Assessment of Dietary Behaviours and Its Relationship with Healthcare Utilization In Adults with Type 2 Diabetes Mellitus

by

Sabrina Saba

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Abstract

Diabetes mellitus is one of the most common non-communicable diseases around the globe, with serious debilitating and life-threatening consequences. It is not just a mere disease, but a complex syndrome made up of several diseases with similar symptoms, signs, and complications when it is not adequately controlled. We aimed to investigate the relative validity of the dietary component of the Summary of Diabetes Self-Care Activities (SDSCA) measure against 3-day food records in individuals with type 2 diabetes mellitus and the relationship between dietary self-care behaviours and health care utilization in adults with type 2 diabetes after a decade of follow-up. Our results suggest that the self-reported dietary component of SDSCA measure was not strongly associated with 3-day food records. We also demonstrated that healthier diet patterns are associated with a protective effect on hospitalization in a population of people living with diabetes in our longitudinal study design, albeit primarily amongst females in the study cohort. Efforts to promote healthy diet should emphasize the clinical benefits. As the prevalence of diabetes continues to rise worldwide, promotion of better eating habit and self-care behaviors for managing type 2 diabetes is increasingly important in order to reduce the burden on the health care system.

Preface

The manuscripts presented in this thesis are the work of Sabrina Saba, in collaboration with her co-authors. Sabrina Saba was responsible for formulating the research questions, completing the data analyses, interpreting the results and writing of the manuscripts. Dr. Nonsikelelo Mathe contributed to data collection and manuscript edits. Dr. Jeffrey Johnson was the supervisory author and was involved with both concept and manuscript formation.

Dedication

This thesis is dedicated to my beloved husband, Galib, who patiently supported me during this nerve wrecking journey.

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List of Abbreviations

ABCD	Alberta's Caring for Diabetes Project
AADE	American Association of Diabetes Educators
AMDR	Acceptable Macronutrient Distribution Ranges
BMI	Body Mass Index
CDA	Canadian Diabetes Association
CDE	Certified Diabetes Educators
CI	Confidence Interval
CVD	Cardiovascular Disease
DR	Dietary Record
DRI	Dietary Reference Intakes
ED	Emergency Department
FFQ	Food Frequency Questionnaire
IDF	International Diabetes Federation
PDA	Personal Digital Assistants
T2DM	Type 2 Diabetes Mellites
SDSCA	The Summary of Diabetes Self-Care Activities
WHO	World Health Organization

Chapter 1

INTRODUCTION

1.1 Background

1.1.1. Diabetes and Type 2 Diabetes

Diabetes mellitus is one of the most common non-communicable diseases around the globe, with serious debilitating and life-threatening consequences (1). It is not just a mere disease but a complex syndrome made up of several diseases with similar symptoms, signs, and complications when it is not adequately controlled (2). There are three types of diabetes mellitus: type 1 diabetes, type 2 diabetes and gestational diabetes, with type 2 diabetes accounting for 90% of all diabetes cases worldwide. Type 2 diabetes is a multifactorial disorder caused by a combination of genetic and environmental factors (3, 4). Aging, obesity, insufficient energy expenditure, alcohol consumption, smoking, are independent risk factors of pathogenesis of type 2 diabetes (4). Excess amount of starch intake, changing dietary energy sources, mainly high fat and sugar intake, and the decrease in dietary fiber intake, contribute to obesity and cause deterioration of glucose tolerance. Even mild obesity (body mass index [BMI] > 25) is associated with a 4-to-5-fold increase in risk of developing diabetes, particularly when accompanied by increased visceral fat mass.

The International Diabetes Federation (IDF) projected that currently 463 million people are living with diabetes and this number is projected to reach 578 million by 2030. Diabetes related mortality is estimated to be over four million in 2019 (5). Almost 11.5 million (29%) Canadians are living with diabetes or prediabetes (6). The costs of treating diabetes nationally have soared from $14 billion in 2008 to just under $30 billion in the year 2019.

For many Canadians with diabetes, adherence to treatment is affected by cost. The majority of Canadians with diabetes pay more than 3% of their income, or over $1,500 per year out-of-pocket for prescribed medications, devices, and supplies (7, 8).

Urbanization and economic growth come hand in hand with dietary changes that increase caloric consumption and decline in overall diet quality (9). In the past two decades it has been shown how unhealthy diets are changing the paradigm of diabetes globally (10-14). After considering personal preferences and metabolic goals, there are recommended dietary patterns which are beneficial for diabetes management (15, 16). Eating Well with Canada's Food Guide recommends consuming a variety of foods from the 4 food groups (vegetables and fruits; grain products; milk and alternatives; meat and alternatives), with an emphasis on foods that are low in energy density and high in volume to optimize satiety and discourage overconsumption (17). The National Institutes of Health and the American College of Sports Medicine recommend that all adults, including those with diabetes, should engage in regular physical activity (18, 19). IDF recommends physical activity at least between three to five days a week, for a minimum of 30-45 minutes (20). Regular physical activity improves body's sensitivity to insulin and helps manage the blood sugar levels (21-23). In conclusion, healthy diet, regular physical activity, smoking cessation and maintenance of a healthy body weight can help in combating the complications of type 2 diabetes (9).

Healthy eating, being physically active, self-monitoring of blood sugar, compliance with medications, good problem-solving skills, healthy coping skills and risk-reduction behaviors are the core components of self-care in diabetes (24, 25). The American Association of

Diabetes Educators (AADE) (26) highlighted self-care in diabetes is essential both for clinicians and educators treating individual diabetic patients. 98% of diabetes care is actually self-care (27, 28). This role creates substantial demand on patients with diabetes for self-care. In fact, one focus group survey of the certified diabetes educators (CDEs) suggested that it takes an additional 122 minutes/day (~2 hours) to follow the routine of self-management (26, 29). However, studies indicate that positive effect of self-care on glucose and HbA1c control (30-32).

1.1.2. The Summary of Diabetes Self-Care Activities (SDSCA) measure

Toobert and colleagues (33) defined diabetes self-care activities by the brief self-reported questionnaire of various components - general diet, specific diet, exercise, blood-glucose testing, foot care, and smoking. There are 12-items on the self-report instrument used for measuring the above-mentioned components of diabetes self-management. In addition to the 12 core items, there are additional 14 other items that can be used to address specific self-management questions, such as medication use. The respondents indicate how many days in the last 7 days they performed a specific behavior in the questionnaire. They can choose from a range of 0 to 7, with higher scores indicating higher performance of self-management activities. A mean score is calculated for each of the five subscales (i.e., diet, exercise, blood glucose testing, foot care, and smoking status). Higher scores indicate higher levels of overall self-management activities (33). As the selfcare behavior fluctuates, the seven-day recall period is expected to give a stable estimate (34). One of the biggest strengths of the measures is that the patient is the main actor in the process, in positions of responsibility and autonomy (29).

Because diabetes self-management is an essential component in achieving glycemic control, it is important to have valid and reliable measures of self-management activities. This measure was validated initially in English-speaking American patients (33), and subsequently translated and validated in different populations (35-38) and gives an idea how patients are adhering to their recommended treatment protocols. This also gives us the idea how important it is to have an integrated coordination of dietitians, nurses, podiatrists, endocrinologist, exercise professionals, and ophthalmologists given the complex nature of diabetes.

1.1.3. Dietary assessment

Effective long-term management of type 2 diabetes needs self-management education and support with a special focus on nutrition therapy. The measurement of dietary intake is necessary to inform, support and evaluate the interventions to combat diabetes and ensure self-care (39, 40). The measurements may include the frequency, amount, and type of food and can vary vastly in regards with methods.

Dietary assessment can be defined as the procedure to analyze the patterns, quantity, and quality of food consumed by individuals or a population (41). Since diet is a major risk-factor for many life-threatening chronic diseases, the assessment is important not only in the study of associations between diet and health-related outcomes but also for nutritional surveillance and the evaluation of the nutritional status of patients in clinical settings (42, 43).

Dietary assessment can be done primarily in two ways, subjective assessment and objective observation (42). 24-hour dietary recall (24HR), dietary record (DR), dietary history, and

Food Frequency Questionnaires (FFQ) are subjective dietary assessment methods that assess an individual's intake. These are mostly self-reported, but a trained interviewer can also be used (41-44). The self-reported dietary assessments can be further divided into two broad categories: methods of real-time recording and methods of recall. The following table shows some frequently used dietary assessment methods with their strength and limitation.

Table 1.1: Dietary assessment methods in epidemiological studies

	Methods	Collected date	Strengths	Limitations
Duplicate diet approach	Collection of duplicate diet sample and direct analysis	Actual intake information during a specific period	Measurement of dietary exposures (e.g., ecological impurities)	Not suitable for large studies
Food consumption record	Objective observation by skilled staff at the household level	Actual intake information during a specific period	Feasible for population with low literacy or those who prepare most meals at home	Individual dietary consumption not accurate; Not suitable among those frequently eat outside the home
24-Hour dietary recall	Subjective measure using open-ended questionnaires administered by a trained interviewer	Actual intake information over the previous 24 hours	Offers comprehensive food intake data; relatively small respondent burden (literacy not required)	Recall bias; skilled interviewer required; interviewer bias; expensive and time-consuming.
Dietary record	Subjective measure using open-ended, questionnaires that are self-administered	Actual intake information throughout a specific period (3-day, 7-day)	Provides detailed intake data; no interviewer required; no recall bias	Under-reporting by literate and self-motivated participants; expensive and time-consuming; possible changes to diet if repeated measures

Dietary history	Subjective measures using open- and closed-ended questionnaires administered by a trained interviewer	Usual intake estimates over a relatively long period	Assesses usual dietary intake	Expensisve and time-consuming; not suitable for epidemiological studies
Food frequency questionnaire	Subjective measure using a predefined, self- or interviewer-administered format	Usual intake estimates over a relatively long period (e.g., 6 months or 1 year)	Assesses usual dietary intake simply; cost-effective and time saving; suitable for epidemiological studies	Specific to study groups and research aims; uses a closed-ended questionnaire; low accuracy (recall bias); requires accurate evaluation of developed questionnaires

Recently, internet applications are being used with the emerging innovations which involve camera and mobile telephone technology to capture food and meal images (45). One of the very limitations of all self-reported dietary assessments is dietary under-reporting or over reporting. This eventually may bias observed diet-disease relationships (46). Where twenty first century comes with high levels of personal attachment to smartphones and their ability to capture real-time data, unintentional under-reporting might be reduced with the use of mobile dietary assessments (47, 48).

1.1.4. 3-day food record

Dietary records collect detailed information about food consumed over a specific period. They are open-ended surveys where the subject records all the foods and drinks consumed over a specific length of time (49) . However, due to day-to-day variations and seasonal

variations in food records, multiple-day food records over four seasons have been used as a reference standard to evaluate other dietary assessment methods (50). Conventionally, 7-day food record is the most commonly used dietary record. One study suggested either a 4-day or a 7-day record can produce similar and consistent records (51). Tremblay et al. (52) showed that a 3-day dietary record can also provide a reliable estimate of the intake of almost all nutrients. Ideally the controlled period should be long enough to provide reliable information on usual food consumption (a minimum of 3 days is required), but this has to be balanced against the likelihood of poor compliance if the recording period is too long (49).
Three-day food record can be assessed conservatively or by new technologies like internet applications. One of the strengths of using open-ended questions is that we can collect abundant information and it gives us the liberty of doing various analyzing. This method can be utilized for the population with a wide range of eating habits and may be used to estimate the average intake. Focusing on the short-term intake can be a drawback for this type of assessment, which may represent their current diet but not the usual diet. This can be curtailed with measuring the average intake. Then again, repeated measure needs resources, in addition it is also time consuming. Self-report data has some limitations. Some respondents may alter their diet intentionally to avoid a burden on responses or even choose to not report actual intake (53, 54). Literacy and high motivation are the driving factor in dietary behavior, which potentially limits their application in some population groups (people with low literacy, immigrants with low language skills, children, elderly, people with difficulty writing). Given that it is a method that requires significant personal and economic resources, and the substantial individual burden on the participant, the 3-day food record is not practical for large population studies.

1.1.5. Hospital Utilization in Type 2 diabetes

Several studies have shown that better endurance with a primary care physician is associated with reduced preventable hospital admissions for ambulatory-care-sensitive conditions (55-58). Primary care physicians handle the majority of medical care for Canadians living with diabetes (59, 60). Since diabetes care has a large self-care component, and can primarily be managed on an outpatient basis, admission to hospital or emergency department (ED) visits can be considered as poor outcomes of the disease. Such poor outcomes come with a heavy burden on the health expenditure.

The WHO definition of health expenditure includes provision of health services from both public and private sources (preventive and curative), family planning activities, nutrition activities and emergency aid designated for health, but does not include provision of water and sanitation services (20). Annual global health expenditure on diabetes in 2019 was estimated to be USD 760 billion by the International Diabetes Federation (IDF) and reported in the ninth editions of the Diabetes Atlas, which represents a 4.5% increase on the 2017 estimate (20). It is projected that expenditure will reach USD 825 billion by 2030 and USD 845 billion by 2045 (20, 61). The North America and Caribbean (NAC) Region has the highest total diabetes related health expenditure of the IDF Regions (USD 324.5 billion), which corresponds to 42.7% of the total diabetes-related health expenditure in 2019. In Canada the total diabetes-related health expenditure in 2019 was USD 12.3 billion.

This gives us a picture about the health costs of detection and treatment of diabetes and diabetes-related complications. Both acute and long-term complications of diabetes add significantly to the overall economic impact of the condition. This accounts for over 50% of the direct health costs which are the costs of hospitalization for diabetes. Simpson at el. and Selby and associates, reported in both of their studies that in one third of their participants, the excess costs of care for diabetes were attributable to cardiovascular disease, end-stage renal disease and ophthalmic disease, which are the complications of diabetes (62, 63). Similar studies reported that almost 50% of expenditures for people with diabetes could be attributable to long-term complications and majority of the subjects had type 2 diabetes (64, 65). Modifiable factors like poor glycemic control, high urine albumin-creatinine ratios, high BMI and low HDL in type 2 patients are the major cause for hospitalization in conjunction with the microvascular and cardiovascular complications (66, 67). Diabetes is a chronic condition that increases the risk of many potentially serious complications and diabetes patients have high rates of admission and readmission to hospital (67-69).

1.2 Objectives

The aim of this thesis was to explore the association between dietary self-care behaviors and health care utilization in adults with type 2 diabetes using data from a the ABCD study (70) which was a large, prospective cohort. In the first study, we want to investigate the relative validity of the dietary component of the Summary of Diabetes Self-Care Activities (SDSCA) measure with 3-day food records in individuals with type 2 diabetes mellitus. The second study assessed the potential association between dietary self-care behaviors and health care utilization, in particular emergency department visit and hospitalization, in adults with type 2 diabetes. We used follow-up data from the ABCD cohort to determine how baseline level of dietary self-care behaviors are associated with healthcare utilization over the decade of follow-up.

1.3 Summary of Research Projects

Project 1: Validation of SDSCA scale with 3-day food records in individuals with type 2 diabetes mellitus

Aim: Healthy nutrition for type 2 diabetes contributes positively to the maintenance of blood glucose within normal range, achieving a healthy body weight and minimizes the risk of complications. It is essential to assess the validity of dietary intake methods to determine if the method is measuring what people are really eating (e.g., the FFQ was often compared with 7-day food records). In the present study, we aimed to investigate the relative validity of the dietary component of the Summary of Diabetes Self-Care Activities (SDSCA) measure against 3-day food records in individuals with type 2 diabetes mellitus. **Method:** Data from the Alberta's Caring for Diabetes (ABCD) cohort were used. Age, sex, marital status, ethnicity, education, employment, income, smoking status, time since diabetes diagnosis, 3-day food record (i.e. two weekdays and one weekend day), diabetes-related dietary practices in last 7 days was collected from a self-reported paper-based questionnaire mailed to 248 participants with type 2 diabetes living in Alberta, Canada. To test the direct association of the SDSCA dietary measure with 3-day food record, chi-square tests followed by logistic regression model were used. **Results:** 53% of the respondents were male. The mean (SD) age of respondents were 66.5 (9.7) years, with the mean diabetes duration of 14.2 (8.6) years. The majority were married (80.1%), non or ex-smokers (93.7%), Caucasian (92.1%) with the household income > CAD $80,000 (56.3%). More than half (63.1%) were unemployed. The mean BMI was 31.3 (6.8) kg/m2. Men who reported consuming protein within the AMDR were less likely to follow the dietary protein recommendation for 5-7 days a week (OR: 0.3, 95%CI: 0.04 to 3.3) in comparison with the 0-4 days a week. In case of fat consumption, females were four times more likely to take fat within the AMDR for 5-7 days a week (0R: 4.3, 95%CI: 1.1 to 16.1, p-value: 0.02), there no association between fat consumption and SDSCA scale in males. Females were less likely to consume sugar above the DRI for 6-7 days a week (0R: 0.3, 95%CI: 0.1 to 1.1, p-value: 0.06). **Conclusion**: Our results suggest that the self-reported dietary component of SDSCA measure was not strongly or consistently associated with 3-day food records. Response patterns differed for males and females.

Project 2: Association of Dietary Self-Care Behavior with Healthcare Utilization: Results from A Prospective Cohort Study

Aim: A limited number of studies observe the multi-dimensional diabetes self-care management behaviors including diet related self-care and health seeking behavior of patients in association with healthcare utilization after a long time of follow-up. This study aims to investigate the relationship between dietary self-care behaviors and health care utilization in adults with type 2 diabetes after a decade of follow-up. **Methods:** Data for this study were obtained from the ABCD cohort, a longitudinal retrospective cohort study with participants living with type 2 diabetes established in 2011, surveyed participants over 5 waves, with the last wave being in 2019. Age, sex, marital status, ethnicity, education, employment, income, smoking status, time since diabetes diagnosis, diabetes-related dietary practices in last 7 days was collected from a self-reported questionnaire mailed to participants. These self-reported data were linked to administrative databases at Alberta

Health Services. We tested the association of the SDSCA dietary responses (from baseline survey) with health care utilization using logistic regression models. **Results:** 55% of the respondents were male. The mean (SD) age of respondents were 64.4 (10.7) years, with the mean diabetes duration of 12.3 (8.9) years. Half of respondents were more than 65 years of age. The majority were married (73.2%), non or ex-smokers (89.4%), Caucasian (92.3%) with the household income > CAD $40,000 (53.7%). More than half (53%) were unemployed. Females who followed dietary recommendation for 6-7 days per week were 30% (OR: 0.7, 95% CI: 0.5 to 1.0) less likely to stay in hospital due to any complications in comparison to women who followed dietary recommendation for 0-3 days per week. In case of hospital visits, it was less likely for both males and females who followed their eating habit 4-5 days and 6-7 days per week in comparison with 0-3 days week. Males who had five or more servings of fruits and vegetables 4-5 days per week were less likely to visit ED (OR: 0.8, 95% CI: 0.5 to 1.3) and stay in the hospital (OR: 0.8, 95% CI: 0.6 to 1.1) in comparison to who had five or more servings of fruits and vegetables 0-3 days per week. Females who had five or more servings of fruits and vegetables 4-5 days per week were significantly (p-value: 0.002) less likely to visit ED (OR: 0.4, 95% CI: 0.02, 0.07) in comparison to who had five or more servings of fruits and vegetables 0-3 days per week. For females, a 30% increased risk of ED visits is indicative of increased risk with poor dietary choice of consuming high fat foods such as red meat or full-fat dairy products. **Conclusion:** We observed reduced utilization of healthcare services among females with type-2 diabetes who more often followed recommended dietary self-care behaviors once socio-demographic status was accounted for, however this pattern was not consistent in case of males.

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Chapter 2

Validation of SDSCA dietary scale with Three-day food records in individuals with type 2 diabetes mellitus

2.1 Introduction

Almost half a billion people are living with diabetes worldwide and the number is projected to increase by 25% in 2030 and 51% in 2045 (1). In Canada, 29% of the population is living with diabetes or prediabetes; approximately 90% of all diabetes cases are type 2 diabetes, making it the most common type of diabetes (2). The International Diabetes Federation (IDF) defines type 2 diabetes mellitus as hyperglycaemia (high blood glucose levels) that is the result of the inability of the body's cells to respond fully to insulin, a situation termed 'insulin resistance’ (3).

Glycemic instability is a severely underestimated problem in type 2 diabetes (4) and is complicated by comorbidities, including obesity and cardiovascular disease. Over the long term, people living with type 2 diabetes mellitus can develop severe life threatening complications that may involve major organs like, brain, eye, heart and kidney (3). Postprandial hyperglycemia represents a direct and independent risk factor for the development of cardiovascular disease (CVD) in type 2 diabetes (5). Studies have conclusively determined that reducing hyperglycemia decreases the onset and progression of microvascular complications (6-8). Diabetic patients aged 65 or older have 2.5 times risk to develop macrovascular disease when compared with population aged <50 (9, 10). Fox at el. (11) showed in the Framingham Study, diabetes as a major risk factor of CVD. A Japanese population-based cohort study observed a correlation between CVD and impaired glucose tolerance. This finding is consistent with the Framingham

Offspring study (12-14). CVD is the primary cause of death in people with either type 1 or type 2 diabetes (15, 16).

Studies have shown that interventions of combined drug and behavioral therapy had persistent positive effects with respect to vascular complications and on rates of death from any cause and from cardiovascular causes (17, 18). When people living with diabetes advance to stages of poorer glycemic control, they are often prescribed oral medication and/or insulin to help control blood glucose levels. Nevertheless, the main foundation of self-management of diabetes is proper nutrition therapy, adequate diabetes education and a physically active healthy lifestyle. It is well known that healthy nutrition contributes positively to the maintenance of blood glucose within normal range, achieving a healthy body weight and minimizes the risk of complications (19).

Diets consisting of combinations of different foods or food groups are beneficial for diabetes management (20). Evidence from prospective studies suggests that different types of healthy dietary patterns with consideration for personal preferences and metabolic goals might play a part in diabetes prevention (21-24). Canada's food guide promotes healthy eating and overall nutritional well-being (25). Decreasing the intake of sodium, saturated and trans fats, and refined sugars and increasing the consumption of vegetables and fruits, unsaturated fats, and whole grains, may have a positive impact on diabetes (26, 27).

Over time many approaches to dietary assessment have been developed (28-31). There are traditional methods including food records, food frequency questionnaires (FFQs), and 24-hour recalls where the information are mainly reported by the subjects themselves (32). Food records ask participants to record all foods and beverages consumed over a specific period of time, usually 3 to 7 days a week is being used since 1990. The 7-day food record has been the 'gold standard' for validating other dietary assessment methods (33). The most important strength of the food record is its level of detail, given its open-ended nature and the fact that it refers to the current diet (i.e. dietary intake estimated at time of consumption). While dietary assessment methods vary greatly in their precision, with food records intentional and unintentional biases may alter the actual reflection of the food record (34). For estimating the usual dietary intake over time (typically 6 months to 1 year) food frequency questionnaires (FFQs) are commonly used. The 24-hour recall method was designed to quantitatively assess current nutrient intake (32). More recently, mobile phones and personal digital assistants (PDAs) with cameras have been used for recording dietary intake (35-39). Although many techniques are still under development, major advances have been made. It is essential to assess the validity of dietary intake methods to determine if the method is measuring what people are really eating (e.g., the FFQ was often compared with 7-day food records) (33).

Objective: In the present study, we aim to investigate the relative validity of the dietary component of the Summary of Diabetes Self-Care Activities (SDSCA) measure against 3-day food records in individuals with type 2 diabetes. We hypothesized that stronger associations between responses to the SDSCA and 3-day food record would provide stronger evidence of validity of the SDSCA measure.

2.2 Methods

Study Design

Participants were adults (>18 years) with type 2 diabetes who were previously enrolled in the ABCD cohort study (40). All ABCD cohort participants completing year three assessment (N = 1942) received an invitation to participate in sub-study investigating diet and physical activity. Among the 533 respondents (27%) who accepted the invitation, a sample of 50% (n= 248) was drawn. We used a random sampling with quotas to reflect distribution across five provincial health zones (North, Central, Edmonton, Calgary and South) in an effort to reflect diabetes prevalence across these regions (i.e., greater prevalence in urban locations). The 248 participants were mailed a study package that included postage-paid return envelope. The Health Research Ethics Board at the University of Alberta granted study approval and all participants provided written informed consent (reference # Pro00016667).

Socio-demographic characteristics

Age, sex, marital status, ethnicity, education, employment, income, smoking status, and time since diabetes diagnosis was collected from a paper-based questionnaire mailed to participants. We calculated BMI in kg/m^2 from participants' self-reported height and weight.

Dietary assessment

All participants completed a 3-day food record (i.e. two non-consecutive weekdays and one weekend day) and were asked to provide in as much detail as possible, descriptions of foods and beverages consumed. We entered the dietary intake data in the Food Processor Diet Analysis and

Fitness Software version 10.13.1 (ESHA Research, Salem, USA) and analyzed them to yield the estimates of mean daily food consumption and nutrient intakes based on the Canada's Food Guide. Eating Well with Canada's Food Guide (CFG), provides age and sex specific dietary recommendations, which includes messaging on choosing foods low in added fat, sugar or salt (41). These recommendations reflect stakeholder (including general public) input for more specific recommendations for Canadians (42) and the need to address the obesity epidemic and reduce risk of chronic disease (43). In addition, CFG serves as a resource for practitioners for communicating healthy eating recommendations to Canadians (25).

SDSCA scale

Diabetes-related dietary practices were measured using the previously validated Summary of Diabetes Self-Care Activities (SDSCA) (22). The instrument is based on the self-reported frequency of completing recommended dietary activities during the past 7 days. SDSCA specific self-care dietary practice items included in these analyses were:

1. "How often did you follow your recommended diet over the last 7 days?"
2. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?
3. On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables?
4. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products? (44)

Responses for all questions ranged from 0 to 7 days. For the purpose of the comparisons and analyses described below, responses to each of these four questions were categorized to: 0-4 days/week and 5-7 days per week. This latter category was intended to represent “most or all” days of the week, matching recommendations from Canada’s Food Guide (26, 41, 42) .

Comparison between the Summary of Diabetes Self-Care Activities (SDSCA) response and 3-day food record:

For SDSCA dietary component **question 1**: “How often did you follow your recommended diet over the last 7 days?”, we compared the Acceptable Macronutrient Distribution Ranges (AMDR) distribution among participants. For **question 2**: “On average, over the past month, how many days per week have you followed your eating plan?”, we compared the dietary reference intakes (DRI) of macronutrients (protein, carbohydrate, fat) intakes with categories of respondents. We hypothesized that participants reporting following a healthy eating pattern >4 days per week in SDSCA measure will be more likely to have their AMDR within range and actual intake of macronutrients close to the DRI.

Epidemiological studies showed that consuming diets high in fruits and vegetables are packed with fibers, vitamins and minerals; hence are associated with lowering the risk of type 2 diabetes (45-49). Findings from controlled trials indicate that increasing intakes of dietary fibers (both soluble and insoluble) can improve glycaemic control, body weight, total and LDL cholesterol, and C-reactive protein (CRP), providing evidence to support the findings relating to total and cardiovascular mortality (50). According to our hypothesis, respondents likely to report consuming ≥5 servings of vegetable and fruits and avoiding processed high-fat foods for >4 days per week in SDSCA measure for **questions 3 & 4**, are expected to have dietary intakes for vitamins, fibers, sugar and fat relatively close to current dietary reference.

Statistical analysis

For socio-demographic characteristics, descriptive analysis was carried out in the overall sample and by sex. Mean imputations were conducted in continuous variables with less than 10% missing data, while modal imputation was used for categorical variables.

Our primary dependent variables are the elements of the 3-day food record. For macronutrients and energy intakes, we compare the actual intakes with Dietary Reference Intakes (DRIs). We categorized participants with regards to the Acceptable Micronutrient Distribution Ranges (AMDR) and Dietary Reference Intakes (DRIs) in two levels according to Canada's Food Guide:

- Those who have the AMDR/DRI range within the reference value
- Those who have the AMDR/DRI range not within (above or below) the reference value.

Our main independent variables are Summary of Diabetes Self-Care Activities (SDSCA) dietary responses to questions 1 through 4 (dichotomized as described above: ≤4 days per week and >4 days per week). Covariates included age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI. As sex differences in energy intake is well-established due to differences in physiological composition (51, 52), all analyses were stratified by sex.

To understand the direct association of the SDSCA dietary measure with 3-day food record, we first performed Chi-square tests to determine if there are any significant association between these two measures. The association was then tested with logistic regression models, adjusting for covariates. After checking for interaction and adjusting for potential effect modifiers and confounding (age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI), we decided to carry forward into the logistic regression model. $P < 0.05$ was considered statistically significant for differences between groups. All statistical analyses were performed using STATA SE, version 16.0 (Stat Corp., College Station, TX, USA.

2.3 Results

Socio-demographic characteristics:

From the sample of 248 participants for the ABCD dietary and physical activity sub-study, 187 completed socio-demographic surveys and provided 3-day food records, representing 75% response rate. We included 176 participants in the analysis, excluding those with incomplete food records (n = 5) and extreme energy intakes, i.e. average energy intake above 5000kcals per day (n = 6) (53). Just over half of the included survey respondents were male (54%). The mean (SD) age of respondents were 66.5 (9.7) years, with the mean diabetes duration of 14.2 (8.6) years. The majority were married (80.1%), non or ex-smokers (93.7%), Caucasian (92.1%) with the household income > CAD $80,000 (56.3%). More than half (63.1%) were unemployed. The mean BMI was 31.3 (6.8) kg/m^2 (table: 2.1)

Comparison between the 3-day food record and Summary of Diabetes Self-Care Activities (SDSCA) response:

The majority (close to 90%) of participants reported consuming protein within the AMDR and it did not differ significantly in SDSCA dietary measure categories (Table: 2.2A) by sex. One-third of males (31%) reported consuming carbohydrate within the range and almost two-thirds (68%) were consuming fat outside the AMDR range, none of which differed in regards with SDSCA categories. 89% and 46% of females reported protein and carbohydrate intakes, respectively, which were within the AMDR range, and no significant association was found with the SDSCA dietary component. On the other hand, a significant difference (p-value: 0.02) was present in relation with the range of AMDR of fat consumption with following the recommended diet over the last 7 days (0-4 and 5-7 days per week) for females.

Men who reported consuming protein within the AMDR were less likely to follow the dietary protein recommendation for 5-7 days a week (OR: 0.3, 95%CI: 0.04 to 3.3) in comparison with the 0-4 days a week (Table 2.2B). Women followed the same pattern of consuming protein (OR: 0.5, 95% CI: 0.1 to 3.1). However, in regards with the consumption of carbohydrate, there was no association with the SDSCA scale (Male; OR: 1.0, 95%CI: 0.4 to 2.6 and Female; OR: 0.9, 95%CI: 0.4 to 2.4). In case of fat consumption, females were four times more likely to take fat within the AMDR for 5-7 days a week (0R: 4.3, 95%CI: 1.1 to 16.1, p-value: 0.02). For male participants there was no association between fat consumption and SDSCA scale.

There was no significant association found between the current dietary reference intakes of macronutrients and following the SDSCA dietary recommendations for 5-7 days a week (table: 2.3A and 2.3B) in comparison with 0-4 days a week and below the dietary reference intakes in either male or female.

The dietary reference intakes of micronutrients varied vastly above and below the recommended ranges. Other than Vitamin-A for males (Chi-square test p-value: 0.05) there were no associations present overall (Table: 2.4A). In the regression model, for the self-reported intakes of micronutrients relative to current dietary reference intakes (Table: 2.4B), consumption of Vitamin A in males was significantly above DRI. They are more than two and a half times more likely to have it 5-7 days a week (0R: 2.6, 95%CI: 0.9 to 6.9, p-value: 0.05) in comparison with 0-4 days a week and below the dietary reference intakes. There was no association between intakes of any other micronutrients relative to current dietary behave of the diabetic individuals.

The fiber intake among men was marginally statistically significant (Chi-square test p-value: 0.06) across SDSCA categories. However, no male participants were consuming fibers above the DRI value in the 5-7 days per week category (Table: 2.5A). Table: 2.5B shows that female less likely to consume sugar above the DRI for 6-7 days a week (0R: 0.3, 95%CI: 0.1 to 1.1, p-value: 0.06).

2.4 Discussion

In this study, we wanted to explore the validity of the dietary component of the brief, self-reported SDSCA measure, by comparing responses with 3-day food records in individuals with type 2 diabetes in Alberta, Canada. Regarding the association between the self-reported dietary component of SDSCA measure and 3-day food records, most of the odds ratios for dietary intake between the two scales were not significantly associated. The only significant association that was present was in female in case of fat consumption. Table 2.2B suggests the OR (4.3) for females in case of fat consumption is similar to the OR (4.5) for males in case of carbohydrate consumption. Table 3B indicated a strong positive association and the direction indicates that the responses between two scales are similar. The OR for protein AMDR were both similar (0.3 or

0.5) for males and females suggests following acceptable macronutrient distribution ranges (AMDR) acts as a protective factor.

The self-reported intakes of protein and carbohydrate for women were within the recommended range and two-thirds reported following the healthy eating plan >4 days per week. While it is recognized that an overall healthy dietary pattern that promotes 30–40% of energy (calories) from low-glycemic index carbohydrates is effective at promoting improved glycemic control, (54) our study shows an agreement between SDSCA response and food record response in females. However, for both males and females the consumption of fat is higher and above the AMDR range.

There have been many studies that tested the validity of the psychometric properties of the SDSCA scale in different languages (55-60). They have been instrumental overall for the construct validity. Previous validation studies were based on factor analyses, and found that all items were loaded in their original domains, providing strong evidence that the questionnaire is structurally valid. For our study we used a criterion validity approach, which tests the relationship between the score of a certain instrument and some external criterion. In our case the external criterion was 3-day food record to validate the SDSCA dietary component. Our study is therefore unique in that nature since there has been no previous study to validate the dietary component of the SDSCA scale against external dietary assessments.

One Finnish Diabetes Prevention Study (DPS) showed that the three-day food records with high fiber and low-fat intake were significant predictors of sustained weight reduction, lessened progression to type 2 diabetes, and lower triglyceride levels. Another study suggested lower intakes of saturated and trans-fat and higher intake of polyunsaturated fat relative to saturated fat may reduce cognitive decline in individuals with type 2 diabetes. (61) Despite respondents reporting consuming five or more servings of fruits and vegetables, their food records were not necessarily consistent with specific recommendations within the CFG to support healthy food choices. Diets that are high in insoluble fiber may offer the best protection against many chronic diseases. Fruits and vegetables are high in cellulose-a type of insoluble fiber. Diets that are high in fiber help in the management of type 2 diabetes. (62)

Saturated and trans fats raise blood cholesterol levels, while unsaturated fats lower blood cholesterol. Saturated fat, found in full-fat dairy products and meat, should account for no more than 10 per cent of your total calories according to Canada's food guide. But our respondents showed higher fat and sugar (p-value: <0.01) consumption.

A major strength of this study is the use of 3-day food records to collect dietary intake data and the use of the Canadian Nutrient File for generating nutrient intakes alongside the SDSCA measure. (63) To mitigate the chances of recall bias the use of the 3-day food records are very efficient even though self-reported measures are known to be prone to social desirability bias. To the best of our knowledge a few studies have examined compared the SDSCA measure with a 3-day food record to establish the relative validity of the dietary component of the SDSCA measure.

This study is not without limitation. In our study the collection of SDSCA scale measure and the 3-day food record were not simultaneous. They are from different timeline although in the same year three months apart from each other. It is recommended that comparison, two measures are collected within a week of each other (32). Despite our efforts to reduce the reporting bias in the assessment of dietary intake, the estimates of the population mean and distributions may be affected by uncertainties. Uncertainties may relate to, for example, portion-size reporting, nutrient content and food composition tables. The population may not represent the average person living with diabetes in Alberta. This sub-sample represents a high income, educated, and mainly Caucasian group.

2.5 Conclusion

Our results suggest that the self-reported dietary component of SDSCA measure was not strongly associated with 3-day food records. Sex difference was a major factor in food record and diabetes self-care dietary behaviors among men and women with type 2 diabetes. In large-scale epidemiological studies, this SDSCA may need to be used repeatedly (several records per year) in association with 3-day food record in order to obtain a complete overview of usual dietary intake in individuals with type 2 diabetes. To further evaluate energy and nutrient intake, development of a calibration equation to adjust for self-reported bias using biomarkers may be needed. Although much has been learned about the role of various dietary factors in the development of diabetes, further studies are warranted to examine synergistic effects of individual components of various dietary patterns and to understand the biological mechanisms underlying the observed associations.

Table 2.1 – Socio-demographic characteristics of the cohort participants			
Study sample	**Male (N=95)**	**Female (N=81)**	**All (n=176)**
Age, mean (SD)	67.52 (9.6)	64.73 (9.9)	66.5 (9.7)
Age, no (%)			
22-44	1 (1.1)	1 (1.2)	2 (1.1)
45-65	29 (30.5)	34 (42)	63 (35.8)
65+	65 (68.4)	46 (56.8)	111 (63.1)
Marital status, no (%)			
Married or common law	86 (90.5)	55 (67.9)	141 (80.1)
Not married	9 (9.5)	26 (32.1)	35 (19.9)
Ethnicity, no. (%)			
Caucasian	85 (89.5)	77 (95.1)	162 (92.1)
Non-Caucasian	10 (10.5)	4 (4.9)	14 (7.9)
Education			
High school and less	45 (47.4)	40 (49.4)	85 (48.3)
College and higher	50 (52.6)	41 (50.6)	91 (51.7)
Employment, no. (%)			
Employed	36 (37.9)	29 (35.8)	65 (36.9)
Others	59 (62.1	52 (64.2)	111 (63.1)
Income			
<$40,000	14 (14.7)	24 (29.6)	382 (21.6)
$40,000–$79,999	35 (36.9)	26 (32.1)	61 (34.7)
>=$80,000	34 (35.8)	17 (21)	51 (28.9)
Do not know/refuse	12 (12.6)	14 (17.3)	26 (14.8)
Smoking status, no. (%)			
Current smoker	6 (6.3)	5 (6.2)	11 (6.3)
Ex-smoker and Non-smokers	89 (93.7)	76 (93.8)	165 (93.7)

Duration of diabetes, mean years (SD)	14.5 (9.6)	13.8 (7.4)	14.2 (8.6)
BMI (kg/m^2), mean (SD)	30.8 (6.6)	32 (7.0)	31.3 (6.8)

Note: Data are N (%) unless otherwise specified.

Table 2.2A: Acceptable Macronutrient Distribution Ranges (AMDR) distribution among participants from 3-day food record and SDSCA dietary question one

Males (N=95)		**0-4 days/week**	**5-7 days/week**	**Total**
Protein AMDR	% within AMDR	96.4(27)	91 (61)	92.6 (88)
	% not within AMDR	3.6 (1)	9 (6)	7.4 (7)
Chi-square value; p-value		0.838; 0.36		
CHO AMDR	% within AMDR	32.1 (9)	32.8 (22)	32.6 (31)
	% not within AMDR	67.9 (19)	67.2 (45)	67.4 (64)
Chi-square value; p-value		0.004; 0.95		
Fat AMDR	% within AMDR	42.8 (12)	26.9 (18)	31.6 (30)
	% not within AMDR	57.2 (16)	73.1 (49)	68.4 (65)
Chi-square value; p-value		2.337; 0.13		
Females (N=81)		**0-4 days/week**	**5-7 days/week**	**Total**
Protein AMDR	% within AMDR	92.9 (26)	86.8 (46)	88.9 (72)
	% not within AMDR	7.1 (2)	13.2 (7)	11.1 (9)
Chi-square value; p-value		0.682; 0.41		
CHO AMDR	% within AMDR	46.4 (13)	45.3 (24)	45.7 (37)
	% not within AMDR	53.6 (15)	54.7 (29)	54.3 (44)
Chi-square value; p-value		0.009; 0.92		
Fat AMDR	% within AMDR	10.7 (3)	33.9 (18)	25.9 (21)
	% not within AMDR	89.3 (25)	66.1 (35)	74.1 (60)
Chi-square value; p-value		**5.156; 0.02**		

Note: Data are percentage (N) unless otherwise specified.

Table 2.2B: Acceptable Macronutrient Distribution Ranges (AMDR) distribution among participants from 3-day food record and SDSCA dietary question one			
Males (N=95)	**0-4 days/week**	**5-7 days/week**	
Macronutrients* (Within AMDR)		OR (95% CI)	p-value
Protein: within AMDR (ref: not within AMDR)	--ref--	0.3 (0.04, 3.3)	0.38
CHO: within AMDR (ref: not within AMDR)	--ref--	1.0 (0.4, 2.6)	0.95
Fat: within AMDR (ref: not within AMDR)	--ref--	0.5 (0.2, 1.2)	0.130.13
Females (N=81)	**0-4 days/week**	**5-7 days/week**	
		OR (95% CI)	p-value
Protein: within AMDR (ref: not within AMDR)	--ref--	0.5 (0.1, 3.1)	0.42
CHO: within AMDR (ref: not within AMDR)	--ref--	0.9 (0.4, 2.4)	0.92
Fat: within AMDR (ref: not within AMDR)	--ref--	4.3 (1.1, 16.1)	**0.03**

*National Research Council (US) Committee on Diet and Health. Diet and Health: Implications for Reducing Chronic Disease Risk. Washington (DC): National Academies Press (US); 1989. 6, Calories: Total Macronutrient Intake, Energy Expenditure, and Net Energy Stores. Available from: https://www.ncbi.nlm.nih.gov/books/NBK218769/

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Table 2.3A: Participants' self-reported intakes relative to current dietary reference intakes (Macronutrients) from 3-day food record and SDSCA dietary question two				
Males (N=95)		**0-4 days/week**	**5-7 days/week**	**Total**
Total energy intake (kcal) DRI	% above DRI	50 (15)	47.7 (31)	48.4 (46)
	% below DRI	50 (15)	52.3 (34)	51.6 (49)
Chi-square value; p-value		0.044; 0.83		
Protein DRI	% above DRI	100 (30)	90.8 (59)	93.7 (89)
	% below DRI	0 (0)	9.2 (6)	6.3 (6)
Chi-square value; p-value		2.955; 0.08		
CHO DRI	% above DRI	93.3 (28)	98.4 (64)	96.8 (92)
	% below DRI	6.7 (2)	1.6 (1)	3.2 (3)
Chi-square value; p-value		1.765; 0.18		
Females (N=81)		**0-4 days/week**	**5-7 days/week**	**Total**
Total energy intake (kcal) DRI	% above DRI	55.2 (16)	63.5 (33)	60.5 (49)
	% below DRI	44.8 (13)	36.5 (19)	39.5 (32)
Chi-square value; p-value		0.535; 0.46		
Protein DRI	% above DRI	93.1 (27)	94.2 (49)	93.8 (76)
	% below DRI	6.9 (2)	5.8 (3)	6.2 (5)
Chi-square value; p-value		0.041; 0.84		
CHO DRI	% above DRI	96.5 (28)	92.3 (48)	93.8 (76)
	% below DRI	3.5 (1)	7.7 (4)	6.2 (5)
Chi-square value; p-value		0.579; 0.45		

Note: Data are percentage (N) unless otherwise specified.

Table 2.3B: Participants' self-reported intakes relative to current dietary reference intakes (Macronutrients) from 3-day food record and SDSCA dietary question two			
Males (N=95)	**0-4 days/week**	**5-7 days/week**	
		OR (95% CI)	p-value
Energy Intake: Above DRI (ref: Below DRI)	--ref--	0.9 (0.4, 2.2)	0.83
Protein: Above DRI (ref: Below DRI)	--ref--	-	-
CHO: Above DRI (ref: Below DRI)	--ref--	4.5 (0.4, 52.5)	0.22
Females (N=81)	**0-3 days/week**	**4-5 days/week**	
		OR (95% CI)	p-value
Energy Intake: Above DRI (ref: Below DRI)	--ref--	1.4 (0.6, 3.5)	0.47
Protein: Above DRI (ref: Below DRI)	--ref--	1.2 (0.2, 7.7)	0.84
CHO: Above DRI (ref: Below DRI)	--ref--	0.4 (0.04, 4.02)	0.46

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Table 2.4A: Participants' self-reported intakes relative to current dietary reference intakes (Micronutrients) from 3-day food record and SDSCA dietary question three				
Males (N=95)		**0-4 days/week**	**5-7 days/week**	**Total**
Vit A DRI	% above DRI	66.7 (26)	83.9 (47)	76.8 (73)
	% below DRI	33.3 (13)	16.1 (9)	23.2 (22)
Chi-square value; p-value		**3.849; 0.05**		
Vit E DRI	% above DRI	5.1 (2)	0 (0)	2.1 (2)
	% below DRI	94.9 (2)	100 (56)	97.9 (93)
Chi-square value; p-value		2.934; 0.08		
Vit K DRI	% above DRI	20.5 (8)	12.5 (7)	15.8 (15)
	% below DRI	79.5 (31)	87.5 (49)	84.2 (80)
Chi-square value; p-value		1.110; 0.29		
Vit C DRI	% above DRI	51.3 (20)	53.6 (30)	52.6 (50)
	% below DRI	48.7 (19)	46.4 (26)	47.4 (45)
Chi-square value; p-value		0.048; 0.83		
Vit B1 DRI	% above DRI	69.2 (27)	67.9 (38)	68.4 (65)
	% below DRI	30.8 (12)	32.1 (18)	31.6 (30)
Chi-square value; p-value		0.020; 0.89		
Vit B2 DRI	% above DRI	79.5 (31)	76.8 (43)	77.9 (74)
	% below DRI	20.5 (8)	23.2 (13)	22.1 (21)
Chi-square value; p-value		0.097; 0.76		
Vit B3 DRI	% above DRI	94.9 (37)	92.9 (52)	93.7 (89)
	% below DRI	5.1 (2)	7.1 (4)	6.3 (6)
Chi-square value; p-value		0.158; 0.69		
Vit B6 DRI	% above DRI	33.3 (13)	62.5 (35)	64.2 (61)
	% below DRI	66.7 (26)	37.5 (21)	35.8 (34)
Chi-square value; p-value		0.174; 0.68		
Vit B12 DRI	% above DRI	66.7 (26)	58.9 (33)	62.1 (59)
	% below DRI	33.3 (13)	41.1 (23)	37.9 (36)
Chi-square value; p-value		0.585; 0.45		
Females (N=81)		**0-4 days/week**	**5-7 days/week**	**Total**
Vit A DRI	% above DRI	80.6 (29)	86.7 (39)	83.9 (68)
	% below DRI	19.4 (7)	13.3 (6)	16.1 (13)
Chi-square value; p-value		0.554; 0.457		
Vit E DRI	% above DRI	2.8 (1)	2.2 (1)	2.5 (2)
	% below DRI	97.2 (35)	97.8 (44)	97.53 (79)
Chi-square value; p-value		0.026; 0.87		
Vit K DRI	% above DRI	30.6 (11)	22.2 (10)	25.9 (21)
	% below DRI	69.4 (25)	77.8 (35)	74.1 (60)
Chi-square value; p-value		0.723; 0.39		
Vit C DRI	% above DRI	55.6 (20)	60 (27)	58 (47)
	% below DRI	44.4 (16)	40 (18)	42 (34)
Chi-square value; p-value		0.162; 0.69		
Vit B1 DRI	% above DRI	75 (27)	62.2 (28)	67.9 (55)
	% below DRI	25 (9)	37.8 (17)	32.1 (26)

Chi-square value; p-value		1.498; 0.22		
Vit B2 DRI	% above DRI	77.8 (28)	82.2 (37)	80.3 (65)
	% below DRI	22.2 (8)	17.8 (8)	19.7 (16)
Chi-square value; p-value		0.249; 0.62		
Vit B3 DRI	% above DRI	91.7 (33)	93.3 (42)	92.6 (75)
	% below DRI	8.3 (3)	6.7 (3)	7.4 (6)
Chi-square value; p-value		0.081; 0.78		
Vit B6 DRI	% above DRI	30.6 (11)	37.8 (17)	34.6 (28)
	% below DRI	69.4 (25)	62.2 (28)	65.4 (53)
Chi-square value; p-value		0.461; 0.49		
Vit B12 DRI	% above DRI	55.6 (20)	62.2 (28)	59.3 (48)
	% below DRI	44.4 (16)	37.8 (17)	40.7 (33)
Chi-square value; p-value		0.368; 0.54		

Note: Data are percentage (N) unless otherwise specified.

Table 2.4B: Participants' self-reported intakes relative to current dietary reference intakes (Micronutrients) and from 3-day food record and SDSCA dietary question three

Males (N=95)	**0-4 days/week**	**5-7 days/week**	
		OR (95% CI)	p-value
Vit A: Above DRI (ref: Below DRI)	--ref--	2.6 (0.9, 6.9)	**0.05**
Vit E: Above DRI (ref: Below DRI)	--ref--	-	-
Vit K: Above DRI (ref: Below DRI)	--ref--	0.5 (0.2, 1.7)	0.29
Vit C: Above DRI (ref: Below DRI)	--ref--	1.1 (0.5, 2.5)	0.82
Vit B1: Above DRI (ref: Below DRI)	--ref--	0.9 (0.4, 2.3)	0.89
Vit B2: Above DRI (ref: Below DRI)	--ref--	0.9 (0.3, 2.3)	0.75
Vit B3: Above DRI (ref: Below DRI)	--ref--	0.7 (0.1, 4.0)	0.69
Vit B6: Above DRI (ref: Below DRI)	--ref--	1.2 (0.5, 2.8)	0.67
Vit B12: Above AMDR (ref: Below DRI)	--ref--	0.7 (0.3, 1.7)	0.45
Females (N=81)	**0-4 days/week**	**5-7 days/week**	
		OR (95% CI)	p-value
Vit A: Above DRI (ref: Below DRI)	--ref--	1.5 (0.5, 5.2)	0.46
Vit E: Above DRI (ref: Below DRI)	--ref--	0.7 (0.05, 13.2)	0.87

Vit K: Above DRI (ref: Below DRI)	--ref--	0.6 (0.2, 1.8)	0.39
Vit C: Above DRI (ref: Below DRI)	--ref--	1.2 (0.4, 2.9)	0.69
Vit B1: Above DRI (ref: Below DRI)	--ref--	0.5 (0.2, 1.4)	0.22
Vit B2: Above DRI (ref: Below DRI)	--ref--	1.3 (0.4, 3.9)	0.62
Vit B3: Above DRI (ref: Below DRI)	--ref--	1.2 (0.2, 6.7)	0.78
Vit B6: Above DRI (ref: Below DRI)	--ref--	1.3 (0.5, 3.4)	0.49
Vit B12: Above DRI (ref: Below DRI)	--ref--	1.3 (0.5, 3.2)	0.54

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Table 2.5A: Participants' self-reported intakes relative to current dietary reference intakes for fiber, sugar, fat from 3-day food record and SDSCA dietary question four				
Males (N=95)		**0-4 days/week**	**5-7 days/week**	**Total**
Fiber DRI	% above DRI	15.8 (12)	0 (0)	12.6 (12)
	% below DRI	84.2 (64)	100 (19)	87.4 (83)
Chi-square value; p-value		3.434; 0.06		
Sugar DRI	% above DRI	81.6 (62)	84.2 (16)	82.1 (78)
	% below DRI	18.4 (14)	15.8 (3)	17.9 (17)
Chi-square value; p-value		0.0716; 0.79		
Fat	No upper limit available but individuals are advised to consume "As low as possible while consuming a nutritionally adequate diet"			
Females (N=81)		**0-4 days/week**	**5-7 days/week**	**Total**
Fiber DRI	% above DRI	30.8 (21)	30.8 (4)	30.9 (25)
	% below DRI	69.2 (47)	69.2 (9)	69.1 (56)
Chi-square value; p-value		0.0001; 0.99		
Sugar DRI	% above DRI	89.7 (61)	69.2 (9)	86.4 (70)
	% below DRI	10.3 (7)	30.7 (4)	13.6 (11)
Chi-square value; p-value		**3.899; 0.04**		
Fat	No upper limit available but individuals are advised to consume "As low as possible while consuming a nutritionally adequate diet"			

Note: Data are percentage (N) unless otherwise specified.

Table 2.5B: Participants' self-reported intakes relative to current dietary reference intakes for fiber, sugar, fat from 3-day food record and SDSCA dietary question four			
Males (N=95)	**0-4 days/week**	**5-7 days/week**	
		OR (95% CI)	p-value
Fiber: Above DRI (ref: Below DRI)	--ref--	-	-
Sugar: Above DRI (ref: Below DRI)	--ref--	1.2 (0.3, 4.7)	0.79
Fat	No upper limit available but individuals are advised to consume "As low as possible while consuming a nutritionally adequate diet"		
Females (N=81)	**0-4 days/week**	**5-7 days/week**	
		OR (95% CI)	p-value
Fiber: Above DRI (ref: Below DRI)	--ref--	1.0 (0.3, 3.6)	0.99
Sugar: Above DRI (ref: Below DRI)	--ref--	0.3 (0.1, 1.1)	0.06
Fat	No upper limit available but individuals are advised to consume "As low as possible while consuming a nutritionally adequate diet"		

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

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Chapter 3

Association of Dietary Self-Care Behavior with Healthcare Utilization: Results from A Prospective Cohort Study

3.1 Introduction

Diabetes, known clinically as diabetes mellitus, is a chronic condition that occurs when there are disordered metabolism and inappropriate hyperglycemia (1). This can be either due to the deficiency of insulin secretion or to a combination of insulin resistance and inadequate insulin secretion to compensate. There are two primary forms of diabetes, with type 2 diabetes being the most common type. Despite being a largely preventable disease, globally 1 in 11 adult has type 2 diabetes, which constitutes 425 million people, with 212 million remaining undiagnosed (2). Care of individuals with diabetes generate a substantial use of health care resources, the greatest impact on hospital stay and expense is from hospitalizations being attributable to chronic complications, especially cardiovascular complications (3). Up to 40% of all hospital admissions for myocardial infarction, stroke, and heart failure occur in the people living with diabetes (4, 5).

Currently 29% of the Canadian population are living with type 2 diabetes (6). Although, mortality rates have decreased considerably in those living with diabetes, the number of individuals affected by heart disease has continued to increase. In 2019, mean annual expenditure per person with diabetes was USD 4,397 (approximately 5,612 CAD) in Canada (2). A substantial portion of direct healthcare expenditure is driven by complications related to diabetes (7). For many Canadians with diabetes, adherence to treatment is affected by cost. The majority of Canadians with diabetes pay out-of-pocket more than 3% of their income, or over $1,500, per year for prescribed medications, devices, and supplies (8, 9).

Management of diabetes is multifactorial, but depends on proper nutrition therapy, adequate diabetes education and choice of a healthy lifestyle (10). Evidence shows that people living with type 2 diabetes can achieve improved glycemic control and reduce complications by engaging in healthy behaviours (10-13). There are seven essential self-care behaviors in people with diabetes which predict good outcomes, namely healthy eating, being physically active, monitoring of blood sugar, compliance with medications, good problem-solving skills, healthy coping skills and risk-reduction behaviors (14). Focusing on these self-care activities, majority of patients with diabetes can significantly reduce the chances of developing long-term complications.

For an adult with type 2 diabetes the estimated amount of time to complete self-care is almost 234 minutes approximately per day(15-17) . Given the complex nature of the disease, an inter-professional team approach is known to be essential for diabetes management (18-20). Population-wide lifestyle change, along with early detection, diagnosis and cost-effective treatment of diabetes are required to save lives and prevent diabetes related complications (21, 22). Only multi-sectoral and coordinated responses with public policies and market interventions within and beyond the health sector can address this issue (23, 24).

Nevertheless, a gap persists between recommendations and clinical practice. While self-care is important, not all patients receive proper education and follow clinical guidelines. For example, patient’s adherence to attend diabetes self-management education programs within the first year of diagnosis was less than 1 in every 10 persons (25). This may be responsible for an increased risk of complications (3), which in turns determines an increased demand for hospital care. Resource consumption related to diabetes mellitus and diabetes morbidity can be monitored with the use of administrative databases in complimentary to the research studies (26).

However, very few studies observe the multi-dimensional diabetes self-care management behaviors including diet related self-care and health seeking behavior of patients in association with healthcare utilization after a long time of follow-up. Therefore, this study aims to investigate the relationship between dietary self-care behaviours and health care utilization in adults with type 2 diabetes after a decade of follow-up. Specifically, this study will:

1. Describe dietary self-care behaviours among adults living with type 2 diabetes,

2. Investigate the relationship between dietary self-care behavior with healthcare utilization.

Hypothesis to be tested:

We hypothesized that those individuals who reported better dietary self-care behaviour will have lower healthcare utilization, that is, fewer hospitalizations and emergency department visits.

3.2 Methods

Design

Data for this study was obtained from the Alberta Caring for Diabetes (ABCD) cohort, a longitudinal retrospective cohort study of adults living with type 2 diabetes. We used self-reported data that have been linked to administrative databases at Alberta Health Services. The ABCD Cohort is a study of 2040 people living with type 2 diabetes in Alberta Canada (27). The cohort was established in 2011, surveyed participants over five waves, with the last wave being in 2019, with a variety of items and measures that have been previously developed, validated and applied in population surveys of people living with diabetes. A total of 1871 participants completed full assessment questions from the 2040 ABCD cohort participants. The Health Research Ethics Board at the University of Alberta granted study approval and all participants provided written informed consent (reference # Pro00016667).

Socio-demographic characteristics at baseline

Age, sex, marital status, ethnicity, education, employment, income, smoking status, and time since diabetes diagnosis was collected from a paper-based questionnaire mailed to participants.

Dietary self-management behavior assessment (SDSCA scale)

Diabetes-related dietary practices was measured using the previously validated Summary of Diabetes Self-Care Activities (SDSCA) (21, 22). The instrument is based on the self-reported frequency of completing recommended dietary activities during the past 7 days. SDSCA specific self-care dietary practice items included in these analyses were:

1. How often did you follow your recommended diet over the last 7 days? – *Q1*
2. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan? – *Q2*
3. On how many of the last seven days did you eat five or more servings of fruits and vegetables? – *Q3*
4. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products? – *Q4*

Responses for all questions ranged from 0 to 7 days. The mean number of days per week participants included low-GI foods in their diets was calculated similar to the SDSCA scoring scale.

Administrative Data

The databases linked include Physician Claims, Discharge Abstract Database (DAD), Alberta Ambulatory Care Reporting System (AACRS) and National Ambulatory Care Reporting System (NACRS). These administrative data were collected for the same length of time as the ABCD cohort including information from the year 2011 to 2019. For the purpose of our analysis, we used emergency department (ED) visit and hospital stay as measures of sporadic healthcare utilization. From 2011 to 2019, each year we obtained the data on ED visits and hospitalization individually. We then sum all the ED visits over the last nine years to create a cumulative variable representing the occurrence of any ED visits over the full follow-up period. We did the same with hospitalizations. These two variables represent the healthcare utilization from the year 2011 to 2019.

Statistical analysis

For healthcare utilization, we gave a yearly breakdown of the ED visits and hospitalization with the cumulative number of the entire follow-up period. Our dependent variables were healthcare utilization (ED visits and hospital stay), and independent variables were Summary of Diabetes Self-Care Activities (SDSCA) dietary responses to Q1 through Q4, age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI. Mean imputations were conducted in continuous variables with less than 10% missing data, while modal imputation was used for categorical variables. As sex differences in food intake is well-established due to differences in physiological composition, all analyses were stratified by sex.

Responses to all the SDSCA dietary measures of Q1, Q2, Q3, Q4 were recoded to three categories:

- 0–3 days per week
- 4-5 days per week
- 6-7 days per week

To explore the relationship between the 4 SDSCA questions (Q1, Q2, Q3, Q4), we created a correlation matrix with Spearman rank-order correlation coefficients for these categorical responses. The healthcare utilization variables were recoded as dichotomous outcomes, whether the event occurred during the full follow-up period or not.

Before assessing the direct association of the SDSCA dietary measures with healthcare utilization, we first performed Chi-square test to determine if there are any significant association between these two measures. We then tested the association of the SDSCA responses (from baseline survey) with health care utilization using logistic regression models. Each SDSCA question was tested on its own. The association of possible covariates was tested for the logistic regression models we used. After checking for interaction and adjusting for potential effect modifiers and confounding (age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes), we decided to carry forward into the logistic regression model. $P < 0.05$ was considered statistically significant for differences between groups. All statistical analyses were performed using STATA SE, version 16.0 (Stat Corp., College Station, TX, USA.)

3.3 Results

Socio-demographic characteristics:

At baseline, among the 1871 study respondents who completed full assessment questions from the 2040 ABCD cohort participants, 1026 (55%) were male and 845 (45%) were female. The mean (SD) age of respondents were 64.4 (10.7) years, with the mean diabetes duration of 12.3 (8.9) years. Half of respondents were more than 65 years of age. The majority were married (73.2%), non or ex-smokers (89.4%), Caucasian (92.3%) with the household income > CAD $40,000 (53.7%). More than half (53%) were unemployed. (Table:3.1)

Dietary behaviours and Health Care Utilization

Almost seventy-five percent of the respondents reported following the eating plan for Q1 and Q2 for ≥4 days per week (Table 3.2). The association between Q2 and the dietary component categories was marginally significant (p-value: 0.05) after being stratified by sex. One third of the participants reported consuming ≥5 servings of fruits and vegetables and avoided processed high fat foods for ≥4 days per week. The Spearman's correlation between SDSCA dietary question showed that there is a strong correlation (rho=0.88) between Q1 – *'How often did you follow your recommended diet over the last 7 days'* and Q2 – *'On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?'*. The remainder of the correlation coefficients indicated weak to moderate relationships (Table 3.3)

Table 4 shows number of ED visits each year in males were almost similar and at around thirty-one percent. For females it was close to thirty-five to thirty-eight percent. Each year, hospitalization was close to fifteen percent in both sexes. In 10 years of follow-up of the cohort, almost 85% visited ED, which was similar in both sexes. Similarly, almost two-thirds of the participants had been hospitalized at some point over the ten years of follow-up (Figure 1A, 1B, 2A, 2B)

Association between the healthcare utilization and Summary of Diabetes Self-Care Activities (SDSCA) response:

There was no association between following the recommended diet (Q1) over the last 7 days and ED visit or hospitalization (Table 3.5A & 3.5B). Men who have been following the recommended diet for diabetes 4-5days per week (OR: 1.0, 95% CI: 0.6 to 1.6) and 6-7 days per week (OR: 0.9, 95% CI: 0.6, 1.4) had similar ED visits in comparison with men who followed recommended diet for 0-3 days per week. For hospital stay, the pattern was similar and there was no association found. In females, those who followed the recommended diet for diabetes 4-5days per week (OR: 0.8, 95% CI: 0.4 to 1.4) and 6-7 days per week (OR: 0.7, 95% CI: 0.4, 1.2) were less likely to visit ED than females who followed dietary recommendation for 0-3 days. There was a significant association when females followed dietary recommendation for 6-7 days, they were 30% (OR: 0.7, 95% CI: 0.5 to 1) less likely to stay in hospital due to any complications in comparison to women who followed dietary recommendation for 0-3 days per (Table 3.5B).

For the second question of the SDSCA - *on average, over the past month, how many DAYS PER WEEK have you followed your eating plan*, similar results were observed for ED visits (Table:

3.6A). Males who followed eating plans 4-5 days per week (OR: 1.1, 95% CI: 0.7 to 1.7) and who followed eating plans 6-7 days per week were no more or less likely to visit ED (OR: 0.9, 95% CI: 0.6 to 1.7) than males who followed their eating plan for 0-3 days per week. Females who followed eating plans 4-5 days per week (OR: 0.6, 95% CI: 0.3 to 1.1) and who followed eating plans 6-7 days per week (OR: 0.6, 95% CI: 0.3 to 1.1) were less likely to visit ED than females who followed their eating plan for 0-3 days per week. In case of hospital visits, it was less likely for both male and female who followed their eating habit 4-5 days and 6-7 days per week in comparison with 0-3 days week (Table: 3.6B) to have hospital stays.

For males who ate five or more servings of fruits and vegetables in last seven days (Q3), there was no association with SDSCA categories. Interestingly, females who reported having five or more servings of fruits and vegetables more often in last seven days (p-value: 0.01) were less likely to visit ED (Table 3.6A). Almost one third of the cohort had hospital stay and it was not associated with having five or more servings of fruits and vegetables in last seven days. This did not differ by sex (Table: 3.6A). In multivariate analysis, men who had five or more servings of fruits and vegetables 4-5 days per week were less likely to visit ED (OR: 0.8, 95% CI: 0.5 to 1.3) and stay in the hospital (OR: 0.8, 95% CI: 0.6 to 1.1) in comparison to who had five or more servings of fruits and vegetables 0-3 days per week. Females who had five or more servings of fruits and vegetables 4-5 days per week were significantly (p-value: 0.002) less likely to visit ED (OR: 0.4, 95% CI: 0.02, 0.07) in comparison to who had five or more servings of fruits and vegetables 0-3 days per week (Table 3.7A). There was no significant association for males in the 6-7 days category. In contrast, females who had five or more servings of fruits and vegetables 6-7 days per week were significantly (p-value: 0.04) less likely to visit ED (OR: 0.7, 95% CI: 0.05, 0.09) in comparison to who had five or more servings of fruits and vegetables 0-3 days per week (Table: 3.7B).

Participants consuming more high fat foods such as red meat or full-fat dairy products (Q4) in account of days was not initially significantly associated with ED visit or hospital stay (Table 3.8A and 3.8B). But the 30% increased risk of ED visits is indicative of increased risk with poor dietary choice in case of female. All other OR indicates that consuming less red meat and sugar acting as a protective factor against healthcare utilization.

3.4 Discussion

The aim of this study was to examine the association between dietary self-care behaviours with healthcare utilization among adults with type 2 diabetes living in Alberta. We wanted to explore from baseline (2011) to the final wave of follow up (2019) if there were less emergency department visits and hospital stays in participants who reported better dietary self-care behaviours (i.e., more in line with recommended dietary intake). After adjustment for significant socio-demographic characteristics, we observed that females who were following their recommended diet for 6-7 days per week had less hospital stays and ate five or more servings of fruits and vegetables more than 3 days per week had less emergency department visits as well as hospital stays. For the rest of the variables the strength of the odds ratios was not statistically significant, however, the direction suggests that females are less likely to have hospital stays when they more often follow the dietary recommendation for diabetes in comparison to the females who followed diet recommendations less often (< four days per week).

We did not find any association between hospital stays and dietary self-care in men, as the multivariate odds ratio suggested that there was no difference in SDSCA dietary measure categories. The lack of an association between dietary self-care behave and hospital utilization has been reported in previous studies (28, 29). One Canadian study showed only a weak association between diet that was measure using 5 questions to assess diet, including asking participants about their eating plan and the frequency and duration of following diet and health care use (28). The lack of previous studies on the potential beneficial effect of dietary self-care on medical service use demands more detailed, longitudinal studies.

The large sample size and the longitudinal nature are big strengths of the study. The sample size consisted of the type 2 diabetes population in Alberta, based on estimates from the Alberta Diabetes Surveillance System and we recognize some ethnic minorities may be less well represented in this sample. However, the study design is not without limitations. For females the direction of the association suggests that better dietary self-care is acting as a protective factor in regards with hospital visits. Nevertheless, we are unable to confirm this due to the design of the study. Also, we did not account for physical activity.

Another strength is the use of well-known and previously validated SDSCA questionnaires. However, the use of self-report dietary questionnaires are known to have measurement errors (31). Recent criticisms have suggested that the nutrition community has mostly ignored the issue of measurement error in self-reported diet and that attempts to adjust for it are “statistical machinations” (32-36). Self-reported dietary intakes while assessing the data must also be viewed as only an estimate of habitual intake and interpretations based on such data must be made with caution.

In summary, the findings in this study indicate that individuals with type 2 diabetes, mainly female, who meet dietary recommendations more than 4 days per week report less hospital visits over 10 years of following compared to those with those who do not follow recommendations as frequently. However, this only told us about the direction of the relation, not the magnitude. To better assess this relationship, both longitudinal and experimental studies are needed to determine whether changes in dietary habit are associated with changes in hospital utilization.

3.5 Conclusion

Overall, we observed reduced utilization of expensive healthcare services among females with type-2 diabetes who more often followed recommended dietary selfcare behavior once socio-demographic status was accounted for. These relationships were not, however, consistently observed in males. Maintaining general health and promoting self-care activities should be a major focus, particularly early in the disease onset, to influence downstream adverse clinical outcomes in people with diabetes. This study provided useful information on how self-care behaviours related to healthcare utilization and this in turn will guide will inform policies and resource allocation relating to the care and management of the type 2 diabetes.

Table 3.1 – Baseline characteristics of the study population			
Study sample	**Male (N=1026)**	**Female (N=845)**	**All (n=1871)**
Age, mean (SD)	64.9 (10.02)	63.8 (11.4)	64.4 (10.7)
Age, no (%)			
22-44	22 (2.1)	35 (4.2)	57 (3.1)
45-65	448 (43.7)	383 (45.3)	831 (44.4)
65+	556 (54.2)	427 (50.5)	983 (52.5)
Marital status, no (%)			
Married or common law	837 (81.6)	533 (63.1)	1370 (73.2)
Not married	189 (18.4)	312 (36.9)	501 (26.8)
Ethnicity, no. (%)			
Caucasian	940 (91.6)	786 (93)	1726 (92.3)
Non-Caucasian	86 (8.4)	59 (7.0)	145 (7.7)
Education			
High school and less	535 (52.1)	453 (53.6)	988 (52.8)
College and higher	491 (47.9)	392 (46.4)	883 (47.2)
Employment, no. (%)			
Employed	484 (47.2)	303 (35.9)	787 (42.1)
Others	542 (52.8)	542 (64.1)	1084 (52.9)
Income			
<$40,000	245 (23.8)	288 (34.1)	533 (28.5)
$40,000–$79,999	330 (32.2)	221 (26.1)	551 (29.5)
>=$80,000	290 (28.3)	163 (19.3)	453 (24.2)
Do not know/refuse	161 (15.7)	173 (20.5)	334 (17.8)
Smoking status, no. (%)			
Current smoker	111 (10.8)	88 (10.4)	199 (10.6)
Ex-smoker and Non-smokers	915 (89.2)	757 (89.6)	1672 (89.4)
Duration of diabetes, mean years (SD)	12.4 (9.1)	12.1 (8.7)	12.3 (8.9)

Note: Data are N (%) unless otherwise specified.

Table 3.2: Baseline response of dietary component according to sex					
SDSCA dietary Component	SDSCA dietary Component categories	Male	Female	Total	p-value
Q1	0-3 days/week	278 (27.1)	195 (23.1)	473 (25.3)	0.09
	4-5 days/week	348 (33.9)	288 (34.1)	636 (34)	
	6-7 days/week	400 (39)	362 (42.8)	762 (40.7)	
Q2	0-3 days/week	280 (27.3)	200 (23.7)	480 (25.7)	**0.05**
	4-5 days/week	353 (34.4)	278 (32.9)	631 (33.7)	
	6-7 days/week	393 (38.3)	367 (43.4)	760 (40.6)	
Q3	0-3 days/week	364 (33.7)	253 (29.9)	599 (32)	0.08
	4-5 days/week	317 (30.9)	253 (29.9)	570 (30.5)	
	6-7 days/week	363 (35.4)	339 (40.2)	702 (37.5)	
Q4	0-3 days/week	434 (42.3)	339 (40.1)	773 (41.3)	0.16
	4-5 days/week	385 (37.5)	305 (36.1)	690 (36.9)	
	6-7 days/week	207 (20.2)	201 (23.8)	408 (21.8)	

Note: Data are N (%) unless otherwise specified. P-value indicates the association between SDSCA dietary question response and the dietary component categories

Table 3.3: Spearman's correlation between SDSCA dietary questions				
	Q1	Q2	Q3	Q4
Q1	--			
Q2	**0.88**	--		
Q3	0.59	0.57	--	
Q4	0.24	0.21	0.16	--

Table 3.4: Number of yearly ED visit and hospitalization of the participants										
ED Visits										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2011-2019
Male N=1026	329 (32.1)	318 (31)	327 (31.9)	328 (32)	295 (28.7)	337 (32.9)	344 (33.5)	324 (31.6)	296 (28.9)	869 (84.7)
Female N=845	307 (36.3)	309 (36.6)	306 (36.2)	303 (35.9)	295 (34.9)	322 (38.1)	317 (37.5)	287 (33.9)	293 (34.67)	738 (87.3)
Hospitalizations										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2011-2019
Male N=1026	145 (14.1)	139 (13.6)	151 (14.7)	149 (14.5)	136 (13.3)	149 (14.5)	163 (15.9)	166 (16.2)	147 (14.3)	617 (60.1)
Female N=845	104 (12.3)	112 (13.3)	119 (14.1)	129 (15.3)	127 (15)	126 (14.9)	123 (14.6)	111 (13.1)	114 (13.5)	495 (58.6)

Note: Data are N (%) unless otherwise specified.

Table 3.5A: Healthcare utilization and response to Q1 among study participants					
Males (N=1026)		**0-3 days/week**	**4-5 days/week**	**6-7days/week**	**Total**
ED visits	yes	237 (85.3)	297 (85.3)	335 (83.7)	869 (84.7)
	no	41 (14.7)	51 (14.7)	65 (16.3)	157 (15.3)
Chi-square value; p-value		0.455; 0.79			
Hospitalization	yes	161 (57.9)	217 (62.4)	239 (59.8)	617 (60.1)
	no	117 (42.1)	131 (37.6)	161 (40.2)	409 (39.9)
Chi-square value; p-value		1.313; 0.52			
Females (N=845)		**0-4 days/week**	**5-7 days/week**	**6-7days/week**	**Total**
ED visits	yes	174 (89.2)	251 (87.1)	313 (86.5)	738 (87.3)
	no	21 (10.8)	37 (12.9)	49 (13.5)	107 (12.7)
Chi-square value; p-value		0.891; 0.64			
Hospitalization	yes	123 (63.1)	164 (56.9)	208 (57.5)	495 (58.6)
	no	72 (36.9)	124 (43.1)	154 (43.5)	350 (41.4)
Chi-square value; p-value		2.130; 0.34			

Note: Data are N (%) unless otherwise specified.

Table 3.5B: Association between healthcare utilization and response to Q1 among study participants					
Males (N=1026)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
Healthcare Utilization		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	1.0 (0.6, 1.6)	0.92	0.9 (0.6, 1.4)	0.55
Hospital stay (ref: No hospital stay)	--ref--	1.2 (0.8, 1.7)	0.36	1.0 (0.7, 1.4)	0.59
Females (N=845)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	0.8 (0.4, 1.4)	0.4	0.7 (0.4, 1.2)	0.21
Hospital stay (ref: No hospital stay)	--ref--	0.7 (0.5, 1.1)	0.1	0.7 (0.5, 1.0)	**0.05**

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Table 3.6A: Healthcare utilization and response to Q2 among study participants					
Males (N=1026)		**0-3 days/week**	**4-5 days/week**	**6-7days/week**	**Total**
ED visits	yes	237 (84.6)	303 (85.8)	329 (83.7)	869 (84.7)
	no	43 (15.4)	50 (14.2)	64 (16.3)	157 (15.3)
Chi-square value; p-value		0.646; 0.72			
Hospitalization	yes	170 (60.7)	212 (60.1)	235 (59.8)	617 (60.1)
	no	110 (39.3)	141 (39.9)	158 (40.2)	409 (39.9)
Chi-square value; p-value		0.059; 0.97			
Females (N=845)		**0-4 days/week**	**5-7 days/week**	**6-7days/week**	**Total**
ED visits	yes	181 (90.5)	240 (86.3)	317 (86.4)	738 (87.3)
	no	19 (9.5)	38 (13.7)	50 (13.6)	107 (12.7)
Chi-square value; p-value		2.370, 0.31			
Hospitalization	yes	122 (61)	163 (58.6)	210 (57.2)	495 (58.6)
	no	78 (39)	115 (41.4)	157 (42.8)	350 (41.4)
Chi-square value; p-value		0.762; 0.68			

Table 3.6B: Association between healthcare utilization and response to Q2 among study participants					
Males (N=1026)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
Healthcare Utilization		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	1.1 (0.7, 1.7)	0.69	0.9 (0.6, 1.7)	0.72
Hospital stay (ref: No hospital stay)	--ref--	0.9 (0.6, 1.2)	0.59	0.8 (0.6, 1.1)	0.29
Females (N=845)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	0.6 (0.3, 1.1)	0.11	0.6 (0.3, 1.1)	0.09
Hospital stay (ref: No hospital stay)	--ref--	0.9 (0.5, 1.3)	0.49	0.7 (0.5, 1.1)	0.14

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Table 3.7A: Healthcare utilization and response to Q3 among study participants					
Males (N=1026)		**0-3 days/week**	**4-5 days/week**	**6-7days/week**	**Total**
ED visits	yes	297 (85.3)	263 (83)	311 (85.7)	869 (84.7)
	no	51 (14.7)	54 (17)	52 (14.3)	157 (15.3)
Chi-square value; p-value		1.086; 0.58			
Hospitalization	yes	215 (62.1)	188 (59.3)	214 (58.9)	617 (60.1)
	no	131 (37.9)	129 (40.7)	149 (41.1)	409 (39.9)
Chi-square value; p-value		0.882; 0.64			
Females (N=845)		**0-4 days/week**	**5-7 days/week**	**6-7days/week**	**Total**
ED visits	yes	231 (91.3)	208 (82.2)	299 (88.2)	738 (87.3)
	no	22 (8.7)	45 (17.8)	40 (11.8)	107 (12.7)
Chi-square value; p-value		**9.835; 0.01**			
Hospitalization	yes	157 (62.1)	151 (59.7)	187 (55.2)	495 (58.6)
	no	96 (37.9)	102 (40.3)	152 (44.8)	350 (41.4)
Chi-square value; p-value		3.018; 0.22			

Table 3.7B: Association between healthcare utilization and response to Q3 among study participants					
Males (N=1026)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
Healthcare Utilization		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	0.8 (0.5, 1.3)	0.45	1.1 (0.7, 1.6)	0.75
Hospital stay (ref: No hospital stay)	--ref--	0.8 (0.6, 1.1)	0.20	0.8 (0.6, 1.1)	0.17
Females (N=845)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	0.4 (0.2, 0.7)	**0.002**	0.7 (0.4, 1.2)	0.15
Hospital stay (ref: No hospital stay)	--ref--	0.8 (0.5, 1.2)	0.36	0.7 (0.5,0.9)	**0.04**

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Table 3.8A: Healthcare utilization and response to Q4 among study participants					
Males (N=1026)		**0-3 days/week**	**4-5 days/week**	**6-7days/week**	**Total**
ED visits	yes	367 (84.6)	328 (5.2)	174 (84.1)	869 (84.7)
	no	67 (15.4)	57 (14.8)	33 (15.9)	157 (15.3)
Chi-square value; p-value		0.145; 0.93			
Hospitalization	yes	266 (61.3)	231 (60)	120 (58)	617 (60.1)
	no	168 (38.7)	154 (40)	87 (42)	409 (39.9)
Chi-square value; p-value		0.648; 0.72			
Females (N=845)		**0-4 days/week**	**5-7 days/week**	**6-7days/week**	**Total**
ED visits	yes	294 (86.7)	264 (86.6)	180 (89.5)	738 (87.3)
	no	45 (13.3)	41 (13.4)	21 (10.5)	107 (12.4)
Chi-square value; p-value		1.174, 0.56			
Hospitalization	yes	203 (59.9)	176 (57.7)	116 (57.7)	495 (58.6)
	no	136 (40.1)	129 (42.3)	85 (42.3)	350 (41.4)
Chi-square value; p-value		0.396; 0.82			

Table 3.8B: Association between healthcare utilization and response to Q4 among study participants					
Males (N=1026)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
Healthcare Utilization		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	1 (0.7, 1.5)	0.82	0.9 (0.6, 1.5)	0.91
Hospital stay (ref: No hospital stay)	--ref--	0.8 (0.6, 1.2)	0.38	0.7 (0.5, 1.1)	0.15
Females (N=845)	**0-3 days/week**	**4-5 days/week**		**6-7 days/week**	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Visited ED (ref: Did not Visit ED)	--ref--	0.9 (0.5, 1.5)	0.75	1.3 (0.7, 2.2)	0.37
Hospital stay (ref: No hospital stay)	--ref--	0.8 (0.6, 1.2)	0.49	0.9 (0.6, 1.2)	0.43

**OR adjusted for age, marital status, ethnicity, education, employment, income, smoking status, duration of type 2 diabetes, BMI

Figure 3.1A: Bar chart of ED visit (Continuous)

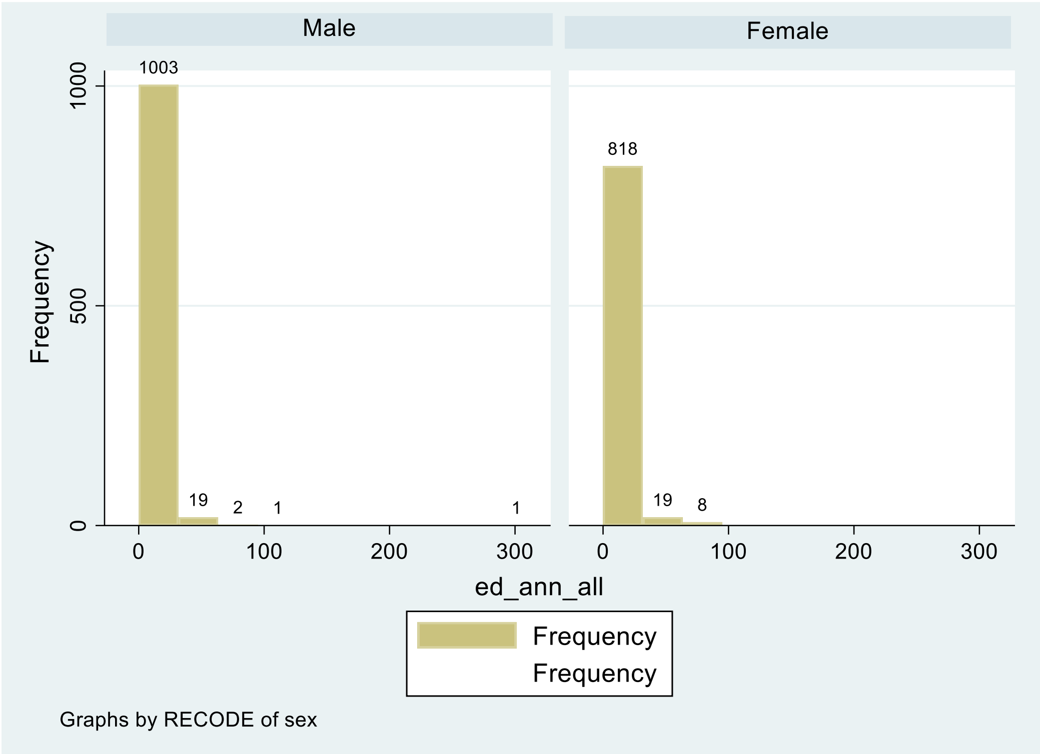


Figure 3.1B: Bar chart ED visit (Binary)

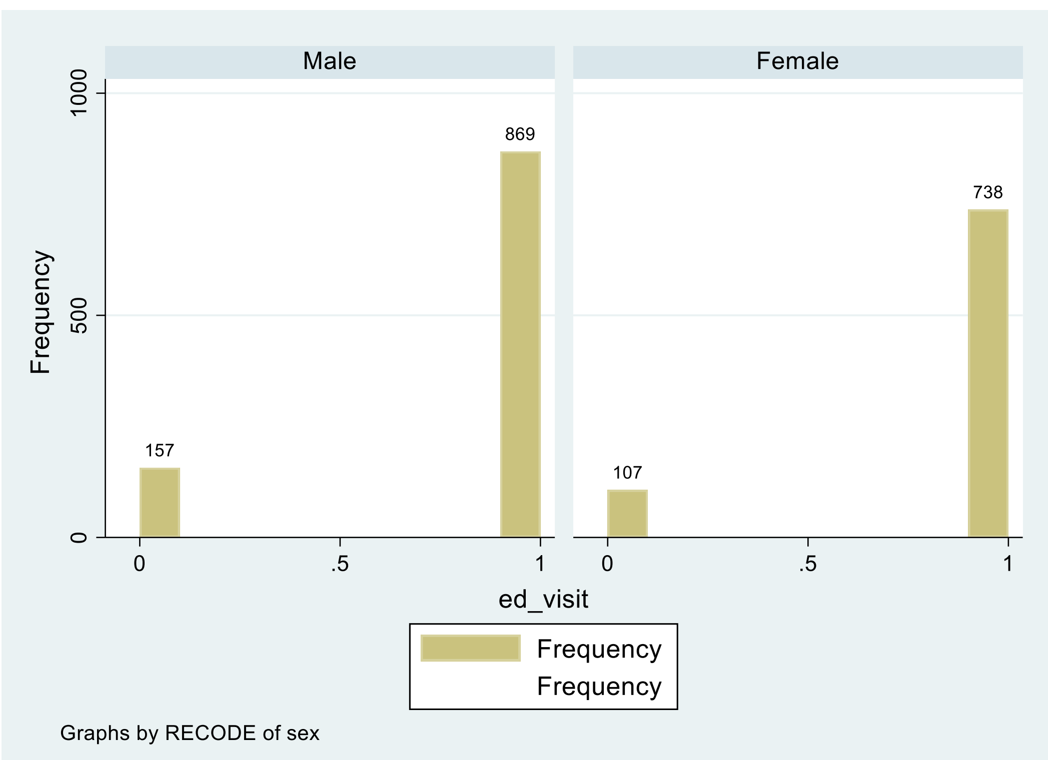


Figure 3.2A: Bar chart Hospital stay (Continuous)

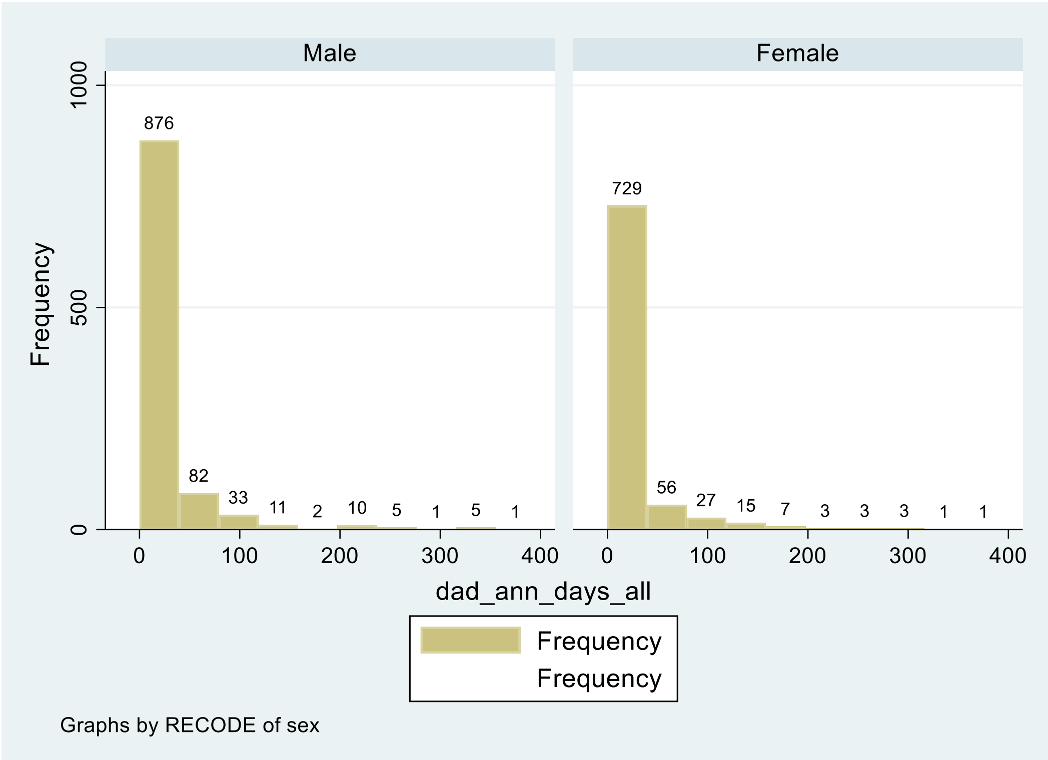
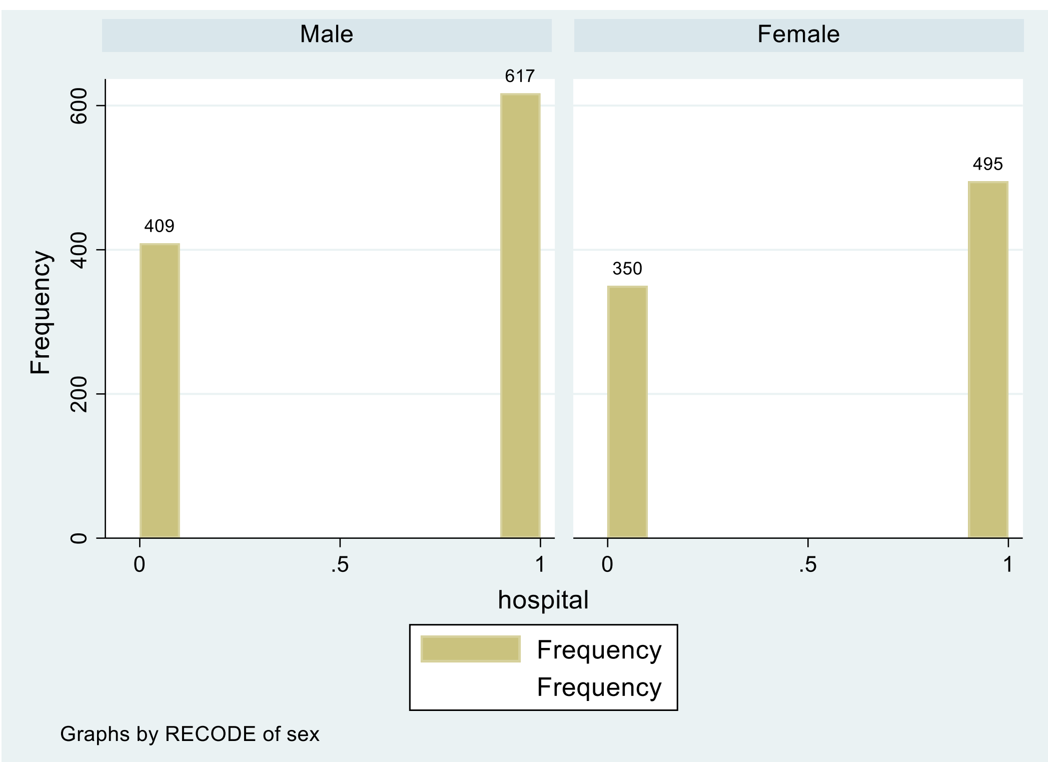


Figure 3.2B: Bar chart Hospital stay (Binary)



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Chapter 4

Discussion and Conclusion

4.1 Summary of Findings

Diabetes once was considered as the disease of the rich (1, 2). Food shortage and famines were associated with a decline in the rate of diabetes, as documented during World War One and Two (3). Many prospective studies have found relations between dietary intake and consequent risk of developing type 2 diabetes. Intake of saturated fats, red meats, sugar and salt increase the risk of insulin resistance and type 2 diabetes (4-6). A 23 year-long cohort study of the Finnish population (7) showed that the poor dietary patterns plays are a risk factor for developing diabetes. Diets that were rich in fruits and vegetables was associated with a reduced risk of type 2 diabetes and in contrast, diets comprised of butter, potatoes, red meat, and whole milk, was associated with a higher risk of type 2 diabetes. Different observational cohorts suggest the same synopsis (8, 9).

Since diet plays a significant role in diabetes development, keeping track of dietary patterns can play an eminent role in reducing the global burden of this disease. In general, there can be secular and geographical trends in diet habits, but these data are heterogeneous in different studies (10). Although studies of diet and health require individual data rather than population, nutritional epidemiology also revealed that there will always be errors while assessing the dietary patterns (11). To avoid this kind of misrepresentation, it is suggested that measures be compare with one another, because no single measure is entirely valid (11-13). This activity which determine the process is known as the assessment of validity (13). This step is necessary to understand diet related diseases like diabetes. Diabetes is responsible for the considerable morbidity and mortality, which are typically separated into macrovascular complications (coronary artery disease, peripheral arterial disease, and stroke) and microvascular complications (diabetic nephropathy, neuropathy, and retinopathy) (14, 15). These complications are the major reason that persons with diabetes use health care services more frequently than persons without diabetes (16-18).

This thesis consists of two research studies. In the first study, we assessed the validity the dietary component of SDSCA scale in comparison with 3-day food record, and the second study explored the relationship between responses to the dietary component of SDSCA scale and healthcare utilization in adults with type 2 diabetes. As mentioned earlier, understanding the association of the dietary component of SDSCA scale and healthcare utilization is important for the evaluation of self-management of people living with type 2 diabetes. Healthy diet is a key component for preventing and managing type 2 diabetes and provides numerous health benefits, including weight management, improved glycemic control, decreased blood pressure, and decreased risk of developing complications and comorbidities. Having a validated measure for the dietary component of the SDSCA scale will make the assessment of the dietary patterns more feasible, which in turn will help to mitigate diabetes comorbidities and healthcare utilization, which was the overall objective of our research.

In our first study, exploring for the association between the self-reported dietary component of SDSCA measure and 3-day food records, we did not find significant and consistent associations between the measures. The three-day food record is an acceptable standard against which other measures can be validated. To our knowledge there was no existing study that examined the validity of the dietary component of the SDSCA scale. One study among Japanese women used a self-administered diet history questionnaire which was similar to the dietary component of the

SDSCA scale and they validated it against the 3-day food record (19). Another study in Japan examined two self-administered diet history questionnaires for and validated them with 24-hour urinary markers (20). Both the study results indicated that the questionnaires, after validated with 3-day food record, may be useful to assess individual habitual nutrient intake in health education at least in the population examined. In our study, the only significant association observed was in females in case of fat consumption, where almost 75 percent of participants reported that their fat consumption was not within the Acceptable Macronutrient Distribution Range (AMDR) range. One study in a population of people living with diabetes showed that forty-two percent of their respondents reported consumption of 30–40% of their daily calories from fat, and 26% reported intakes of 40% of their daily calories from fat, which aligns with the significant result of our study (21).

Our study showed significant association of dietary intake of Vitamin A consumption in SDSCA measure when validated with 3-day food record. For other vitamins and minerals, we could not find any conclusive result. One reason for the lack of association may be underreporting by respondents. Many studies found higher proportion of under-reporters among women, which remained unclear whether men underreport to a lesser degree than women, or whether they underreport to the same degree but from a higher energy requirement and therefore fewer fall below a single cut-off applied across all subjects (22, 23). Another reason maybe the overall low consumption of vitamin rich foods. It is widely understood that most adults do not consume enough vitamin and mineral rich foods. Overall, the diet history from our study provided an estimates of energy intake, macronutrients, and micronutrients intakes in a sample of older adults with type 2 diabetes mellitus.

Our second study, explored from baseline (2011) to the final wave of follow up (2019) of older adults with type 2 diabetes, to see if there is less emergency department visit and hospital stay in participants who reported better dietary self-care behavior (i.e., more in line with recommended dietary intake). There was some evidence of reduced health care utilization among those who followed better dietary behaviors (24, 25) . This was more evident in females than males in our study, where we observed that females who were following their recommended diet for 6-7 days per week were approximately 30% less likely to have hospital stays and those who ate five or more servings of fruits and vegetables more than 3 days per week were also about 30% less likely to have emergency department visits or hospital stays. Interestingly, among females who reported consuming more red meat and high-fat dairy most days during the week (i.e., less healthy dietary intake), there was a 30% increased odds of ED visits over the following 10 years. These findings align with a previous cross-sectional study where female diabetic patients with healthier eating habits reported having a better quality of life (25). However, one study on gender differences in healthcare utilization suggested that women who suffer from diabetes use more healthcare services and have a higher morbidity rate compared with men (26). Thus, the differences we observed with females and males, where there were no consistent differences in health care utilization, may be due to differences in self-reporting of dietary behaviours, or differences in secular trends of health care utilization.

4.2 Implications of Research

Our study explored the dietary components of SDSCA measured and to our knowledge this is the very first study that validated the dietary component against a 3-day food record. The results from our study can be cited as evidence to strengthen any future experimental study design or longitudinal study design. We always have to keep in mind that one measure that has been validated in one setting, may not be valid in another setting (13). To understand the variety of dietary patterns and specific foods that are beneficial for type 2 diabetes, we need validated measuring scales. While the SDSCA is considered valid and used in several languages as a whole, the dietary component part can be as useful as the separate scale. A strong correlation coefficient between Q1 – 'How often did you follow your recommended diet over the last 7 days' and Q2 – 'On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?' suggests these two questions are quite similar. Further, in our second study on the relationship between SDSCA responses at baseline and health care utilization showed us that the ORs from Q1 and Q2 in relation with healthcare utilization is quite similar. Based on this finding we can recommend using either Q1 or Q2, just to make the dietary scale more compact and concise.

The 2018 Clinical Practice Guidelines on Nutrition Therapy from Diabetes Canada (27) suggests nutrition therapy can reduce glycated hemoglobin (A1C) by 1.0% to 2.0% and, when used with other components of diabetes care, can further improve clinical and metabolic outcomes. It is suggested that everyone with diabetes should receive nutrition counselling by a registered dietitian, but there is no mention of recommended food's benefit regarding the healthcare utilization. Our study suggested that recommended dietary intake for diabetes acts as a protective factor regarding ED visit and hospitalization, particularly so for females, presumably through better health outcomes. We believe this should be incorporated within these guidelines, to provide additional support for the existing recommendations for dietary self-care.

By incorporating the evidence supporting the association between dietary self-care and expensive health care utilization into the guidelines, health care professionals might become better educated on this relationship and could convey this information to patients even better. Patients who are not currently following the recommendations might be more likely to engage in healthy eating to receive a meaningful benefit such as improved general health, fighting depression, fatigues and achieve overall vitality. Ideally, this would help lead to better health within this clinical population, and reduced burden of the disease on patients, as well as associated long-term health care costs in Canada.

4.3 Strengths and Limitations

One of the major strengths of this thesis involves the use of data from a large population-based cohort. The use of data from a prospective cohort of this nature is unique, as most Canadian epidemiological studies use population data available only through administrative health records, which lack important covariates and are often incomplete. The ABCD cohort survey included various measures and questionnaires used to assess a variety of factors associated with health in type 2 diabetes. Measures that were selected for inclusion into the cohort survey have previously been validated for use in type 2 diabetes. However, we recognize that the cohort sample may not represent the average person living with diabetes in Alberta. This sub-sample represents a relatively higher income, educated, and mainly Caucasian group and devoid of indigenous population.

Using 3-day food record as the reference for validation is another strength of our research. It can be easily applied to diverse groups with a wide range of eating habits and may be used to estimate the average intake of a certain population (12, 28, 29). One thing to consider in our study is that the collection of SDSCA scale measure and the 3-day food record were not simultaneous. They are from different timeline. Participants' self-care dietary practices and intake data were collected three/six months prior to the 3-day food record data in the same year. We sent invitation letters for participation in the 3-day food record with the year 3 follow-up questions. Participants send us the consent forms in a span of six months after getting the invite. It is recommended that comparison, two measures are collected within a week of each other (30). Self-reported measures are also known to be prone to social desirability bias, however the short length of the food recording technique lessen the chances of recall bias. One of the drawbacks of using recorded data can be that it may represent the current diet but not the usual diet. Some respondents may alter their diet intentionally to avoid a burden on responses or even choose to not report actual intake which can affect both the types of food chosen and the quantities consumed (12, 31, 32).

4.4 Conclusion

In summary, this thesis provides stronger support to the guideline of Eating Well with Canada's Food Guide and Diabetes Canada's 2018 Clinical Practice Guidelines: Nutrition Therapy for dietary recommendation. We have generated new evidence about the validity of the dietary component of the well-known SDSCA measure, which could inform a more efficient use of this measure in the future. We also demonstrated that healthier diet patterns are associated with a protective effect on hospitalization in a population of people living with diabetes in our longitudinal study design, albeit primarily amongst females in the study cohort. We may be better able to motivate patients with type 2 diabetes to follow the recommended diet and follow dietary self-care measures, to achieve improvements in overall quality of life. Incorporating evidence surrounding the benefits of diet on healthcare utilization into the guidelines will allow patients and clinicians alike to become better informed of this relationship. Efforts to promote healthy diet should emphasize the clinical benefits. As the prevalence of diabetes continues to rise worldwide, promotion of better eating habit and self-care behaviors for managing type 2 diabetes is increasingly important in order to reduce the burden on the health care system.

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