

**Barriers and facilitators in meal planning strategies for glycemic control in
individuals with type 1 diabetes in Beijing, China**

By: Jennifer Lyu

Senior Honors Thesis

Department of Nutrition
University of North Carolina at Chapel Hill
2017

Approved:

Advisor: Elizabeth Mayer-Davis

Second Reader: Wei Liu

ABSTRACT

Type-1 diabetes (T1D) incidence in China is one of the lowest among the world but is steadily increasing each year. Without proper matching of insulin injections with dietary intake, patients with T1D face challenges with maintaining healthy blood glucose levels. Currently, there is very limited research that has focused on the nutrition aspect of T1D self-management among patients in China. This study aims to further investigate the nutrition aspect of T1D management in China by exploring how nutrition knowledge may be influencing adherence to meal planning and carbohydrate counting among T1D patients in China. The study also aims to investigate other potential barriers that may influence adherence to meal planning and carbohydrate counting. Two online nutrition surveys were developed through Qualtrics Survey Software: one survey was targeted towards patients with T1D (n=82) and one survey was targeted towards health care providers (n=11) from Peking University People's Hospital in Beijing, China. The mean age of patient participants was 26.0 ± 7.2 years. Approximately 74.4% of patient participants were female. Majority of patient participants were also underweight/healthy weight (BMI < 23.0), from urban residence, and have at least a college level of education. Overall, patient participants scored higher on nutrition knowledge questions related to nutrition labels (70.6 ± 20.2) versus questions regarding healthy foods and diet (non-label) questions (60.9 ± 17.1). Only 35.4% of patient participants reported counting carbohydrates 'Every day.' The study also found the most common major barrier reported by patients was the desire to eat more food than what their doctor recommended. Other common barriers included wanting to read food labels, but not being able to because many of the foods consumed by patients do not have labels and because labels were hard for patients to understand. The sample of providers were all female and included 9 physicians, 1 nurse, and 1 dietitian. Descriptive statistics showed 81.8% of providers believing meal plans were too stringent for patients and 72.7% agreeing that meal plans were not practical because they included foods the patient did not normally consume. Overall, the study found no significant associations between nutrition knowledge and adherence to meal planning and carbohydrate counting. The study also did not find any significant associations between total number of barriers perceived and adherence to meal planning and carbohydrate counting. This suggests a more flexible insulin regimen is needed in China to allow for more flexible dietary patterns, as opposed to a fixed insulin regimen that is currently being utilized by majority of T1D patients in China. Cost and accessibility of healthy foods were also not perceived to be significant barriers to meal planning and T1D management by both patients and health care providers. Given the small sample size of this study, more research is needed in the future to test these associations between nutrition knowledge and adherence to meal planning and carbohydrate counting, as well as total number of barriers perceived and adherence to meal planning and carbohydrate counting.

This original research involved the analysis of data obtained from patients in an online T1D community in China and from providers from the Peking University People's Hospital in Beijing, China. I would like to thank my advisor and mentors Elizabeth J. Mayer-Davis, PhD, at the University of North Carolina at Chapel Hill and Wei Liu at the Peking University People's Hospital in Beijing, China, without whose constructive advice, support, and statistical analysis assistance this research would not have been possible. This project was supported by the Summer Undergraduate-Taylor Research Fellowship.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURE	iv
CHAPTERS	
I. INTRODUCTION AND STUDY AIMS	1
II. LITERATURE REVIEW	5
T1D Description.....	5
T1D Global Incidence.....	6
T1D Potential Etiologies.....	7
T1D Pathogenesis.....	7
Environmental Triggers of Autoimmunity and T1D.....	8
T1D Micro- and Macrovascular Conditions.....	8
Psychosocial Concomitants.....	11
T1D Management.....	11
T1D in China.....	13
III. MANUSCRIPT	18
Abstract.....	19
Introduction.....	20
Methods.....	21
Results: Patient Perspective.....	25
Results: Provider Perspective	41
Discussion.....	48
Strengths and Limitations.....	50
Conclusions.....	50
Future Steps.....	51
IV. REFERENCES	52

LIST OF TABLES AND FIGURE

Table	Page
Definitions of Pre-diabetes and Diabetes.....	2
Basic Demographics of T1D Patients (before collapsing variables)	30
Basic Demographics: Patients (n=82) (after collapsing of variables)	31
Frequency of Adhering to Recommended Dietary Advice Received from Diabetes or Health Care Provider.....	32
Frequency of Viewing Nutrition Information on Labels by T1D Patients.....	33
Barriers to Adhering to Meal Plans Among T1D Patients.....	34
Demographics vs. Nutrition Knowledge Questions (Mean % Accurate)	35
Demographics vs. Adherence to Meal Plans and Carbohydrate Counting.....	36
Demographics vs. Barriers 1-3.....	37
Demographics vs. Barriers 4-6.....	38
Demographics vs. Barriers 7-9.....	39
Barriers 1-9 vs. Adherence to Meal Plan and Carbohydrate Counting.....	40
Basic Demographics of Health Care Providers.....	43
Frequency of Recommendations to T1D Patients.....	43
Frequency of Advising Referrals and Counseling to T1D Patients.....	44
Frequency of Recommending Dietary Advice to T1D Patients.....	44
Frequency Checking the Following Complications in T1D Patients.....	45
Providers' Perspective of What is Most Essential for T1D Management.....	46
Barriers to Adherence of Meal Plans Among T1D Patients Perceived by Health Care Providers.....	47
Figure	
Nutrition Knowledge and Adherence to Meal Plan DAG Diagram.....	51

CHAPTER I

INTRODUCTION AND STUDY AIMS

Introduction

Diabetes is a chronic metabolic disease characterized by blood glucose levels that are above normal due to deficiencies of insulin production or function.¹ Glucose is a simple sugar produced by the breakdown of sugars and starches from the diet and is used for energy by the body.² Insulin is a hormone, released by beta cells within the islets of Langerhans of the pancreas, that the body needs to get glucose from the blood stream into the cells of the body.^{3,4} When insulin binds to its receptor on the cell, it signals a cascade of reactions that leads to the phosphorylation of , a serine-threonine protein kinase that stimulates the translocation of glucose transporter 4 (GLUT4), found in the heart, skeletal muscles, and adipocytes, to move to the cell surface and accelerate glucose uptake.^{5,6} There are two major types of diabetes. Type-1 diabetes (T1D) is characterized by body's inability to produce insulin due to the autoimmune destruction of the beta cells in the pancreas.¹ As a result, there is no insulin to bind to the receptor, thus no AKT signaling and no translocation of GLUT4 to uptake glucose from cells. Type-2 diabetes (T2D) is characterized by impaired insulin signaling and therefore insulin resistance, in which the body requires a higher level of insulin than normal to facilitate uptake of glucose into cells.⁷ Over time, the pancreas is unable to make enough insulin to keep blood glucose at normal levels.⁷ Other types of diabetes include gestational diabetes.⁷ Prediabetes is a term that refers to a transition state in which the amount of glucose in the blood is above the normal ranges but not high enough to be considered diabetes.⁸ According to the CDC, 86 million American adults- more than 1 out of 3 – have prediabetes. Of this total, 15-30% of people with pre-diabetes will develop type-2 diabetes within 5 years.⁹ Further, 9 out of 10 people do not know they have prediabetes.⁹

Diabetes may be diagnosed by measuring hemoglobin A1C levels (A1C), fasting plasma glucose (FPG), and by an oral glucose tolerance test (OGTT) (Table 1).⁸ The A1C test measures your average blood glucose for the past 2 to 3 months. According to the American Diabetes Association, diabetes is diagnosed at an A1C of greater than or equal to 6.5%.⁸

Prediabetes is diagnosed at an A1C between 5.7% and 6.4%.⁸ For the FPG test, fasting is defined by not having anything to eat or drink (except water) for at least 8 hours before the test.⁸ This test is usually done first thing in the morning before breakfast. Diabetes is diagnosed at fasting blood glucose of greater than or equal to 126 mg/dl.⁸ Prediabetes is diagnosed at fasting blood glucose of 100 mg/dL to 125 mg/dL.⁸ The OGTT is a two hour test that checks your blood glucose levels before and two hours after you drink a special sweet drink.⁸ This test signifies how your body processes glucose. Diabetes is diagnosed at 2 hour blood glucose of greater than or equal to 200 mg/dL.⁸ Prediabetes is diagnosed at 2 hour blood glucose of 140 mg/dL to 199 mg/dL.⁸ The focus of this investigation will be type-1 diabetes.

Table 1. Definitions of Prediabetes and Diabetes⁸

	Hemoglobin A1C (%)	Fasting Plasma Glucose (FPG)	OGTT (2 hour plasma glucose)
Prediabetes	5.7-6.4%	100-125 mg/dL	140-199 mg/dL
Diabetes	≥ 6.5%	≥ 126 mg/dL	≥ 200 mg/dL

According to the International Diabetes Federation, in 2015, there were 415 million people worldwide living with diabetes.¹⁰ By 2040, this number is projected to increase to 642 million people.¹⁰ Of this total amount, the Western Pacific region of the world accounts for the highest rates of diabetes with 153.2 million people living with the disease in 2015 and 214.8 million people projected to have the disease by 2040.¹⁰ Compared to T2D, which accounts for about 90% to 95% of all diagnosed cases of diabetes, T1D accounts for only about 5%.¹¹ Among the Western Pacific region, an estimated 60,700 children under the age of 15 have type 1 diabetes, with approximately 10,000 newly diagnosed in 2015. Over 30,000 of these children are in China, supporting the evidence that China consists of the largest number of people with T1D in this region.^{10,12} Although evidence suggests the incidence of T1D in China is increasing, knowledge on T1D care in China is severely outdated. One study conducted by the International Diabetes Federation between 2001 and

2002 found that children and adolescents with T1D in China had the lowest mean daily insulin dose and the lowest frequency of self-monitoring of blood glucose among Western Pacific countries.¹³ This may explain the high HbA1C level for the sample, a mean of 80.3 mmol/mol (9.5%).^{12,13}

Diabetes requires meticulous treatment and care that involves regular blood glucose checking and management of insulin dosing regimens unique to each individual. The coordination of insulin with dietary intake is essential among people with T1D so as to maintain near-normal blood glucose levels and prevent micro- and macrovascular complications, including neuropathy, retinopathy, kidney disease, ketoacidosis, hypertension, stroke, and heart disease.^{12,14} This integration is achieved through individualized diabetes nutrition therapy, which typically involves one of two approaches: (1) fixed daily insulin doses matched to consistent carbohydrate intake with respect to time and amount or (2) flexible daily insulin doses accommodating variability in food intake, typically using carbohydrate counting.¹² There is not a 'one-size-fits-all' eating pattern for diabetes. Healthcare providers and dietitians should collaboratively develop eating plans with each individual with diabetes and provide ongoing implementation support.

In China, dietitians are largely absent from continuing diabetes education for individuals with T1D in China, and few patients regularly practice self-monitoring of blood glucose or carbohydrate counting.¹² Barriers to improving T1D care in China include the high cost of blood glucose strips and blood glucose meters, both of which are not covered by health insurance.¹² On average, one-third of an urban family's income is spent on care for patients with T1D in China.¹² Further, the lack of diabetes education and the common requirement for inpatient admission to receive diabetes education serve as major barriers. Other barriers include misconceptions relating to Chinese traditional medicine, time limitations of healthcare providers, and discrimination against individuals with T1D.¹²

These barriers contribute to the reason why China continues to lag behind the United States and Europe in T1D care and further pushes the need for more research into what

specific needs T1D patients are lacking currently in order to best formulate effective resolutions to improve treatment and management.

STUDY QUESTIONS AND AIMS

This proposed project plans to employ standard quantitative and qualitative data collection methods to address the following research questions:

1. Does nutrition knowledge influence adherence to recommended meal plan and carbohydrate counting among patients with T1D in Beijing, China?
2. What are other perceived challenges that influence adherence to recommended meal plans and carbohydrate counting among patients with T1D in Beijing, China?

To address these questions, the research study will investigate two main aims as described below:

AIM 1: Use quantitative methods to assess nutrition knowledge among T1D patients and to describe perceived barriers by T1D patients in order to investigate two associations: (a.) the association between nutrition knowledge and adherence to meal planning and carbohydrate counting and (b.) the association between total number of barriers perceived and adherence to meal planning and carbohydrate counting.

Data collection occurred through distribution of a personal link to an online survey to interested T1D patients that were part of a T1D online community in China.

For Aim 1, there were three hypotheses:

1. There is a positive association between nutrition knowledge and adherence to meal planning and carbohydrate counting among T1D patients in China.
2. There is a negative association between total number of barriers perceived and adherence to meal planning and carbohydrate counting.
3. Other barriers that may influence adherence to meal planning and carbohydrate counting include cost and access to healthy foods recommended by the patients' provider.

AIM 2: Use survey methods to assess perspectives from healthcare providers on major barriers to T1D patients in Beijing, China.

Data collection occurred through distribution of an anonymous link to an online survey to health care professionals (physicians, nurses, and registered dietitians) that provide clinical care to patients with T1D at Peking University People's Hospital in Beijing, China.

I hypothesized that health care providers from the Peking University People's Hospital believe a rigid meal plan to be a common and major barrier for T1D patients in China..

Chapter II
LITERATURE REVIEW

T1D Description

Type 1 diabetes (T1D) is a chronic disease characterized by the body's inability to produce insulin due to the autoimmune destruction of beta cells in the pancreas.¹ Insulin is an important hormone in our body because it exerts a wide variety of biological actions, including regulation of glucose metabolism and protein synthesis.³ Once insulin binds to an extracellular insulin receptor, a number of cellular substrates are phosphorylated, leading to the activation of multiple downstream signaling pathways.³ Most specifically, the phosphorylation of phosphatidylinositol (PIP2) by phosphatidylinositol-3-kinase (PI3K) leads to the phosphorylation of AKT, a serine-threonine protein kinase that stimulates the translocation of glucose transporter 4 (GLUT4), found in the heart, skeletal muscles, and adipocytes, to move to the cell surface and accelerate glucose uptake.^{15,16} AKT also plays a more direct role in signaling protein synthesis and glucose metabolism for energy. Therefore, lack of insulin secretion inhibits the downstream cascade of substrate phosphorylation and thus, AKT activation, resulting in hyperglycemia, in which there is an excess amount of glucose accumulated in the blood that is unable to enter catabolic energy producing pathways.

T1D Global Incidence

Reports on global variation in incidence, prevalence, and temporal trends in type 1 diabetes (T1D) are largely based on findings from large T1D registry studies, such as the World Health Organization Multinational Project for Childhood Diabetes (DIAMOND), EURODIAB, and the SEARCH for Diabetes in Youth (SEARCH) study.¹⁷

In 2006, the DIAMOND project examined the trends in incidence of T1D (per 100,000 a year) from 1990-1999 in children aged ≤ 14 years from 114 populations in 57 countries. Out of a total of 84 million children, 43,013 cases of T1D were diagnosed, and over this time period, the average annual increase in incidence was 2.8%, with a slightly higher rate of 3.4% from 1995-1999 compared to a rate of 2.4% from 1990-1994.^{17,18}

These estimated trends showed statistically significant increases across continents (4.0% in Asia, 3.2% in Europe, and 5.3% in America), except in Central America and the West Indies where the trend showed a decrease of 3.6%.^{17,18} The DIAMOND project concluded that such increases in incidence reports during this short period of time is less likely a result of genetic shifts, but rather environmental factors and the interactions between genes and the environment.^{17,18}

From 1989-94, the EURODIAB Ace Study group reported 16,362 cases of T1D in 44 centers throughout Europe and Israel covering a population of approximately 28 million children.¹⁹ Similar to the DIAMOND project, the standardized annual incidence rate varied greatly from 3.2/100,000 person years in Macedonia to 40.2/100,000 person years in Finland.^{17,19} During this time period, there was an annual increase in T1D incidence of 3.4%, and in some central regions of Europe, this rate has been reported to be higher.^{17,19} Additionally, the rates of increase were found to be highest in the youngest age group: ages 0-4 years (6.3%, 95% CI 1.5-8.5%), which suggests an immediate challenge to caring for T1D in a toddler and an earlier onset of T1D also implies a longer burden of disease.¹⁷

Similarly, in the United States, the most recent research shows an unadjusted estimated T1D incidence rate of 1.4% annually (from 19.5 cases per 100,000 youths per year in 2002-2003 to 21.7 cases per 100,000 youths per year in 2011-2012, $P=0.03$). In adjusted pairwise comparisons, the annual rate of increase was greater among Hispanics than among non-Hispanic whites (4.2% vs. 1.2%, $P<0.001$).²⁰

T1D Potential Etiologies

The explanation for the wide disparities in T1D incidence between populations and ethnic groups may involve variance in the distribution of genetic susceptibility markers, differences in the distribution of environmental disease determinants, or the combination of both.²¹ When looking at genetic susceptibility markers, the most important genes are located within the major histocompatibility complex (MHC) HLA class II region on chromosome 6p21 (Insulin-dependent diabetes mellitus, IDDM1), accounting for about 45% of genetic susceptibility for T1D.²² While these genes carry an immune response function involving the presentation of antigenic peptides to T-lymphocytes, their specific contribution to the pathogenesis of T1D remains unclear.²³ Further, T1D represents a heterogeneous and polygenic disorder with approximately 40 non-HLA loci contributing to disease susceptibility already identified, but only two with known functions.¹⁵ IDDM2 on chromosome 11p5.5 contributes about 10% towards disease susceptibility.²³ This locus is a polymorphic region that maps to a variable number of tandem mini-satellite repeats (VNTR), with short class 1 VNTR alleles predisposing to T1D.²³ Another locus associated with T1D is IDDM12 on chromosome 2q33, which has an apparent action on the cytotoxic T-lymphocyte-associated protein (CTLA-4), that is associated with immune responsiveness.²³

T1D Pathogenesis

In the 1980s Eisenbarth' proposed a model that postulates that everyone is born with a degree of susceptibility to develop type 1 diabetes: for some this susceptibility is high, for others very low.¹ Susceptibility is largely inherited, residing predominantly in the HLA genotypes DR and DQ, and to a lesser extent in a host of other genetic loci (IDDM) susceptibility genes.¹ The HLA locus is thought to confer about 50% of the genetic susceptibility, roughly 15% from two other genes – insulin-VNTR (IDDM-2) and CTLA-4 (IDDM12) – with minor contributions from the other IDDM genes.¹ These susceptibility genes are thought to be important regulators of the immune response. Other genes associated with either rare syndromes including diabetes or other autoimmune conditions might also provide important insights into the immune pathogenesis of type 1 diabetes.¹

Environmental triggers may then alter immune function and initiate β -cell destruction. Putative triggers include viruses, environmental toxins, or foods (early exposure to cow's milk proteins, cereals, or gluten).¹ A close relation has been identified only with congenital rubella. Supportive evidence for the autoimmune pathogenesis of T1D comes from the susceptibility of these individuals to other autoimmune conditions including Hashimoto's thyroiditis, Graves' disease, Addison's disease, coeliac disease, myasthenia gravis, and vitiligo.¹ Although recent knowledge has contributed to our understanding of the pathogenesis of T1D, there remains no unifying theory of disease causation. However, the hygiene hypothesis has shown to partly align with type 1 diabetes. This hypothesis stems from observations that atopic disorders such as asthma are more common in affluent than in traditional societies, their prevalence rising with increasing modernization, and that such disorders are less frequent in children in large families or those families receiving day care than in children in small families or those not in day care. These findings suggest that children in these circumstances are less exposed to infections or other immune challenges early in life that act as protective environment influences.¹ This hypothesis however lacks credible scientific support in the causation of T1D.

Environmental Triggers of Autoimmunity and T1D

Ecological correlation between incidence and various environmental, health, and economic indicators suggest that differences in environmental risk factors, such as nutrition and lifestyle may be important in determining country's incidence rate.¹⁶ Environmental risk determinants for T1D may also be classified into three groups: viral infections, early infant diet (e.g. breastfeeding versus early introduction of cow milk's components), and toxins.²³ Further, The Environmental Determinants of Diabetes in the Young (TEDDY) study is a multicenter, multinational, epidemiological study that aims to identify infectious agents, dietary factors, or other environmental exposures that are associated with increased risk of autoimmunity and T1D.²⁴ This study also aimed to identify the factors influencing specific phenotypic manifestations such as early age of onset of T1D.²⁴ Psychosocial stress was also explored as a potential trigger for T1D.²⁴ In one finding of the study related to infant feeding and the effect of infant formulas on the risk of islet autoimmunity and type 1 diabetes (T1D), researchers found that islet autoimmunity risk is not reduced, and may be

increased, by using hydrolyzed compared with nonhydrolyzed cow's milk-based infant formula as the first formula in infants at increased genetic risk for T1D.²⁵ Thus, while the TEDDY study looks at many ecological evidence for triggers of T1D, it also suggests there are other environmental factors that may greatly be contributing to T1D development and progression. These factors, however, are still being explored and researchers are further investigating if there are specific genetic susceptibilities involved among different groups of individuals.²⁴

T1D Complications: Micro- and Macrovascular Conditions

Long-term diabetes-related complications may be characterized as both microvascular and macrovascular conditions, which account for most of the increased morbidity and mortality associated with the disease.¹ Microvascular complications include retinopathy, nephropathy, and neuropathy. Diabetic nephropathy is the most common cause of renal failure in the developed world. Diabetic nephropathy progresses through a series of recognizable steps from subclinical disease, to the earliest detectable phase of microalbuminuria (defined as a urinary albumin excretion rate $>20 < 200$ μg per day) to overt nephropathy or macroalbuminuria (>200 μg per day) with renal dysfunction and eventual end-stage renal disease. Macrovascular complications include cardiovascular, cerebrovascular, and peripheral vascular disease.¹ Screening of individuals with T1D for microalbuminuria should be instituted early in the course of their disorder: the Canadian Diabetes Association suggests annual screening every year with a random urine albumin-creatinine ratio in post pubertal individuals with diabetes of duration 5 years or greater. Positive screening tests should be confirmed with further random albumin-creatinine ratios or timed urine collections for 2-3 months. Persistent positive results require introduction of renoprotective measures, including further intensification of glycaemic control and control of hypertension or hyperlipidaemia, or both, if present. First-line drugs of choice include angiotensin-converting enzyme inhibitors or angiotensin receptor-blocking agents, both of which are highly effective in slowing progression of renal disease in this population.¹

Microvascular conditions

Diabetic retinopathy is the most common cause of acquired blindness in the western world, with a prevalence rate of proliferative retinopathy of about 20-25% in T1D. It also progresses through recognizable stages from early non-proliferative changes, previously called background retinopathy (microaneurysms, exudates, and hemorrhages), which appear in almost all individuals with T1D by about 20 years' duration, to preproliferative retinopathy and then to proliferative retinopathy and macular oedema.¹ Screening for diabetic retinopathy should begin 5 years after diagnosis in individuals of 15 years of age or older and be done yearly.¹ The presence of diabetic retinopathy requires enhanced attention to glycaemic, blood pressure, and lipid control, with laser therapy in sight-threatening diabetic retinopathy.

Diabetic neuropathy refers to a complex group of conditions falling into two major categories: focal and generalized.¹ Focal neuropathies include carpal tunnel syndrome, peroneal nerve and third cranial nerve palsies, and diabetic amyotrophy (proximal nerve conditions). The most common generalized neuropathy is sensorimotor polyneuropathy, which often first presents as a peripheral neuropathy alone, but often also affects the autonomic system with cardiac dysfunction, gastroparesis, and erectile dysfunction.¹ Peripheral neuropathy, in conjunction with peripheral vascular disease, can lead to skin ulceration of the lower limbs, poor healing and gangrene, and amputation.¹ Good foot care may greatly lower the risk of these outcomes. Screening for neuropathy should also begin about 5 years after type 1 diabetes diagnosis with appropriate methods: testing at the great toe with a 10 gauge monofilament to detect loss of sensitivity, and clinical assessment for the other manifestations. Attention to glycaemic control represents the first step in management; if unsuccessful in controlling symptoms, referral to a specialist is recommended. Attention to preventive foot care is also essential.¹

Macrovascular complications

The relative risk of cardiovascular disease in T1D can be as much as 10-fold greater than that in non-diabetic individuals.¹ Risk factors for cardiovascular disease in type 1 diabetes include presence of diabetic nephropathy, autonomic neuropathy, dyslipidemia, and hypertension. Reduction of risk of vascular disease includes attention to healthy lifestyle

(weight control and physical activity), smoking avoidance, with optimum glycaemic, blood pressure (<130/80 mmHg in adults), and lipid control.¹

Psychosocial concomitants

Past research has shown children from single parent families and low socioeconomic status are more likely to present in diabetic ketoacidosis at disease onset, have more episodes of diabetic ketoacidosis during the course of their diabetes, attend clinic less frequently, and are less likely to maintain good glycaemic control than those from two-parent and well-off families.¹ Other researchers have also reported an increased prevalence of depression in adults with type 1 diabetes.¹ Type 1 diabetes have also been shown to be associated with eating disorders, and are often associated with insulin omission to control weight through induced glycosuria, poor glycaemic control, and early onset of diabetes-related complications.¹

T1D Management: Insulin

Insulin was first discovered in 1921 and was initially thought to represent a cure for T1D. However, acute morbidity and mortality as well as a series of chronic complications still occur.²³ The Diabetes Control and Complications Trial (DCCT) research group showed the importance of strict metabolic control for the delay and prevention of chronic complications.²³ Devices that promote home blood glucose monitoring and routine determination of HbA1c are important for individuals to have euglycaemia without risk of severe hypoglycaemia.²³ Most individuals in more developed countries are now treated with recombinant human insulin, which has allowed the ability to alter the insulin molecule for improved pharmacokinetics. Thus, insulin analogues are now available that can be absorbed more rapidly and that can decrease the variability of insulin absorption. In many diabetes centers, it is recommended that rapid-acting insulin be administered with each meal, either with insulin pens or with pumps. The availability of rapid-acting insulin has also contributed to the greater use of insulin pumps. These pumps, although expensive, allow for the setting of multiple basal rates of insulin administration and bolus administration with each meal. Similar effects can be obtained with multiple daily injections of rapid-acting insulin combined with long-acting insulin.

There are now also devices that sample interstitial glucose by placement of a subcutaneous sensor, or use of an electric current to bring glucose to the skin surface by iontophoresis. One device uses a subcutaneous sensor and provides up to 3 days of glucose monitoring. Continuous monitoring with alarms for high glucose and low glucose concentrations, as well as allowing patients to modify their insulin administration (with multiple injections of rapid-acting insulin or insulin pumps) in real-time on the basis of glucose values is most ideal.²³

Some other types of insulin pumps are programmed to release different amounts of insulin based on the time of the day. For example, basal insulin is the continuous release of small doses of insulin, while bolus insulin is a 'surge' of insulin released close to the consumption of a meal in order to control for the increase in blood glucose.²⁶

T1D Management: Nutrition and Dietary Intake

In addition to insulin treatment, dietary adjustments are an essential regulator of blood glucose. The American Diabetes Association (ADA) published nutrition recommendations emphasizing individualization of dietary advice with a focus on the effects of nutrition therapy on metabolic control.¹ The most recent ADA recommendations reiterate that there is no "one-size-fits-all" diet for individuals with diabetes and that food choices should only be limited when supported by scientific evidence.²⁷ In the United States, one study reported that adults with T1D had a higher mean percentage of energy from fat and protein and a lower mean percentage of energy from carbohydrates compared to controls.²⁷ A similarly higher mean percentage of energy from fat compared to controls has also been observed in several small samples of youth T1D in the U.S. and in Europe.^{20,27}

In contrast to fixed insulin dosing, carbohydrate counting is one meal planning approach that promotes a flexible insulin-dosing regime, allowing for the adjustment of the prandial insulin dose for actual carbohydrate intake in T1D patients.²⁸ Carbohydrate counting requires T1D patients to be educated on how to calculate carbohydrate amounts in each meal in order to predict the correct insulin dose required to maintain a normal postprandial blood glucose level.²⁸ Carbohydrate counting has been shown to reduce hemoglobin A1C levels, particularly in adult groups due to a greater likelihood of adults learning and applying this approach in comparison to children or adolescents.²⁸

T1D Management: Transplantations

Other forms of treatment include pancreas and more specifically islet transplantation. Limitations of this treatment however include the reliability of organ donors and the need for continuous immunosuppression. The immunosuppression is needed not only to prevent rejection, but also to block recurrent autoimmune islet destruction.²³

T1D Management: Gene Therapy

Gene therapy might be promising for promotion of euglycaemia. Two recent studies, one using gut K cells and the other involving liver cells, showed that the insulin gene delivery could be both glucose responsive and establish euglycaemia.²³

Further, drugs for prevention of specific complications include ACE inhibitors for nephropathy, rigorous control of lipids with new generation statins, and protein kinase C inhibitors.²³

T1D IN CHINA

T1D in China: Incidence and Temporal Trends in China

According to a recent systematic review and meta-analysis of incidence and temporal trends of type 1 diabetes in China, the overall incidence of type 1 diabetes (per 100 000 person-years) in mainland China has increased rapidly from 0.57 (95% CI 0.43-0.75) in 1990 to 1.04 (0.64-1.68) in 2000 and 3.36 (1.66-6.82) in 2010 ($p < 0.0001$).²⁹ The mean annual increase in incidence was 9.0% (5.1-15.9), and the increase was numerically higher in boys (10.6%, 95% CI 4.7-23.6) than in girls (7.2%, 2.7-18.8)²⁹. Incidence was significantly higher in girls than in boys (IRR 1.23, 95% CI 1.12-1.36; $p < 0.0001$) and this disparity was most profound in children aged 5-9 years (1.71, 1.27-2.29; $p = 0.00036$).²⁹ The IRR for urban versus rural areas was 1.82 (1.37-2.41; $p = 0.0001$).²⁹

Another study investigating childhood type-1 diabetes incidence trend in Shanghai, China reported the incidence to have a mean annual increase of 14.2% per year during 1997-2011.²⁷ The study suggested that if this increasing trend continues, the number of new type 1 diabetes cases will double from 2016 to 2020, and prevalent cases will sextuple by 2025.²⁷

Another study looked at type 1 diabetes incidence rates and trends among children and adolescents aged 0-19 in rural Zhejiang province.³⁰ This study reported an average annual increase of 12% over the course of the study period from 2007-2013, as well as a steep rise of 33.6% in diabetes incidence in children under the age of 5 years old.³⁰

In mainland China, the overall incidence of T1D was 0.74 (95% CI 0.55-1.00) per 100,000 person years between 1980 and 2013.²⁹ Although the incidence rates in China are relatively low compared to the United States and Northern regions of Europe, China has the largest number of people with T1D in the Western Pacific Region.³¹ Within China, the highest incidence was found in the region of Wuhan (4.6 per 100,000 per year) and lowest in Zunyi (0.1 per 100,000 per year).³² Further, in one recent study, T1D is characterized by different geographical distributions, with the North region having the highest prevalence of 120.5 per 100,000 persons, then the East following with 80.0 per 100,000 persons, and finally the Southwest region with 59.8 per 100,000 persons.³³ The colder climate, high-sugar diet, higher fat composition, and less dietary fiber found in northern regions of China may explain the higher incidence found.³³

As incidence of T1D in China is expected to continue rising, it is important for researchers to take into account the environmental factors, such as diet, that plays an important role in diabetes self-management.

T1D in China: Self-management

Currently, data on T1D care outside the United States and Europe are limited. Between 2001-2002, the International Diabetes Federation conducted a cross-sectional study on glycemic control and diabetes self-management, and found that children and adolescents with T1D in China had the lowest mean daily insulin dose and the lowest frequency of self-monitoring blood glucose (SMBG) among Western Pacific countries.^{12,13} This low SMBG frequency poses a significant barrier for physicians in China as well, who cannot advise patients appropriately with respect to diet because of a lack of SMBG information (most patients do not bring SMBG results to their outpatient visits).¹² In a recent study performed in Guangzhou city, a relatively developed district in China, an information-motivation-behavioral skills (IMB) model of health behavior was used among type-1 diabetes patients to investigate behavioral factors affecting the practice of SMBG.³⁴ The study found major

SMBG information deficits including 50.9% of participants not understanding the meaning of high blood sugar before exercises and 47.3% not understanding the kind of food that should be taken when blood sugar was low.³⁴ In addition, one-fifth of participants did not understand the different meanings of HbA1c and SMBG results and the necessity to practice both.³⁴ The lack of diabetes educators in China and the common requirement of inpatient admission to receive diabetes education are major barriers to proper T1D patient self-management.¹² Other motivation obstacles included 85.5% of participants viewing the cost of testing to be “too expensive” or adhering to doctor’s recommendations to be “painful” (72.7%).³⁴ Although insulin is covered in part by most health insurance policies, insulin injection tools, blood glucose testing strips and blood glucose meters are not covered by insurance.¹² Behavioral limitations involved 63.6% of participants feeling it was difficult to discuss diabetes with workmates and friends, and 58.2% finding it challenging to buy test strips conveniently.¹² These findings suggest possible reasons for study’s low compliance rate (36.4%) of the American Diabetes Association recommendation to test blood glucose three times daily.³⁴ These results based on the IMB framework are important findings that may provide potential-focused education targets for diabetes health care providers.³⁴

T1D in China: Nutrition Therapy

In 2014, the first study to assess the integration of diabetes nutrition therapy, self-management practices, and dietary intake among T1D patients in a developing country was conducted in China.¹² Researchers of this study found that there was a low frequency of diabetes nutrition therapy approaches, such as carbohydrate counting.¹² Instead, data from the study suggest majority of diabetes nutrition therapy consists of matching fixed insulin doses to a diet that is rigid with respect to amount and timing.¹² This method of nutrition therapy makes it difficult for some T1D patients to adhere to due to the desire to consume a more flexible and diverse diet.

Further, the study showed that fewer than half of participants had ‘ever’ met with a dietitian, and it suggested that dietitians are only used in high-risk situations.¹² Only 18% had attended an education session in the preceding 12 months, which may explain why only 12% of participants sometimes use carbohydrate counting and 32% sometimes follow

an eating plan given to them by their healthcare provider.¹² This is notably in contrast to youth with T1D in the US, where 97% have been taught carbohydrate counting and 86% report using this method 'often.'¹² As a result, lack of nutrition education from this study indicated an insufficient foundation among type 1 diabetes patients to implement changes to their diet.¹² From the study, 74% of participants desired to learn more about how food interacts with their diabetes care.¹² Therefore, there is a strong need in China for more integration of nutrition education by trained clinical dietitians during routine patient care.

T1D in China: Dietary Patterns

A recent study that compared the dietary intakes of individuals with T1D to individuals to that of individuals without T1D, found most participants to follow a fixed insulin regimen matched with a rigid meal plan, with respect to timing and amount of food.³⁵ Overall, compared to individuals without T1D, individuals with T1D in China had a lower mean percentage of energy from carbohydrates and a higher mean percentage of energy from fat and protein.³⁵ Additionally, participants who were on fixed insulin regimens had higher intake of wheat products and consumed less fruit, but more high-fat cakes and dairy compared to those without T1D.³⁵ Higher consumption of high-fat cakes was suggested to be a result of sugar-free cakes tending to be higher in fat, and patients may have been instructed to focus on low-sugar, low-carbohydrate foods, rather than fully comprehend the totality of the nutritional information.³⁵ However, in a later study it was found that consumption of high-fat cakes was inversely associated with HbA1c levels in T1D participants and consumers of wheat products had significantly lower LDL cholesterol compared to non-consumers.³⁶ Individuals with T1D on fixed insulin regimen also restricted fruit intake, which suggests another result of focusing on low, sugar or low-carbohydrate intake without considering the aspects of an overall healthy, balanced diet.³⁵ Lack of physician-patient time and dietitian involvement in T1D care in China may be potential barriers to comprehensive educational nutrition counseling.³⁵ On the other hand, participants on basal-bolus regimens were less likely to consume fried foods and more likely to consume fish/shellfish.³⁵ This group also consumed more protein than those with T1D on a fixed insulin regimen.³⁵ Thus, given the lower amounts of fried foods consumed, this group of participants with T1D had a generally healthier diet than those with T1D on a

fixed insulin regimen. It was therefore suggested that T1D patients on a basal-bolus insulin regimen are likely more motivated to adhere to self-management relating to dietary intake and nutrition.³⁵ In both insulin regimen groups, participants with T1D had an overall higher intake of vegetables, fungi/seaweed, and low-fat cakes compared to individuals without T1D. Fungi is often used as an example for a “sugar free” food during diabetes education courses and the increased intake of low-fat cakes, such as biscuits/crackers is often consumed to treat hypoglycemia in China.³⁵ The study also found that participants with T1D overall consumed less dietary fiber than non-T1D participants, and further found that mean fiber intakes were below the recommended level of 14 g/1000 kcal.³⁵ Thus, given that fiber is associated with reduced all-cause mortality and reduced cardiovascular disease risk among individuals with diabetes, there is a need to identify strategies to help promote an increase in dietary fiber intake in future research.³⁵

T1D in China: Stigma

A major barrier to improving care for individuals with type 1 diabetes is the stigma that exists towards the disease, which has led to stereotyping, labeling, and devaluing of individuals with T1D.³⁷ One of the reasons underlying this stigma may be the extremely low incidence of the disease.^{18,37} Its rarity establishes those with T1D to be portrayed as unusual, or ‘monsters’ by society.³⁷ The stigma surrounding T1D in China has led to difficulties for individuals to establish friendships and relationships with others.³⁷ Further, there is a government regulation that states individuals with ‘severe endocrine and metabolic diseases’ should not be admitted to universities or junior colleges, or employed by the government. The resulting structural discrimination has caused individuals with T1D to hide their diabetes in order to gain acceptance into colleges or jobs.³⁷ This stigma has also prevented many individuals to seek proper treatment, or sufficiently adhere to treatment plans in fear of having to inject their insulin dose in a public setting.³⁷ Health care providers should therefore take a holistic, rather than solely biomedical approach, when advising patients with T1D, in order to account for how stigma may have a confounding effect on T1D self-management.³⁷

Chapter III
Manuscript

ABSTRACT

Type-1 diabetes (T1D) incidence in China is one of the lowest among the world but is steadily increasing each year. Without proper matching of insulin injections with dietary intake, patients with T1D face challenges with maintaining healthy blood glucose levels. Currently, there is very limited research that has focused on the nutrition aspect of T1D self-management among patients in China. This study aims to further investigate the nutrition aspect of T1D management in China by exploring how nutrition knowledge may be influencing adherence to meal planning and carbohydrate counting among T1D patients in China. The study also aims to investigate other potential barriers that may influence adherence to meal planning and carbohydrate counting. Two online nutrition surveys were developed through Qualtrics Survey Software: one survey was targeted towards patients with T1D (n=82) and one survey was targeted towards health care providers (n=11) from Peking University People's Hospital in Beijing, China. The mean age of patient participants was 26.0 ± 7.2 years. Approximately 74.4% of patient participants were female. Majority of patient participants were also underweight/healthy weight (BMI < 23.0), from urban residence, and have at least a college level of education. Overall, patient participants scored higher on nutrition knowledge questions related to nutrition labels (70.6 ± 20.2) versus questions regarding healthy foods and diet (non-label) questions (60.9 ± 17.1). Only 35.4% of patient participants reported counting carbohydrates 'Every day.' The study also found the most common major barrier reported by patients was the desire to eat more food than what their doctor recommended. Other common barriers included wanting to read food labels, but not being able to because many of the foods consumed by patients do not have labels and because labels were hard for patients to understand. The sample of providers were all female and included 9 physicians, 1 nurse, and 1 dietitian. Descriptive statistics showed 81.8% of providers believing meal plans were too stringent for patients and 72.7% agreeing that meal plans were not practical because they included foods the patient did not normally consume. Overall, the study found no significant associations between nutrition knowledge and adherence to meal planning and carbohydrate counting. The study also did not find any significant associations between total number of barriers perceived and adherence to meal planning and carbohydrate counting. This suggests a more flexible insulin regimen is needed in China to allow for more flexible dietary patterns, as opposed to a fixed insulin regimen that is currently being utilized by majority of T1D patients in China. Cost and accessibility of healthy foods were also not perceived to be significant barriers to meal planning and T1D management by both patients and health care providers. Given the small sample size of this study, more research is needed in the future to test these associations between nutrition knowledge and adherence to meal planning and carbohydrate counting, as well as total number of barriers perceived and adherence to meal planning and carbohydrate counting.

INTRODUCTION

In China, the incidence of T1D is very low, but is continuing to increase each year. The overall incidence of T1D (per 100 000 person-years) increased from 0.57 in 1990 to 1.04 in 2000, to 3.36 in 2010.³⁸ In one Shanghai study, the incidence in childhood T1D had a mean annual increase of 14.2% per year during 1997-2011.³⁸ If this increasing trend continues, the number of T1D cases is expected to double from 2016 to 2020 and prevalent cases are expected to sextuple by 2025.³⁸ This growing incidence calls for a greater need of proper T1D treatment and management.²⁹ While there is currently very limited research that has specifically investigated meal planning strategies and T1D self-management in China, few studies have shown an overall poor T1D management among patients.¹² One study suggested a limited education on diabetes and nutrition are likely contributors to this poor management.¹² Past research has also found that majority of T1D participants in the study matched fixed insulin doses to a diet that is rigid with respect to amount and timing, rather than practiced a flexible insulin dosing regime with carbohydrate counting in which patients injected differing amounts of insulin according to the calculated amounts of carbohydrates consumed in the meal.¹² It is likely that low adherence to recommended meal plans may be a result of the rigid diet that makes it difficult for patients to eat what they desire.¹² Lack of education regarding flexible insulin dosing regimens may explain why there are very few T1D patients in China who follow this approach. Additionally, there exists an overarching stigma towards T1D in China that may ultimately play a role in preventing many individuals with T1D to actively seek care or adhere to specific dietary recommendations.³⁷ Thus, it is also necessary for health care providers to be aware of this stigma in order to apply a holistic approach when providing care to patients with T1D.

The current findings on meal planning and T1D management in China represent only a small sample of patients with T1D. Therefore this study aims to further explore the nutrition aspect of T1D self-management in China, as well as the potential barriers that may influence proper treatment and care.

METHODS

The Partner Study

This study is a cross-sectional study that was conducted alongside a partner study titled *Development of Type 1 Education Materials for Use by Patients Living in China*. The focus of this partner study was to develop a Chinese, culturally adapted T1D educational material, based on a commonly used T1D education book in the United States called, *A First Book for Understanding Diabetes* (FBUD). This adaptation was based on information collected from T1D patients and health care providers at the Peking University People's Hospital in Beijing, China. Patients and caregivers were asked to read the current FBUD adaptation and after reading each chapter of the book, were asked to evaluate the content for its clarity and helpfulness. These chapter evaluations were accomplished through the completion of a brief survey and further feedback and suggestions for revisions of the adaptation were provided through focus group interviews with patients and caregivers. Health care providers at the Peking University People's Hospital were also asked to complete a survey aimed at collecting information on current clinical practices for T1D patient treatment and management.

Patient participants in this partner study included 3 main groups: adult patients (≥ 18 years) classified as having T1D by the endocrinology specialists at the Peking University People's Hospital based on diabetic ketone acidosis at the onset of the disease (and the age of onset at less than 35 years of age), adolescents with T1D (12-17 years), and adult caregivers of children with T1D who are < 18 years of age. Healthcare providers participating in this study include endocrinologists, nurses, and dietitians at the Peking University People's Hospital.

Study researchers and collaborating providers discovered that the original U.S. version of FBUD lacked sufficient nutrition information necessary for handling dietary intake with T1D self-management and care for Chinese patients. Therefore, the goal of this study was to work with both patients and providers of the Peking University People's Hospital to further investigate the nutrition aspect of T1D self-management in China and the major

challenges that patients are facing in relation to adherence to meal planning strategies and T1D care.

Development of Study Materials: Patient and Provider Nutrition Online Surveys

Two online nutrition surveys were developed for this study: one survey was targeted towards patients with T1D in China and one survey was targeted towards health care providers at the Peking University People's Hospital in Beijing, China. The patient nutrition survey included questions regarding basic demographics, nutrition knowledge, recommendations received by providers regarding T1D management, adherence to meal plans, and perceived barriers when managing their diet with their T1D care. Questions for this survey were translated and modified from the 3C Nutrition Ancillary Study Supplemental Questionnaire, and the Nutrition Knowledge Survey (NKS)^{12,39}. The nutrition knowledge questions included in the Patient Nutrition Survey were divided into two categories: Healthy Foods (non-label) Questions and Nutrition Label Questions. The Healthy Foods (non-label) Questions involved general questions regarding foods included in a healthy diet, as well as some dietary questions specifically for T1D patients related to certain foods' effects on the rate of blood glucose levels and estimated number of carbohydrates contained in certain foods. The Nutrition Label Questions assessed the patients' ability to read and understand food labels.

The provider survey included questions regarding the providers' basic demographics (i.e. sex, occupation, years of experience, etc.), recommendations given to type-1 patients, as well as the frequency of providing these recommendations. This survey also asks providers what they perceived were their patients' most challenging barriers to adhering to meal planning strategies, as well as what they saw were the most helpful factors to promoting patient self-care. Baseline demographic questions were taken and modified from the Survey of Attitudes and Practices Among Family Physicians.⁴⁰

Participants: Patient Recruitment

Participants (n=82) who took the Patient Nutrition Survey were recruited through an online community directed by a respiratory therapist at Beijing Children's Hospital. This online community was created through "WeChat," a commonly used app in China that

allows for networking and group communications. This app is used as a platform to promote motivation, encouragement, and assistance among type-1 diabetes patients in China. An advertisement for the study was posted on this online community and interested members of this community were instructed to contact a member of the UNC research team by email (a separate email account was created for the purposes of this study) and with a standard message written in Chinese on the advertisement that instructed how participants should express their interest to join the study. Once email of interest was received, the UNC researcher generated a personal link to the online survey through Qualtrics Survey Software for each interested participant patient. This personal link was different for each participant and could only be used once. This prevented the link from being massively distributed across the web. The personal link also allowed for the respondent's data to be automatically saved as the participant progressed through the survey. If the participant needed to leave the survey before finishing, they could return to the last question they left off at any time on any device. The UNC researcher then responded to each participant's email of interest with a standard message translated in Chinese that thanked the participant for his/her interest and included the personal link to the survey. The message also noted that if the participant were to have any further questions regarding the study, to email Dr. Wei Liu (WL). Each response message with the personal link was also sent to WL to ensure all communications between the patient and UNC researcher were clear and no possible questions by the patient were left unanswered. For members of the online community who had trouble sending their email of interest directly to the UNC researcher's email account due to technical difficulties, these members contacted WL. WL then forwarded the "WeChat" usernames of these individuals to the UNC researcher who kept a working list of these usernames. A list of personal links were generated for these individuals, and included in the standard response message. However, instead of sending the email directly back to the participant, the response message with the personal link was emailed to Dr. Liu, with the "WeChat" username as the subject title, and then Dr. Liu forwarded this email along to the participants.

Participants: Provider Recruitment

Providers (n=11) recruited for this study included endocrinologists, nurses, and dietitians from the Peking University People's Hospital. An anonymous link was distributed by email to these providers by Dr. Liu. Multiple survey takers can use one anonymous link, which differs from the personal link, which only allows for one user. Since these providers are trustworthy colleagues of Dr. Liu and given the anticipated smaller sample pool, an anonymous link was utilized for efficiency.

Study Incentives

Once the survey was completed, both patients and providers were given a \$2 telephone gift card, transmitted electronically within 24 hours.

All procedures were approved by the University of North Carolina Office of Human Research Ethics and the Peking University Biomedical Institutional Review Board, and all participants provided online informed consent prior to taking the online survey.

Statistical Analyses

Data collected from the survey was organized in a Microsoft Excel spreadsheet through double entry and validation for controlling possible errors in translating the information. The variables were coded in accordance with the response and, whenever possible, were categorized to facilitate the analysis and understanding of results. Data analysis regarding the associations between nutrition knowledge and demographic variables utilized T-tests to assess for significance. A Chi-Square test (Fisher's Exact test for $n \leq 5$) and Yate's correction factor (for $n \leq 10$) was utilized to test for significance of associations between nutrition knowledge and adherence, as well as between barriers and adherence. For purposes of analysis, BMI was calculated from each patient's height and weight information.

RESULTS: PATIENT PERSPECTIVE

Patient Responses

There was a total of n=99 initial responses to the patient survey. Of this total, 91 participants agreed to the consent form and continued to take the survey, while 8 participants disagreed to give consent and therefore did not take the survey. The following questions in survey displayed a decrease in participant number where from questions 1-32, there were n=88 participants who responded and remained in response until questions 14-32, where this number decreased to n=82 participants responding. Thus, all data that was analyzed for this study utilized the sample size of 82 to represent all participants who completed the entirety of the survey in order to maintain a sense of consistency during analysis of the data. The survey was set up such that participants had to complete the previous questions before moving on to the next set of questions. Therefore, this decrease in participant response may be a result of patients completely exiting out of the survey, possibly due to length or technical difficulties. However, reasons for the survey incompleteness are not certain.

Patient Descriptive Statistics

Patient Demographics

Table 2 shows the original basic demographic data collected from the Patient Nutrition Survey. Due to the small sample sizes found within each of the demographic variable categories, variables that included more than two groups were dichotomized for the purposes of later data analysis (Table 3).

Overall, more than half of the sample patient participants who completed the entirety of the survey (n=82) were less than 30 years old, with the mean age of the sample being 26 years (Table 3). About 74% of participants were female and majority of participants were of underweight/healthy weight (BMI < 23). Additionally, more than half of participants self-reported being from urban residence, were single, and had at least a college level education.

Diabetes and Meal Planning Education

Data from the Patient Nutrition Survey showed 75.0% of patient participants reported receiving previous diabetes education, with approximately 83.3% of participants reported receiving this education from a physician. Further, approximately 72.7% of participants have been given an eating plan by their physician or dietitian. Of this percentage, when asked in how many of the past seven days they adhered to this meal plan, approximately 31.7% reported adhering for seven days, yet 15.0% adhered none of the days. Additionally, when asked from what source participants receive information about managing their diet with diabetes, 84.2% reported receiving information from the internet/web.

Frequency of Adhering to Recommended Dietary Advice Received from Dietitian or Health Care Providers

Counting carbohydrates (CC) is one meal-planning tool utilized by T1D patients that involves adjusting the amount of insulin injected to the amounts of carbohydrates consumed.²⁸ For this study, 32.9% of participants reported either never counting carbohydrates or only CC when blood glucose was abnormal (Table 4). The remainder 67.1% of participants reported CC every day or some days. More than half of participants also reported choosing low glycemic index foods, limiting sweets, and eating more fruits and vegetables 'Every Day' (Table 4). About 40.2% of participants also reported 'Never' to using dietary exchanges for their T1D management.

Awareness of Dietary Intake Amount among T1D Patients

Approximately 87.8% of T1D participants reported that they knew how much they should be eating; however 39.0% reported eating more than they should. Further, more than half of participants (56.1%) disagree with the survey statement, "I eat until I feel full."

Frequency/Motivation of Reading Food Labels

When looking at frequency of reading food labels, 75.6% of participants reported that they 'often look at food labels.' Furthermore, Table 5 shows that more than half of participants look at the amount of carbohydrates and sugar on the label 'All the time.' In contrast, only 35.4% of participants look at serving size 'All the time.'

Patient Perceived Barriers

The most common major barrier reported by approximately 62.2% of patient participants in relation to managing one's dietary intake with their T1D was the challenge of wanting to eat more than what the doctor recommended (Table 6). The second most common barrier was reported by 37.8% of participants that wanted to read the food labels but could not because many of the foods they ate did not have food labels. The third most popular barrier was reported by 23.2% of patient participants that claimed they wanted to read the food label but could not because the food label was hard to understand.

Patient Data Analysis

Nutrition Knowledge Trends

Overall, patient participants scored higher in accuracy on the 'Nutrition Label' (NL) questions ($70.6\% \pm 20.2$) than on the 'Healthy Foods (non-label)' (HFNL) questions ($60.9\% \pm 17.1$). A T-test was utilized to assess significance between demographic variables and the two categories of nutrition knowledge questions (Table 7). The data shows females scoring significantly higher than males on the HFNL questions ($p=0.031$). Likewise, on the same HFNL questions, participants who had a higher education level ("College, Masters degree or higher") scored higher than participants who had a senior high school education or less ($p=0.014$). On the NL questions, students scored higher than the other occupations ($p=0.045$).

Nutrition Knowledge and Adherence

Table 8 shows the analysis performed between the two types of nutrition knowledge questions and its association with adherence to both meal plans and carbohydrate counting. A Chi-Square test (Fisher's Exact test for $n \leq 5$) and Yate's correction factor (for $n \leq 10$) was utilized to test for significance. The only significant finding in this data shows that those who scored less than 50% on the HFNL questions had the highest adherence for carbohydrate counting. There were also no significant findings found between adherence and demographic variables (Table 9).

Barriers Perceived By T1D Patients

Tables 10a, 10b, and 10c show all nine barrier statements included in the patient survey crossed with demographic variables. A two-sample proportions test was utilized to test for significance. The results show there was a significantly higher percentage of underweight/healthy weight than overweight/obese for both agreement and disagreement with the statement, 'I do not read food labels because I don't think it's important.' For this same barrier statement, it was also found that there was a significantly higher percentage of participants with a college education or higher versus those with a senior high school education or less who reported in agreement with this statement ($p=0.032$). Participants with a college education or higher also showed a significantly higher percentage in perceiving food labels being hard to understand as a major barrier ($p=0.041$). For the third barrier statement, regarding many of the foods participants consume do not have food labels, females showed a significantly higher percentage than males for both agreement and disagreement with this experiencing this barrier ($p=0.002$). There was also a significantly higher percentage of underweight/healthy weight than overweight/obese for both agreement and disagreement with the statement, 'I do not like the foods my doctor recommends' ($p=0.004$). For this same barrier statement, there was a significantly higher percentage of 'Single' versus 'Married or in a domestic relationship' who reported in agreement with and disagreement with the statement ($p=0.032$). Another significant finding showed those who had a college education or higher had a significantly higher percentage of participants reporting their family/friends do not like the foods their doctor recommends. Participants from urban residence had a significantly higher percentage of participants than those from rural residence that found food to be too expensive ($p=0.001$). Those who were single had a significantly higher percentage than those married or in a domestic relationship for both being in agreement with and in disagreement with expense of food as a major barrier ($p=0.047$). Finally, for this same barrier, those with a college education level or higher experienced expense as a major barrier more than those with a senior high school education or less ($p=0.001$). When it comes to accessibility of food, participants from urban residence perceived access to healthy foods as a more of a barrier than participants from rural residence ($p=0.003$). There were also more participants of

college education level that perceived accessibility ($p=0.006$) and knowing how to cook or prepare the foods their doctor recommends ($p=0.003$) as majors barrier.

Barriers and Adherence

The study found that wanting to eat more food than what the doctor recommends was significantly associated with a lower meal plan adherence among the T1D patients ($p=0.018$) (Table 11). Further, the study found that not reading the food labels because it's not important was associated with a low adherence to carbohydrate counting ($p=0.01$). Low adherence to carbohydrate counting was also significantly associated with wanting to read the food labels but don't because the labels are hard to understand ($p=0.024$). Other potential barriers showed no significant associations with adherence to meal planning or carbohydrate counting. There were also no significant associations between total number of barriers perceived and adherence.

Table 2. Basic Demographics of T1D Patients (before collapsing variables)

Variable Name	Mean±SD (Min-Max) or % (n)
Age	25.60±7.69 (2.50-40.00)
Sex	
Male	28.4% (25)
Female	71.6% (63)
Height	161.03±13.01 (90.00-183.00)
Weight	57.11±16.62 (15.00-120.00)
Residence	
Urban	64.8% (57)
Rural	35.2%(31)
Marital Status	
Single, never married	58.0% (51)
Engaged	3.4%(3)
Married or domestic partnership	34.1%(30)
Widowed	0.0% (0)
Divorced	3.4%(3)
Separated	1.1%(1)
Highest level of education	
Below primary school	8.0% (7)
Primary school	4.6%(4)
Junior high school	11.4% (10)
Senior high school	13.6% (12)
Vocational school	12.5%(11)
College	40.9%(36)
Masters and/or higher	9.1%(8)
Current Employment	
Worker	10.2% (9)
Farmer	0.0% (0)
Technology	6.8% (6)
Management	11.4% (10)
Teacher	4.6%(4)
Business	11.4% (10)
Health Care	6.8% (6)
House keeping	2.3% (2)
Student	28.4% (25)
Retired	0.0% (0)
Other	18.2% (16)
Age of First Diagnosis of Diabetes	16.68±7.61 (0.50-32.00)
Name of the ppt's hospital	
Name of hospital given	88.6% (78)
I don't know	11.4% (10)

Table 3. Basic Demographics: Patients (n=82) (after collapsing of variables)

	Mean±SD (Min-Max) or % (n)
Age	26.00±7.18 (7.00-40.00)*
≤ 29 years	61.0% (50)
≥ 30 years	39.0% (32)
Sex	
Male	25.6% (21)
Female	74.4% (61)
BMI	21.99±5.80
Underweight/Healthy weight (<23.0)	76.8% (63)
Overweight/Obese (≥23.0)	23.2% (19)
Residence	
Urban	67.1% (55)
Rural	32.9%(27)
Marital Status	
Single	62.2% (51)
Married or domestic partnership	37.8%(31)
Highest level of education	
Vocational school/Senior high or less	47.6% (39)
College, Masters, or higher	52.4% (43)
Current Employment	
Student	26.8% (22)
Other	73.2% (60)
Duration of diabetes (years)	9.05±7.48

* = value of 2.5 was omitted from the data analysis ; significance level $\alpha=0.05$ from t-test

Table 4. Frequency of Adhering to Recommended Dietary Advice Received from Dietitian or Health Care Providers

	% (n)			
	Every Day	Some days	Only when blood glucose is abnormal	Never
Keep track of calories	29.3% (24)	37.8% (31)	8.5% (7)	24.4% (20)
Count carbohydrates	35.4% (29)	31.7% (26)	13.4% (11)	19.5% (16)
Choose low glycemic index foods (foods that tend to raise blood sugar slowly i.e. non-fat milk or yogurt, whole grains, beans, green vegetables, tomatoes)	65.9% (54)	24.4% (20)	8.5% (7)	1.2% (1)
Use dietary exchanges	22.0% (18)	32.9% (27)	4.9% (4)	40.2% (33)
Keep track of fat grams	39.0% (32)	30.5%(25)	11.0% (9)	19.5% (16)
Limit sweets	59.8% (49)	25.6% (21)	8.5% (7)	6.1%(5)
Limit high fat foods (ex: deep fried)	50.0% (41)	34.2% (28)	8.5% (7)	7.3%(6)
Choose 'healthy' fats and oils (ie. vegetable oil, olive oil)	30.5%(25)	41.5% (34)	7.3% (6)	20.7%(17)
Drink more milk	50.0% (41)	32.9% (27)	6.1%(5)	11.0% (9)
Eat more fruits and vegetables	78.1% (64)	17.1% (14)	2.4% (2)	2.4% (2)
Eat more fiber and whole grains	48.8% (40)	39.0% (32)	3.7% (3)	8.5% (7)
Eat foods high in protein	37.8% (31)	48.8% (40)	6.1%(5)	7.3% (6)
Limit alcohol intake	65.9% (54)	13.4% (11)	0.0% (0)	20.7%(17)

Table 5. Frequency of Viewing Nutrition Information On Labels By T1D Patients

	% (n)				
	All the time	Most of the time	Sometimes	Rarely	Never
Calories	25.6% (21)	12.2% (10)	29.3% (24)	18.3%(15)	14.6% (12)
Carbohydrates	62.2% (51)	19.5% (16)	11.0% (9)	2.4% (2)	4.9% (4)
Saturated fat	29.3% (24)	14.6% (12)	20.7%(17)	24.4% (20)	11.0% (9)
Trans fat	35.4% (29)	12.2% (10)	20.7%(17)	18.3%(15)	13.4% (11)
Sugar	68.3% (56)	22.0% (18)	7.3% (6)	1.2% (1)	1.2% (1)
Sodium	14.6% (12)	18.3%(15)	15.9% (13)	31.7% (26)	19.5% (16)
Cholesterol	14.6% (12)	17.1% (14)	28.1% (23)	24.4% (20)	15.9% (13)
Fiber	20.7%(17)	18.3%(15)	28.1% (23)	23.2% (19)	9.8% (8)
Protein	24.4% (20)	29.3% (24)	19.5% (16)	14.6% (12)	12.2% (10)
Serving Size	35.4% (29)	22.0% (18)	11.0% (9)	17.1% (14)	14.6% (12)

Table 6. Barriers to adhering to meal plans among T1D patients

Statements	% (n)
I do not like the foods my doctor recommends.	
Strongly Agree	6.1%(5)
Agree	12.2% (10)
Neutral	40.2%(33)
Disagree	30.5%(25)
Strongly Disagree	11.0% (9)
I want to eat more foods than what my doctor recommends.	
Strongly Agree	20.7%(17)
Agree	41.5% (34)
Neutral	23.2% (19)
Disagree	13.4% (11)
Strongly Disagree	1.2% (1)
My family and/or friends do not like the foods that my doctor recommends I eat.	
Strongly Agree	4.9% (4)
Agree	9.8% (8)
Neutral	26.8%(22)
Disagree	41.5% (34)
Strongly Disagree	17.1% (14)
The foods my doctor recommends are too expensive.	
Strongly Agree	4.9% (4)
Agree	9.8% (8)
Neutral	26.8%(22)
Disagree	41.5% (34)
Strongly Disagree	17.1% (14)
The foods that my doctor recommends are not easily accessible.	
Strongly Agree	4.9% (4)
Agree	9.8% (8)
Neutral	26.8%(22)
Disagree	41.5% (34)
Strongly Disagree	17.1% (14)
I do not know how to prepare or cook the food that my doctor recommends.	
Strongly Agree	4.9% (4)
Agree	9.8% (8)
Neutral	26.8%(22)
Disagree	41.5% (34)
Strongly Disagree	17.1% (14)

Table 7. Demographics vs. Nutrition Knowledge Questions (Mean % Accurate)

	Healthy Foods (non-labels) Nutrition Knowledge Questions		Nutrition Labels-Nutrition Knowledge Questions	
	Mean Percentage % Correct (\pm S.D.)	p-value	Mean Percentage % Correct (\pm S.D.)	p-value
Age		0.841		0.868
\leq 29 years	61.2 \pm 17.2		70.9 \pm 20.2	
\geq 30 years	60.4 \pm 17.3		70.1 \pm 20.6	
Sex				
Male	54.0 \pm 15.0	0.031	63.9 \pm 24.2	0.083
Female	63.3 \pm 17.3		72.8 \pm 18.4	
BMI		0.797		0.344
Underweight/Healthy weight (<23.0)	61.2 \pm 18.4		69.4 \pm 21.0	
Overweight/Obese (\geq 23.0)	60.0 \pm 12.4		74.4 \pm 17.5	
Residence		0.692		0.378
Urban	60.4 \pm 16.2		71.9 \pm 19.0	
Rural	62.0 \pm 19.2		67.7 \pm 22.6	
Marital Status		0.736		0.860
Single	60.4 \pm 16.8		70.9 \pm 20.4	
Married or domestic partnership	61.7 \pm 17.9		70.0 \pm 20.3	
Highest level of education		0.014		0.685
Vocational school/Senior high or less	56.1 \pm 18.1		69.6 \pm 20.5	
College, Masters, or higher	65.3 \pm 15.2		71.4 \pm 20.2	
Current Employment		0.148		0.045
Student	56.4 \pm 16.4		77.9 \pm 15.1	
Other	62.6 \pm 17.2		67.9 \pm 21.3	

* = value of 2.5 was omitted from the data analysis ; significance level $\alpha=0.05$ from t-test

Table 8. Demographics Vs. Adherence to Meal Plans and Carbohydrate Counting

	Meal Plan Adherence		p value	Carbohydrate Counting Adherence			p value
	High (%) (=5 days or more)	Low % (=4 days or less)		High (%) (=Every day)	Moderate (%) (=Some days)	Low (%) (=Only when blood glucose is abnormal or Never)	
Age			0.863				0.594
≤ 29 years	59.5	65.2		50.0	63.6	63.6	
≥ 30 years	40.5	34.8		50.0	36.4	36.4	
Sex			0.646				0.199
Male	21.6	30.4		43.8	18.2	21.8	
Female	78.4	69.6		56.3	81.8	78.2	
BMI			0.755				0.212
Underweight/Healthy (<23.0)	78.4	78.3		93.8	72.7	72.7	
Overweight/Obese (≥23.0)	21.6	21.7		6.3	27.3	27.3	
Residence			0.802				0.824
Urban	67.6	60.9		62.5	72.7	67.3	
Rural	32.4	39.1		37.5	27.3	32.7	
Marital Status			0.472				0.075
Single	56.8	69.6		50.0	90.9	60.0	
Married or domestic partnership	43.2	30.4		50.0	9.1	40.0	
Highest level of education			0.743				0.601
Senior high school or vocational school	48.6	56.5		56.3	36.4	47.3	
College, Masters, or higher education	51.4	43.5		43.8	63.6	52.7	
Current Employment			0.878				0.522
Student	27.0	21.7		37.5	27.3	23.6	
Other	73.0	78.3		62.5	72.7	76.4	

* = value of 2.5 was omitted from the data analysis ; significance level $\alpha=0.05$ from chi-square test (Fisher's exact test for $n \leq 5$); Yate's correction factor applied to samples of $n \leq 10$

Table 9a. Demographics vs. Barriers 1-3

	1=I do not read food labels because I don't think it's important		p value	2=I want to read the food labels but do not because the labels are hard to understand		p value	3=I want to read the food labels but many of the foods I eat do not have food labels		p value
	Yes	No		Yes	No		Yes	No	
Age			0.798			0.686			0.646
≤ 29 years	62.5%	55.6%		64.3%	57.5%		55.6%	63.6%	
≥ 30 years	37.5%	44.4%		35.7%	42.5%		44.4%	36.4%	
Sex			0.607			0.704			0.002
Male	23.4%	33.3%		28.6%	22.5%		7.4%	34.5%	
Female	76.6%	66.7%		71.4%	77.5%		92.6%	65.5%	
BMI			0.016			0.903			0.894
Underweight/Healthy (<23.0)	71.9%	94.4%		78.6%	75.0%		74.1%	78.2%	
Overweight/Obese (≥23.0)	28.1%	5.6%		21.4%	25.0%		25.9%	21.8%	
Residence			0.809			0.108			0.202
Urban	67.2%	66.7%		76.2%	57.5%		77.8%	61.8%	
Rural	32.8%	33.3%		23.8%	42.5%		22.2%	38.2%	
Marital Status			0.864			1.000			0.273
Single	60.9%	66.7%		61.9%	62.5%		51.9%	67.3%	
Married or domestic partnership	39.1%	33.3%		38.1%	37.5%		48.1%	32.7%	
Highest level of education			0.032			0.041			0.263
Senior high school or vocational school	40.6%	72.2%		35.7%	60.0%		37.0%	52.7%	
College, Masters, or higher education	59.4%	27.8%		64.3%	40.0%		63.0%	47.3%	
Current Employment			0.700			0.701			0.894
Student	25.0%	33.3%		23.8%	30.0%		29.6%	25.5%	
Other	75.0%	66.7%		76.2%	70.0%		70.4%	74.5%	

Significance level $\alpha=0.05$ from two sample proportions test

Table 9b. Demographics vs. Barriers 4-6

	4=I do not like the foods my doctor recommends		p value	5=I want to eat more foods than what my doctor recommends		p value	6=My family/friends do not like the foods that my doctor recommends I eat.		p value
	Yes	No		Yes	No		Yes	No	
Age			0.069			0.905			1.000
≤ 29 years	73.5%	52.1%		66.7%	60.0%		60.4%	61.8%	
≥ 30 years	26.5%	47.9%		33.3%	40.0%		39.6%	38.2%	
Sex			1.000			0.645			0.914
Male	26.5%	25.0%		16.7%	27.1%		27.1%	23.5%	
Female	73.5%	75.0%		83.3%	72.9%		72.9%	76.5%	
BMI			0.004			0.819			0.743
Underweight/Healthy (<23.0)	91.2%	66.7%		83.3%	75.7%		79.2%	73.5%	
Overweight/Obese (≥23.0)	8.8%	33.3%		16.7%	24.3%		20.8%	26.5%	
Residence			0.273			0.751			0.536
Urban	58.8%	72.9%		75.0%	65.7%		70.8%	61.8%	
Rural	41.2%	27.1%		25.0%	34.3%		29.2%	38.2%	
Marital Status			0.032			0.475			0.766
Single	76.5%	52.1%		75.0%	60.0%		64.6%	58.8%	
Married or domestic partnership	23.5%	47.9%		25.0%	40.0%		35.4%	41.2%	
Highest level of education			0.763			0.441			0.013
Senior high school or vocational school	44.1%	50.0%		33.3%	50.0%		35.4%	64.7%	
College, Masters, or higher education	55.9%	50.0%		66.7%	50.0%		64.6%	35.3%	
Current Employment			0.849			1.000			0.489
Student	29.4%	25.0%		25.0%	27.1%		22.9%	32.4%	
Other	70.6%	75.0%		75.0%	72.9%		77.1%	67.6%	

Significance level $\alpha=0.05$ from two sample proportions test

Table 9c. Demographics vs. Barriers 7-9

	7=The foods that my doctor recommends are too expensive.		p value	8=The foods that my doctor recommends are not easily accessible.		p value	9=I do not know how to prepare or cook the foods that my doctor recommends.		p value
	Yes	No		Yes	No		Yes	No	
Age			0.234			0.876			0.282
≤ 29 years	54.3%	69.4%		61.7%	60.0%		54.5%	68.4%	
≥ 30 years	45.7%	30.6%		38.3%	40.0%		45.5%	31.6%	
Sex			0.710			1.000			1.000
Male	28.3%	22.2%		25.5%	25.7%		25.0%	26.3%	
Female	71.7%	77.8%		74.5%	74.3%		75.0%	73.7%	
BMI			0.934			1.00			0.369
Underweight/Healthy (<23.0)	78.3%	75.0%		76.6%	77.1%		81.8%	71.1%	
Overweight/Obese (≥23.0)	21.7%	25.0%		23.4%	22.9%		18.2%	28.9%	
Residence			0.001			0.003			0.346
Urban	82.6%	47.2%		80.9%	48.6%		72.7%	60.5%	
Rural	17.4%	52.8%		19.1%	51.4%		27.3%	39.5%	
Marital Status			0.047			0.734			0.388
Single	52.2%	75.0%		59.6%	65.7%		56.8%	68.4%	
Married or domestic partnership	47.8%	25.0%		40.4%	34.3%		43.2%	31.6%	
Highest level of education			0.001			0.006			0.003
Senior high school or vocational school	30.4%	69.4%		34.0%	65.7%		31.8%	65.8%	
College, Masters, or higher education	69.6%	30.6%		66.0%	34.3%		68.2%	34.2%	
Current Employment			0.674			0.578			0.513
Student	23.9%	30.6%		23.4%	31.4%		22.7%	31.6%	
Other	76.1%	69.4%		76.6%	68.6%		77.3%	68.4%	

Significance level $\alpha=0.05$ from two sample proportions test

Table 10. Barriers 1-9 vs. Adherence to Meal Plan and Carbohydrate Counting

	Meal Plan Adherence			Carbohydrate Counting Adherence			p value
	High	Low	p value	High (=Every day)	Moderate (=Some days)	Low (=Only when blood glucose is abnormal or Never)	
1= I do not read the food labels because I don't think it's important.			0.934				0.011
Yes	78.4%	73.9%		56.3%	63.6%	87.3%	
No	21.6%	26.1%		43.8%	36.4%	12.7%	
2=I want to read the food labels but do not because the labels are hard to understand.			0.343				0.024
Yes	59.5%	43.5%		31.3%	27.3%	61.8%	
No	40.5%	56.5%		68.8%	72.7%	38.2%	
3=I want to read the food labels but many of the foods I eat do not have food labels.			0.862				0.554
Yes	40.5%	34.8%		31.3%	18.2%	36.4%	
No	59.5%	65.2%		68.8%	81.8%	63.6%	
4=I do not like the foods my doctor recommends.			0.801				0.343
Yes	45.9%	39.1%		31.3%	27.3%	47.3%	
No	54.1%	60.9%		68.8%	72.7%	52.7%	
5=I want to eat more foods that what my doctor recommends.			0.018				0.088
Yes	24.3%	4.3%		0.0%	27.3%	16.4%	
No	75.7%	95.7%		100.0%	72.7%	83.6%	
6=My family/friends do not like the foods that my doctor recommends I eat.			0.559				0.563
Yes	67.6%	56.5%		56.3%	45.5%	61.8%	
No	32.4%	43.5%		43.8%	54.5%	38.2%	
7=The foods that my doctor recommends are too expensive.			0.482				0.350
Yes	64.9%	52.2%		56.3%	36.4%	60.0%	
No	35.1%	47.8%		43.8%	63.6%	40.0%	
8=The foods that my doctor recommends are not easily accessible.			1.000				0.345
Yes	59.5%	56.5%		62.5%	36.4%	60.0%	
No	40.5%	43.5%		37.5%	63.6%	40.0%	
9=I do not know how to prepare or cook the food that my doctor recommends.			0.063				0.240
Yes	62.2%	36.4%		43.8%	36.4%	60.0%	
No	37.8%	68.2%		56.3%	63.6%	40.0%	
Total Number of Barriers			0.138				0.254
0-4 barriers	31.0%	55.6%		50.0%	63.6%	38.2%	
5 more barriers	69.0%	44.4%		50.0%	36.4%	61.8%	

Significance level $\alpha=0.05$ from two proportions test; chi-square test (Fisher's exact test for $n \leq 5$) for CC adherence, Yate's correction factor applied to samples of $n \leq 10$

RESULTS: PROVIDER PERSPECTIVE

Provider Responses

There was a total of n=15 initial responses to the patient survey. All 15 participants agreed to the consent form, however for all questions of the survey, only n=11 participants filled out responses. Since the first question already showed 3 people missing, this suggests these 3 individuals decided to close out of the survey after agreeing to the consent form, or it is also possible that they experienced technical difficulties. However, reasons for the incompleteness of the survey by these 3 individuals are not certain.

Provider Descriptive Statistics

Provider Demographics

All of the providers in this study were female (Table 12). Approximately 82.8% (9) of providers were physicians and there was one nurse and one dietitian in the study. About 72.7% of providers have practiced their occupation for more than 10 years.

Recommendations to T1D Patients

Data collected shows majority of providers reporting 'Never' to recommending to their patients what to do for symptoms of high or low blood glucose (Table 13). Further more than half of providers report 'Never' to recommending what a "healthy diet" is for people with T1D and more than half of providers report never recommending counseling about dietary intake for glycemic control to their T1D patients. Additionally, when patients are first diagnosed with T1D, about 63.6% of providers report recommending a referral to a dietitian, however majority of providers report never recommending 'diet counseling by family physician,' 'group support meetings,' or 'family member support counseling' (Table 14). In terms of recommendation related to dietary advice, approximately 82% report recommending a meal plan to 'Every patient' with T1D and about 64% of providers report recommending counting carbohydrates to 'Every patient' (Table 15). Additionally, approximately 73% report recommending low glycemic foods to 'Every patient.'

Table 16 shows the frequency of complications providers' check for in their T1D patients. Almost all providers (90.9%) report checking hemoglobin A1C every 3 months or more and more than half of providers (63.6%) report checking for diabetic ketoacidosis every 3 months or more.

Providers' Perception on T1D Self-Management and Barriers for T1D Patients

More than half of providers (63.6%) believe T1D patients have more difficulties in changing their lifestyle than do other people who do not have T1D (Table 17). Further, 90.9% of providers believe managing diet is essential for managing blood glucose and all providers believe that insulin treatment is the most effective medication for reducing HbA1C level. When investigating providers' perception on patients' most perceived barriers, 81.8% believe meal plans are too rigid for patients, while 72.7% believe meal plans are not practical and include foods the patient does not normally consume (Table 18). Further majority of patients believe food expense and accessibility are not major barriers for their T1D patients.

Table 11. Basic Demographics of Health Care Providers

Variable Name	Mean±SD (Min-Max) or % (n)
Sex	
Male	0% (0)
Female	100.0% (11)
Occupation	
Physician	82.8% (9)
Nurse	9.1%(1)
Dietitian	9.1% (1)
Duration of Occupation	
Less than 5 years	9.1%(1)
5-10 years	18.2%(2)
More than 10 years	72.7%(8)
Total patients seen each day	
Less than 50 patients	72.7%(8)
50-100 patients	27.3%(3)
100 or more patients	0.0%(0)
Percentage of patients seen with T1D	8.82±6.83 (2.00-29.00)

Table 12. Frequency of Recommendations to T1D Patients

	% (n)			
	At all or most health care visits	Only when I suspect a patient has abnormal blood glucose	Only for patients who are interested	Never
Maintain healthy levels of physical activity.	0.0%(0)	18.2% (2)	27.3%(3)	54.6%(6)
What to do for symptoms of low blood glucose	0.0%(0)	18.2% (2)	0.0%(0)	81.8% (9)
What to do for symptoms of high blood glucose	0.0%(0)	27.3%(3)	0.0%(0)	72.7%(8)
What a “healthy diet” is for people with type-1 diabetes	0.0%(0)	27.3%(3)	18.2% (2)	54.6%(6)
Counseling about dietary intake for glycemic control	0.0%(0)	27.3%(3)	18.2% (2)	54.6%(6)

Table 13. Frequency of Advising Referrals and Counseling to T1D Patients

	% (n)			
	All the time	Sometimes	Only for patients who are interested	Never
Referral to a dietitian.	63.6%(7)	27.3%(3)	9.1%(1)	0.0%(0)
Diet counseling by the family physician.	36.4%(4)	18.2% (2)	0.0%(0)	45.5%(5)
Group support meetings	18.2% (2)	18.2% (2)	18.2% (2)	45.5%(5)
Family member support counseling	27.3%(3)	18.2% (2)	9.1%(1)	45.5%(5)
Weight loss counseling	45.5%(5)	45.5%(5)	0.0%(0)	9.1%(1)

Table 14. Frequency of Recommending Dietary Advice to T1D Patients

	% (n)			
	Every patient	Some patients	Only patients who experience problems	Never
To follow a meal plan.	81.8% (9)	9.1%(1)	9.1%(1)	0.0%(0)
Keep track of calories.	90.9%(10)	0.0%(0)	9.1%(1)	0.0%(0)
Count carbohydrates	63.6%(7)	9.1%(1)	18.2% (2)	9.1%(1)
Keep track of fat grams.	63.6%(7)	9.1%(1)	27.3%(3)	0.0%(0)
Limit sweets.	90.9%(10)	0.0%(0)	9.1%(1)	0.0%(0)
Limit high fat foods (ex: deep fried)	72.7%(8)	9.1%(1)	18.2% (2)	0.0%(0)
Drink more milk.	0.0%(0)	36.4%(4)	54.6%(6)	9.1%(1)
Eat more fruits and vegetables.	54.6%(6)	18.2% (2)	18.2% (2)	9.1%(1)
Eat more fiber and whole grains.	54.6%(6)	18.2% (2)	27.3%(3)	0.0%(0)
Choose low glycemic index foods.	72.7%(8)	0.0%(0)	18.2% (2)	9.1%(1)
Use dietary exchanges.	36.4%(4)	18.2% (2)	18.2% (2)	27.3%(3)

Table 15. Frequency checking the following complications in T1D patients

	% (n)				
	Every 3 months or more	Every 6 months	1x per year	Less than 1x per year	Never
Neuropathy	9.1%(1)	0.0%(0)	81.8% (9)	9.1%(1)	0.0%(0)
Retinopathy (and other eye complications)	9.1%(1)	0.0%(0)	72.7%(8)	18.2% (2)	0.0%(0)
Nephropathy	27.3%(3)	0.0%(0)	45.5%(5)	27.3%(3)	0.0%(0)
Skin complications	0.0%(0)	0.0%(0)	54.6%(6)	27.3%(3)	18.2% (2)
Foot complications	0.0%(0)	0.0%(0)	81.8% (9)	18.2% (2)	0.0%(0)
Diabetic Ketoacidosis (DKA)	63.6%(7)	0.0%(0)	0.0%(0)	36.4%(4)	0.0%(0)
Hypertension	63.6%(7)	0.0%(0)	9.1%(1)	27.3%(3)	0.0%(0)
Stroke	0.0%(0)	0.0%(0)	63.6%(7)	36.4%(4)	0.0%(0)
Gastroparesis	9.1%(1)	0.0%(0)	54.6%(6)	18.2% (2)	18.2% (2)
Mental Health	18.2% (2)	0.0%(0)	36.4%(4)	36.4%(4)	9.1%(1)
Lipids	63.6%(7)	0.0%(0)	9.1%(1)	27.3%(3)	0.0%(0)
Hemoglobin A1C	90.9%(10)	0.0%(0)	0.0%(0)	9.1%(1)	0.0%(0)

Table 16. Providers' perception of what is most essential for T1D management

Statement	% (n)
Patients with type-1 diabetes have more difficulties in changing their lifestyle than do other people who do not have type-1 diabetes.	
Strongly Agree	36.4%(4)
Agree	27.3%(3)
Neutral	18.2% (2)
Disagree	18.2% (2)
Strongly Disagree	0.0%(0)
Most patients with type-1 diabetes have low compliance in medication taking behavior compared to other patients that do not have type-1 diabetes.	
Strongly Agree	9.1%(1)
Agree	9.1%(1)
Neutral	27.3%(3)
Disagree	54.6%(6)
Strongly Disagree	0.0%(0)
Managing diet is essential for managing blood glucose.	
Strongly Agree	63.6%(7)
Agree	27.3%(3)
Neutral	9.1%(1)
Disagree	0.0%(0)
Strongly Disagree	0.0%(0)
Insulin treatment is the most effective medication for reducing HbA1C level.	
Strongly Agree	63.6%(7)
Agree	36.4%(4)
Neutral	0.0%(0)
Disagree	0.0%(0)
Strongly Disagree	0.0%(0)

Table 17. Barriers to adherence of meal plans among T1D patients perceived by health care providers

Statement	% (n)
Meal plans are not practical and include foods that the patient does not normally consume	
Strongly Agree	27.3%(3)
Agree	45.5%(5)
Neutral	18.2% (2)
Disagree	9.1%(1)
Strongly Disagree	0.0%(0)
Meal plans are too rigid	
Strongly Agree	27.3%(3)
Agree	54.6%(6)
Neutral	9.1%(1)
Disagree	0.0%(0)
Strongly Disagree	9.1%(1)
Meal plans contain food that is too expensive	
Strongly Agree	0.0%(0)
Agree	18.2% (2)
Neutral	36.4%(4)
Disagree	27.3%(3)
Strongly Disagree	18.2% (2)
Meal plans contain food that is not easily accessible	
Strongly Agree	0.0%(0)
Agree	18.2% (2)
Neutral	36.4%(4)
Disagree	27.3%(3)
Strongly Disagree	18.2% (2)

DISCUSSION

The study found that overall nutrition knowledge among patient participants is limited. However, no significant associations were found between nutrition knowledge and adherence to meal plans and carbohydrate counting. Additionally, the study found major barriers of managing diet with T1D perceived by patients included wanting to eat more food than what the patients' provider recommended, and not being able to read food labels due to the lack of labels on many food products and due to a lack of understanding the content on the label. The providers in the study also reported the stringent structure of meal plans to be a major barrier for their patients. Cost and accessibility of healthy foods were not major barriers reported by either patients or providers in the study.

The study's finding that patients scored higher in accuracy on nutrition questions related to label reading than on healthy foods and diet (non-label) related questions is further supported by the descriptive statistics showing approximately 76% of patient participants reporting looking at food labels often and the fact that more than half of providers report never advising their patients on what a "healthy diet" is. Additionally, majority of participants seem to be aware of the need to look at the amount of carbohydrates on the label. However, less than half of patient participants are not frequently looking at serving size on food labels, the other main component of labels for T1D patients to focus on when readily planning meals and counting carbohydrates. This may however be explained by one commonly reported barrier by patients that many of the foods they consume in general do not have food labels on them, and the possibility that many of the food labels in China do not have serving size listed on the label, and instead only list the total amount of grams in the entire package of food. Data analysis further showed that females scored higher on the HFNL questions, however, this may be influenced by the fact that there were a much larger proportion of females than males who took the survey. Additionally, the significant finding that those who scored less than 50% on the HFNL questions had a higher adherence to carbohydrate counting was opposite of what was expected. It is possible that these participants only received education on only carbohydrate counting and none on general 'healthy foods and diet' education.

When investigating trends between barriers and demographic variables, for significant findings that involved the same group having a higher percentage in both the agreement with and disagreement with the barrier statement (i.e. BMI and Barrier 1), may be explained by a much greater proportion of individuals in that group (i.e. Underweight/Healthy weight) compared to its latter (i.e. Overweight/ Obese). Overall, results also suggest that those with a college education or higher perceive significantly more barriers than those of a lesser education level. This may be explained that those of higher education are likely older participants who are independent and may have to deal with management on their own versus those who are of senior high school education or lesser education may likely represent adolescents of the study who may not perceive as many barriers because of care by their parents or caregiver. This may also explain why those of higher education level see preparing and cooking the foods their doctor recommends as more of a barrier since these individuals may be older and more independent and thus are responsible for feeding themselves. Further, while the data suggests that overall expense of food is not a major perceived by patients, those from urban areas report cost of food to be more of a barrier compared to reports from participants of rural areas. This may be explained by the likelihood that foods in urban areas are generally more expensive than in rural areas, and the likelihood that many participants from rural areas may rely on home grown food. Likewise, accessibility of foods may not be as big of an issue for participants from rural areas if their food is grown in their backyard. Further looking from the provider's perspective, despite majority of providers reporting managing diet as an essential component for managing blood glucose, more than half report never recommending counseling about dietary intake for glycemic control. Yet, almost, 82% of providers report advising their patients to follow a meal plan. These discrepancies between these reports may relate to response bias by the provider in terms of social desirability and knowing what they should be advising their patient even if they may not in fact advise the listed recommendations. Finally, providers perceive the strict structure of meal plans to be their T1D patients' most challenging barrier, which aligns with patients' reported desire to 'eat more food that what their doctor recommended'.

STRENGTHS AND LIMITATIONS

The strengths of this study include the collection and analysis of primary data. Limitations, however, involve the relatively small sample size used for both patients and providers. Response bias, which includes social desirability, may also have influenced patient and provider responses to lean towards what they think should be the correct response. Furthermore, use of an online community limits the sample for the study to include only T1D patients who have access to a technological device that allows them to access this online platform. The dropped responses shown in both the patient and provider surveys suggest possible fatigue bias by participants who may have felt the length of the survey to be too long. The fatigue bias may also contribute to answers that may not be as genuine towards the end of the survey, as patients or providers become more concerned with simply finishing the survey. The surveys also lacked specifically defined terms that promoted more participants to self-report answers as they see fit. For example, urban and rural were not clearly defined, and depended on the participant's own definition of 'urban' and 'rural.'

CONCLUSIONS

The strict structure of meal plans were found to be a common and major barrier to adherence as perceived by both patients and providers in this study. This suggests a more flexible insulin regimen is needed that involves more education on carbohydrate counting. This regimen would require patients to learn how to properly adjust insulin according to the amounts of carbohydrates consumed, however it will allow for patients to eat a more flexible diet and consume more foods they desire. No significant associations were found between nutrition knowledge and adherence to meal planning and carbohydrate counting. Further no significant associations were found between total number of barriers perceived and adherence to meal planning and carbohydrate counting. Cost of food and accessibility of healthy foods recommended by the patients' health care provider are not major perceived barriers to managing dietary intake with T1D self-management in this study.

FUTURE STEPS

Given the small sample size and these limitations, future research is needed test the associations between nutrition knowledge and adherence, as well as total number of barriers perceived and adherence. A linear regression will also be performed to further test for the relationship between nutrition knowledge and adherence, and barriers and adherence, while controlling for other confounders (i.e. income, education). Future research should also further investigate other variables that may influence the relationship between nutrition knowledge and adherence, such as the overarching stigma that exists towards the disease.

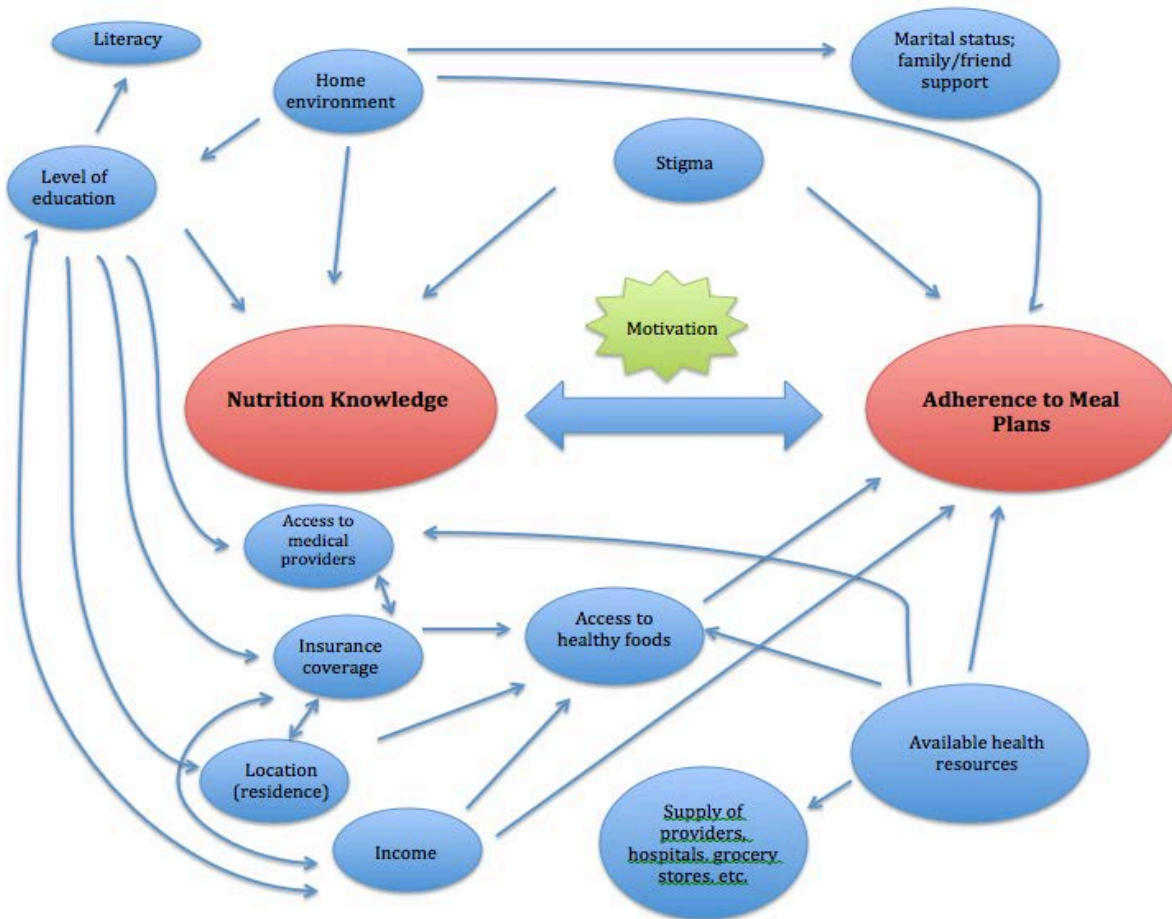


Figure 1. Nutrition Knowledge and Adherence to Meal Plan DAG diagram

REFERENCES

1. Daneman D. Type 1 diabetes. *Lancet* (London, England) 2006;367:847-58.
2. Alberti KGMM, Zimmet Pf. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus. Provisional report of a WHO consultation. *Diabetic medicine* 1998;15:539-53.
3. Type 1 Diabetes Basics. American Diabetes Association 2017. (Accessed September 2016, at <http://www.diabetes.org/diabetes-basics/type-1/?loc=db-slabnav>.)
4. What are Islet Cells? . Diabetes Research Institute Foundation 2016. (Accessed September 2016, at <https://www.diabetesresearch.org/islet-cells>.)
5. Penumathsa SV, Thirunavukkarasu M, Zhan L, et al. Resveratrol enhances GLUT - 4 translocation to the caveolar lipid raft fractions through AMPK/Akt/eNOS signalling pathway in diabetic myocardium. *Journal of cellular and molecular medicine* 2008;12:2350-61.
6. Belman JP, Bian RR, Habtemichael EN, et al. Acetylation of TUG protein promotes the accumulation of GLUT4 glucose transporters in an insulin-responsive intracellular compartment. *Journal of Biological Chemistry* 2015;290:4447-63.
7. Type 2 Diabetes American Diabetes Association, 2017. (Accessed September 2016, at <http://diabetes.org/diabetes-basics/type-2/?loc=db-slabnav>.)
8. Diagnosing Diabetes and Learning About Prediabetes American Diabetes Association 2017. (Accessed October 2016, at <http://www.diabetes.org/diabetes-basics/diagnosis/>.)
9. Prevention CfDCA. Prediabetes Atlanta, GA Centers for Disease Control and Prevention 2014:Diabetes Statistics Report.
10. Diabetes: Facts and Figures International Diabetes Federation 2015. (Accessed October, 2016, at <http://www.idf.org/about-diabetes/facts-figures>.)
11. Diabetes: Basics Centers of Disease Control and Prevention, 2015. (Accessed October 2016, at <https://www.cdc.gov/diabetes/basics/diabetes.html>.)
12. Jaacks LM, Liu W, Ji L, et al. Diabetes nutrition therapy and dietary intake among individuals with Type 1 diabetes in China. *Diabetic medicine : a journal of the British Diabetic Association* 2015;32:399-406.
13. Craig ME, Jones TW, Silink M, Ping YJ. Diabetes care, glycemic control, and complications in children with type 1 diabetes from Asia and the Western Pacific Region. *Journal of diabetes and its complications* 2007;21:280-7.
14. Living with Diabetes: Diabetes Complications American Diabetes Association, 2017. (Accessed October, 2016, at <http://diabetes.org/living-with-diabetes/complications/>.)
15. Atkinson MA, Eisenbarth GS, Michels AW. Type 1 diabetes. *The Lancet* 2014;383:69-82.
16. Patterson C, Dahlquist G, Soltesz G, Green A, Group EAS. Is childhood-onset type I diabetes a wealth-related disease? An ecological analysis of European incidence rates. *Diabetologia* 2001;44:B9-B16.

17. Maahs DM, West NA, Lawrence JM, Mayer-Davis EJ. Chapter 1: Epidemiology of Type 1 Diabetes. *Endocrinology and metabolism clinics of North America* 2010;39:481-97.
18. group Dp. Incidence and trends of childhood Type 1 diabetes worldwide 1990-1999. *Diabetic medicine : a journal of the British Diabetic Association* 2006;23:857-66.
19. Variation and trends in incidence of childhood diabetes in Europe. EURODIAB ACE Study Group. *Lancet (London, England)* 2000;355:873-6.
20. Mayer-Davis EJ, Lawrence JM, Dabelea D, et al. Incidence Trends of Type 1 and Type 2 Diabetes among Youths, 2002–2012. *New England Journal of Medicine* 2017;376:1419-29.
21. Soltesz G, Patterson C, Dahlquist G. Worldwide childhood type 1 diabetes incidence—what can we learn from epidemiology? *Pediatric diabetes* 2007;8:6-14.
22. Buzzetti R, Quattrocchi CC, Nisticò L. Dissecting the genetics of type 1 diabetes: relevance for familial clustering and differences in incidence. *Diabetes/metabolism reviews* 1998;14:111-28.
23. Atkinson MA, Eisenbarth GS. Type 1 diabetes: new perspectives on disease pathogenesis and treatment. *The Lancet* 2001;358:221-9.
24. Krischer JP. The Environmental Determinants of Diabetes in the Young (TEDDY) study: study design. *Pediatr Diabetes* 2007;8:286-98.
25. Hummel S, Beyerlein A, Tamura R, et al. First Infant Formula Type and Risk of Islet Autoimmunity in The Environmental Determinants of Diabetes in the Young (TEDDY) Study. *Diabetes care* 2017;40:398-404.
26. Insulin Pumps American Diabetes Association 2017. (Accessed November 2016, at <http://www.diabetes.org/living-with-diabetes/treatment-and-care/medication/insulin/insulin-pumps.html>.)
27. Zhao Z, Sun C, Wang C, et al. Rapidly rising incidence of childhood type 1 diabetes in Chinese population: epidemiology in Shanghai during 1997–2011. *Acta diabetologica* 2014;51:947-53.
28. Fu S, Li L, Deng S, Zan L, Liu Z. Effectiveness of advanced carbohydrate counting in type 1 diabetes mellitus: a systematic review and meta-analysis. *Scientific Reports* 2016;6.
29. Wang B, Yuan J, Yao Q, et al. Incidence and temporal trends of type 1 diabetes in China: a systematic review and meta-analysis. *The Lancet Diabetes & Endocrinology* 2016;4:S13.
30. Wu HB, Zhong JM, Hu RY, et al. Rapidly rising incidence of Type 1 diabetes in children and adolescents aged 0-19 years in Zhejiang, China, 2007 to 2013. *Diabetic medicine : a journal of the British Diabetic Association* 2016;33:1339-46.
31. McGuire H, Ji L. The 3-C Study - strong partnerships to improve care for people with type 1 diabetes in China *Diabetes Voice* 2011;56:12-5.
32. Yang Z, Wang K, Li T, et al. Childhood diabetes in China. Enormous variation by place and ethnic group. *Diabetes care* 1998;21:525-9.
33. Fu JF, Liang L, Gong CX, et al. Status and trends of diabetes in Chinese children: analysis of data from 14 medical centers. *World journal of pediatrics : WJP* 2013;9:127-34.

34. Qin ZY, Yan JH, Yang DZ, Deng HR, Yao B, Weng JP. Behavioral Analysis of Chinese Adult Patients with Type 1 Diabetes on Self-monitoring of Blood Glucose. *Chinese medical journal* 2017;130:39-44.
35. Jaacks LM, Du S, Mendez MA, et al. Comparison of the dietary intakes of individuals with and without type 1 diabetes in China. *Asia Pacific journal of clinical nutrition* 2015;24:639-49.
36. Jaacks LM, Crandell J, Mendez MA, et al. Dietary patterns associated with HbA1c and LDL cholesterol among individuals with type 1 diabetes in China. *Journal of diabetes and its complications* 2015;29:343-9.
37. Jaacks LM, Liu W, Ji L, Mayer-Davis EJ. Type 1 diabetes stigma in China: a call to end the devaluation of individuals living with a manageable chronic disease. *Diabetes research and clinical practice* 2015;107:306-7.
38. Zhao Z, Sun C, Wang C, et al. Rapidly rising incidence of childhood type 1 diabetes in Chinese population: epidemiology in Shanghai during 1997-2011. *Acta Diabetol* 2014;51:947-53.
39. Rovner AJ, Nansel TR, Mehta SN, Higgins LA, Haynie DL, Laffel LM. Development and validation of the type 1 diabetes nutrition knowledge survey. *Diabetes care* 2012;35:1643-7.
40. Fogelman Y, Goldfracht M, Karkabi K. Managing diabetes mellitus: A survey of attitudes and practices among family physicians. *Journal of community health* 2015;40:1002-7.