRESSING, oil/vinegar, regular				00	1 tbsp or 15 ml	S	M	L
153. MAYONNAISE on sandwiches				00	1 tbsp or 15 ml	S	M	L
154. CORIANDER, MINT, PARSLEY (includes chutneys)	01				4-5 stalks or 1 tbs ground	S	X	L
155. COCONUT, fresh, in cooking, desserts, chutneys				00	1 tbsp or 1" piece	S	M	L
156. SOUTH ASIAN PICKLES, oil based (mango, lime, chili)			02		1 tsp	S	X	L
157. PICKLES in brine (such as dills, relish, Kanji)				00	1/2 dill or 1 tbsp	S	M	L
158. SOY SAUCE, in cooking, added to food				00	1 tsp	S	M	L
159. GINGER	02				1/2 tsp	X	M	L
160. FRESH GARLIC (includes use in cooking)	02				1/2 tsp	X	M	L

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MISCELLANEOUS cont.	How often? *Write in ONE column only* Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
161. CHILIES, green, red	02				1 small	X	M	L
162. ADDED SALT AT TABLE on raw or cooked dishes				00	2 sprinkles	S	M	L
163. SUGAR SUBSTITUTES (such as Equal, Nutrasweet)				00	1 pak or 1 tablet	S	M	L

. FOR THE FOLLOWING QUESTIONS, PLEASE MARK **X** IN THE BOX THAT BEST DESCRIBES YOUR ANSWER

1. Are you a (*Please mark one box only*):

- [ ] Non-vegetarian (eats **ALL** meat, chicken and fish)
- [ ] Vegan (eats **NO** meat, **NO** chicken, **NO** fish, **NO** milk/dairy foods, **NO** eggs)
- [X] Lacto-vegetarian (eats milk/dairy foods, but **NO** meat, **NO** chicken, **NO** fish, **NO** eggs)
- [ ] Lacto-ovo vegetarian (eats milk/dairy foods and eggs, but **NO** meat, **NO** chicken, **NO** fish)
- [ ] Semi-vegetarian (eats meat occasionally)
- [ ] Vegetarian who eats chicken and fish, but **NO** meat

2. How much of the visible fat on the meats do you eat? (*Please mark one box only*):

- [ ] most of it
- [ ] some of it
- [ ] as little as possible
- [X] do not eat meat

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3. How often do you eat the skin on chicken? (*Please mark one box only*):

- [ ] always
- [ ] often
- [ ] sometimes
- [ ] never
- [x] do not eat chicken

4. What kind of fat do you usually use for cooking curries, sabji? (*Please mark one box only*):

- [x] vegetable oil
- [ ] pure ghee or butter
- [ ] do not cook
- [ ] vegetable shortening or vegetable ghee
- [ ] other, please specify: ________________

5. What kind of fat do you usually use for frying? (*Please mark one box only*):

- [x] vegetable oil
- [ ] pure ghee or butter
- [ ] do not fry
- [ ] vegetable shortening or vegetable ghee
- [ ] other, please specify: ________________

6. What kind of fat do you usually use for baking? (*Please mark one box only*):

- [ ] butter
- [ ] vegetable shortening or vegetable ghee
- [ ] margarine
- [ ] pure ghee
- [x] do not bake
- [ ] vegetable oil
- [ ] other, please specify: ________________

7. What type of oil do you usually use? (*Mark all that apply*):

- [ ] corn oil
- [ ] sunflower oil
- [ ] vegetable oil
- [ ] canola oil
- [ ] soybean oil
- [ ] mustard oil
- [ ] peanut oil
- [x] olive oil
- [ ] sesame oil or Til
- [ ] coconut oil
- [ ] other, please specify: ________________

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8. How often do you eat fried foods? *(Please mark one box only)*:

At home	Away from home
[ ] daily	[ ] daily
[ ] 4-6 times per week	[ ] 4-6 times per week
[ ] 1-3 times per week	[ ] 1-3 times per week
[x] less than 1 per week	[x] less than 1 per week

9. How often do you eat fresh fruits and vegetables? *(Please mark one box only)*:

- [ ] more than 6 servings per day
- [ ] 5-6 servings per day
- [ ] 2-4 servings per day
- [x] less than 1 serving per day

10. How often do you eat "take out" or meals away from home? *(Please mark one box only)*:

- [ ] daily
- [ ] 4-6 times per week
- [ ] 1-3 times per week
- [x] less than 1 per week

11. How often do you use coconut oil in cooking or coconut milk (liquid removed from shredded coconut which has been soaked in water)?

[ ] often [ ] sometimes [x] never

12. What type of the following items do you use? *(Please mark one box per line)*:

butter	[x] regular	[ ] light	[ ] both	[ ] none
margarine	[ ] regular	[ ] light	[ ] both	[x] none
mayonnaise	[ ] regular	[ ] light	[ ] both	[x] none
cream cheese	[ ] regular	[ ] light	[ ] both	[x] none
salad dressing	[ ] regular	[ ] calorie-wise	[ ] both	[x] none
sour cream	[ ] regular	[ ] light	[ ] both	[x] none

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13. VITAMINS

During the last year, did you take any of the following multivitamins or multivitamins with minerals?

If no, put an **X** in the box NONE and continue to the next item.

If yes, please write the brand name, if known, the number of **pills** taken **per week** *(mark X)* and the number of **years** and **months** that you took them in the past.

VITAMINS/SUPPLEMENTS	None	More than 7 per week	7 per week	3-5 per week	1-2 per week	How long taken in years and months?	
Multiple vitamins, no minerals Brand: [illegible]			X			06 yrs	mo
Multiple plus iron Brand:	X					yrs	mo
Multiple plus minerals Brand: Centrum	X		X			06 yrs	mo
B complex: Brand:	X					yrs	mo
Brewer's yeast	X					yrs	mo
Cod liver or halibut oil	X					yrs	mo

Do not include your intake of multivitamins for the following. For each item, please mark **(X)** the number of **pills** taken **per week,** the number of **years** or **months** that you took them in the past and the **strength** you currently take (for example, 500 mg of Vitamin C).

	None	More than 7 per week	7 per week	3-5 per week	1-2 per week		
Vitamin C only	X					yrs	mo

- ☐ 250 mg or less
- ☐ 500
- ☐ 1,000
- ☐ 1,500 or more

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VITAMINS/SUPPLEMENTS cont.	None	More than 7 per week	7 per week	3-5 per week	1-2 per week	How long taken in years and months?
Vitamin E only	☒	☐	☐	☐	☐	☐☐ yrs ☐☐ mo
☐ 200 IU or less						
☐ 400						
☐ 800						
☐ 1,000 or more						
Vitamin A only	☒	☐	☐	☐	☐	☐☐ yrs ☐☐ mo
☐ 5,000 IU or less						
☐ 10,000						
☐ 15,000						
☐ 25,000 or more						
Beta carotene only	☒	☐	☐	☐	☐	☐☐ yrs ☐☐ mo
☐ 5,000 IU or less						
☐ 10,000						
☐ 15,000						
☐ 25,000 or more						
Other vitamins:						
Folic Acid	☒	☐	☐	☐	☐	☐☐ yrs ☐☐ mo
Pyridoxin	☑	☐	☐	☐	☐	☐☐ yrs ☐☐ mo
B12	☒	☐	☐	☐	☐	☐☐ yrs ☐☐ mo
Other: ________	☒	☐	☐	☐	☐	☐☐ yrs ☐☐ mo

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VITAMINS/SUPPLEMENTS cont.	None	More than 7 per week	7 per week	3-5 per week	1-2 per week	How long taken in years and months?
Iron only	X					yrs mo
50 mg or less						
100						
200						
300 or more						
Calcium only	~~X~~		~~X~~			06 yrs mo
500 mg or less						
X 1,000 (600mg)						
1,500						
2,000 or more						
Magnesium only	X					yrs mo
100 mg or less						
200						
300 or more						
Selenium only	X					yrs mo
50 ug or less						
100						
150						
200 or more						

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VITAMINS/SUPPLEMENTS cont.	None	More than 7 per week	7 per week	3-5 per week	1-2 per week	How long taken in years and months?
Zinc only	X					yrs mo

- [ ] 20 mg or less
- [ ] 50
- [ ] 75
- [ ] 100 or more

14. Other health or nutritional products (example, ginseng) *Please specify:*

	None	More than 7 per week	7 per week	3-5 per week	1-2 per week	How long taken in years and months?
Garlic pills	X					yrs mo
Metamucil, psyllium, Isabgol	X					yrs mo

NAME OF ITEM	More than 7 per week	7 per week	3-5 per week	1-2 per week	How long taken in years and months?
calcium 600mg + Vitamin D3 400IU		X			06 yrs mo
					yrs mo
					yrs mo
					yrs mo
					yrs mo
					yrs mo

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Other FOODS or BEVERAGES consumed frequently	How often? *Write in ONE column only* Per Day	Per Week	Per Month	Per Year or Never	Average Serving	Your Serving Size: Less Than Average (small)	Average (medium)	More Than Average (large)
1.						S	M	L
2.						S	M	L
3.						S	M	L
4.						S	M	L
5.						S	M	L
6.						S	M	L
7.						S	M	L
8.						S	M	L
9.						S	M	L
10.						S	M	L

Appendix F

Differences in protein intake between vegetarians and omnivores in the Prevention Matters S-S.

Mean intake differences of total protein, animal-based protein and plant-based protein between vegetarians and omnivores. Liner regression model adjusted for age, sex and total calorie intake.

	Omnivore (n = 46)	Vegetarian (n = 50)	p-value
Total Protein (g)	78.9 (75.5, 82.4)	72.2 (68.9, 75.4)	0.01
Animal-based Protein (g)	37.6 (33.7, 41.6)	29.8 (26.1, 33.6)	0.01
Plant-based Protein (g)	38.7 (36.8, 40.5)	41.8 (40.1, 43.6)	0.02